Response to

Request for Additional Information No. 47 (829, 842, 880), Revision 0

8/22/2008

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 18 - Human Factors Engineering
Application Section: FSAR Ch 18

Question 18-7:

NUREG 0711 section 8.4.2 and 8.4.3 contains program elements related to concept of operation.

DC FSAR section 18.7.2.3 states that an "HSI design implementation plan" specifies how the automation criteria and the role of operators as supervisors of automation are translated into the design guidance for the HSI.

DC FSAR section 18.7.4.3 states the same plan describes how the HFE and Control Room Design Team organizes and presents the alarms, displays, and controls on the HSIs.

The staff has not been able to locate this implementation plan.

Please describe the location of the plan if it is a subset of the topical report or FSAR. Please submit the implementation pan for review if it is a stand alone document.

Response to Question 18-7:

In general, functional allocations are determined by comparing the performance and the cost of humans and automation. Allocation decisions are made to maximize system functions performance. A set of automation criteria applicable to the U.S. EPR human system interface (HSI) design is shown in Functional Allocation Implementation Plan Appendix B, which is available for inspection in AREVA NP offices. U.S. EPR functions are allocated based on these automation criteria. Generally, functions automated in EPR predecessors plants are automated in the U.S. EPR design. The HSI is designed to accommodate the number of operators, the role of the operators and the amount of automation such that operator work load is optimized.

The HSI Design Implementation Plan has been completed. The HSI Design Implementation Plan describes how alarms, displays, and controls are designed. The alarm management design guide, which describes how functional requirements are analyzed to assign alarm priority and presentation, is in development. The alarm management design guide and a new revision of the HSI Design Implementation Plan will be available for review after December 2008 and after January 2009, respectively. At that time, the new revision of the HSI Design Implementation Plan will be available for inspection at AREVA NP offices.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 18-8:

NUREG 0711 section 8.4.4 contains 5 criteria that specify alternative approaches and studies be evaluated to ensure the HFE designs used are consistent with latest HFE principles.

The applicant did not address the criteria in this section.

Please provide a detailed description of how the 5 criteria in NUREG 0711 section 8.4.4 were addressed.

Response to Question 18-8:

The human system interface (HSI) concepts are based on predecessor EPR plant designs and utilize similar control of system functions and instrumentation and controls (I&C) concepts. The concept design implements a modern I&C design based on operating experience gained internationally in new plant designs and retrofits in existing plants with digital I&C equipment. Human performance issues identified in the U.S. EPR modified design will be analyzed, tracked, and resolved.

Activities such as concept testing, mock-up activities, trade-off evaluations, and performance-based tests are utilized at various stages of the design to verify the design supports the development of the concept design, addresses human performance concerns, and it is technically feasible. These test and evaluations are part of the evolution of the EPR design. The U.S. EPR human factors engineering (HFE) design team has performed mock-ups and concept testing to evaluate differences in requirements between Europe and the U.S.

Alternate design concepts are evaluated before the final design is selected. The U.S. EPR HSI design concept supports the design characteristics and criteria. HSI performance requirements were identified based on the functional requirements specifications, digital I&C equipment requirements, and human performance requirements. The criteria for addressing concepts HSI design for the U.S. EPR will be described in a new revision of the HSI Design Implementation Plan. The new revision of the HSI Design Implementation Plan will available for inspection at AREVA NP offices after January 2009.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 18-9:

NUREG-0711 section 8.4.5 (1) describes the HFE style guide.

The applicant states that an HSI style guide is used in the design of the HSI features, layout, and environment. The level of detail provided is insufficient to verify all style guide related criteria have been implemented.

Please submit the style guide for review or provide sufficient descriptions and examples that demonstrate how the criteria in this section have been addressed. If the style guide has not been competed please provide estimated completion date.

Response to Question 18-9:

The style guide provides consistency within the human system interface (HSI) design and addresses the guidance provided by NUREG-0700. The information in the U.S. EPR style guide is based on NUREG-0700, industry experience, AREVA NP experience, and EPR predecessor plant experience. A plant-specific style guide is developed through an analysis of the plant's established conventions (e.g., color, abbreviations, symbology) and general human factors engineering (HFE) guidance for the specific HSI technologies to be implemented. The topics in the HSI Style Guide address the scope of HSIs including the design, form, function, and operation of the HSIs and environmental characteristics relevant to human performance. For example, the style guide addresses general layout rules (e.g.,. a top-to-bottom; left-to-right approach). The symbols and labels are designed and oriented to support operator use. The inclusion of symbols on the screens are centered on the operator's needs.

The HSI style guide is a living document and is revised throughout the HFE design process as the U.S. EPR design matures and "COL applicant" input is received/understood. It is maintained and readily accessible through U.S. EPR document management system. The style guide will be available for inspection after December 2008 in AREVA NP offices.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 18-10:

NUREG-0711 section 8.4.5 (4):
When developing functional requirements for monitoring and control capabilities that may be provided either in the control room or locally in the plant, the following factors should be considered: Communication, coordination, workload, feedback, local environment, inspection, test, and maintenance , importance to safety.

FSAR section 18.7 does not address how feedback is used when developing functional requirements.

Please explain how feedback is used when developing functional requirements for monitoring and control capabilities

Response to Question 18-10:

Monitoring and control requirements are specified in the instrumentation and controls (I&C) functional specification for each of the plant systems. These requirements are translated by human factors engineering (HFE) Team members to functional human system interface (HSI) requirements. The HSI requirements are then translated into the features of the HSI. During this process, factors such as communication, coordination, workload, feedback, local environment, inspection, testing, maintenance, and importance to safety are considered. HSI that require feedback are captured in the functional and task requirements. Detailed guidance on the process of translating monitoring and control requirements into HSI features is provided in the HSI Design Implementation Plan. The features will be refined based on operator feedback from using the system design features. The process for capturing the system functional requirements is defined in the I&C Functional Requirements Specification document. The HSI Design Implementation Plan revision and the I&C Functional Requirements Specification document will be completed by the end of January 2009. At that time, it will be available for inspection at AREVA NP offices.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 18-11:

NUREG-0711 section 8.4.5 (4):
When developing functional requirements for monitoring and control capabilities that may be provided either in the control room or **locally in the plant***, the following factors should be considered: Communication, coordination, workload, feedback,* **local environment***, inspection, test, and maintenance , importance to safety.*

NUREG-0711 section 8.4.5 (8):
For the remote shutdown facility and local control stations,requirements should address constraints imposed by the ambient environment (e.g., noise,temperature, contamination) and by protective clothing (if necessary).

Environmental issues such as lighting, acoustics, personnel protection equipment, and ambient conditions suitable for personnel are included in the scope of the style guide(Sections 18.7.5, 18.7.6.2) for the Main Control Room. No mention is made of local environment associated with local control stations. Local control stations are not addressed within chapter 18.7.

Please explain how Local control stations (Including the remote shutdown facility) will be addressed within the HSI design.

Response to Question 18-11:

The remote shutdown facility contains similar human system interface (HSI) features to the main control room (MCR). The U.S. EPR HSI style guide will address the HSI design features associated with control stations. The U.S. EPR HSI style guide, to be issued by the end of October 2008 applies to the remote shutdown station HSI design. Environmental conditions (e.g., lighting, acoustics, ventilation) for the control station are specified in the appropriate system requirements description.

A separate human factors engineering (HFE) style guide will be produced by the end of September 2009 to address environmental issues such as lighting, acoustics, ambient conditions suitable for personnel, and protective clothing (if necessary) for the facilities included in the scope of the HFE program, defined in U.S. EPR FSAR Tier 2, Section 18.1.1.3, which includes the remote shutdown station and local control stations. The HFE and HSI style guides provide direction to engineering disciplines (e.g., structural engineers) for the design of non-control room based HSIs (e.g., local control stations). U.S. EPR FSAR Tier 2, Section 18.7.5 will be revised to include this information.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Section 18.7.5 will be revised as described in the response and indicated on the enclosed markup.

Question 18-12:

NUREG-0711 section 8.4.5 (8):
HSI characteristics should support human performance under the full range of environmental conditions, e.g., normal as well as **credible extreme conditions**. *For the main control room requirements should address conditions such as loss of lighting, loss of ventilation, and main control room evacuation.*

Human performance under credible extreme conditions is not addressed in the DC application chapter 18.7.

Please address the HSI characteristics supporting human performance under credible extreme conditions including the specific examples within this criterion.

Response to Question 18-12:

Requirements concerning credible extreme conditions are captured during the engineering design process. Design requirements for the control rooms and human system interfaces (HSI) within the scope of the human factors program human performance requirement for designing for extreme conditions are captured. In accordance with the design control process, the control rooms and HSIs are then designed to conform to those requirements. By following the procedures and guidance provided by the human factors program, the HSIs in areas that are postulated for use in credible extreme conditions, such as a local control station or the remote shutdown station, are designed to ensure operators are able to effectively use the HSI during those extreme conditions. As the design of the control rooms, local control stations, and the HSI evolves, details concerning exact HSI characteristics that support human performance are specified.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 18-13:

NUREG-0711 criteria 8.4.6.1 and 8.4.6.2: These criteria summarize the characteristics of trade-off evaluations and performance based tests.

In DC FSAR section 18.7.7, the applicant states that testing and evaluation is conducted throughout the HSI design at various stages of the development so that the complex HSI design functions properly before the design process is resolved and validation occurs. Chapter 18.1, figure 18.1-2 shows V&V interim checks after each major milestone. The applicant provided a programmatic level description stating that activities such as concept testing, mock-up activities, trade-off evaluations, and performance based tests are utilized at various stages of the design. The applicant states the criteria used to decide which type of testing or evaluation technique to use is contained in the V&V implementation plan contained in Chapter 18.10. Chapter 18.10 does not contain these criteria nor any description of the techniques listed above in the context of various stages of design. (Integrated system validation is noted as a performance based test - Is performance based testing used in other design stages?)

1. Please explain which testing and evaluating techniques are being used and how they interface with the V&V interim checks.
2. For the techniques being used, please explain how the NUREG criteria listed above are applied.
3. As currently stated in DC FSAR section 18.7.7, please document the criteria being used for applying testing or evaluation techniques

Response to Question 18-13:

Activities such as concept testing, mock-up activities, trade-off evaluations, and performance-based tests are utilized at various stages of the design to verify the design supports the development of the concept design, addresses human performance concerns and is technically feasible. These test and evaluations are part of the evolution of the U.S. EPR design. The U.S. EPR human factors engineering (HFE) design team has performed mock-ups and concept testing to evaluate differences in requirements between Europe and the U.S.

1. The human system interface (HSI) design will maintain the operator's eight core performance areas: monitoring and sampling, sensing, information processing, interpreting, decisions making, memory information storage and retrieval, controlling, and responding – communicating. As described in U.S. EPR FSAR Tier 2, Section 18.10.3.5, the U.S. EPR will perform human performance-based test during initial ISV to verify and validate the operator's response to plant conditions from the HSI, makes control decision, and executes control actions.

   A verification and validation implementation plan has been developed; however, additional details are being added relative to the criteria associated with testing and evaluation techniques. The new revision will be ready for inspection Q3Y09 at AREVA NP offices. Additional details regarding testing, evaluation techniques, and associated criteria for the U.S. EPR are provided in this document.
2. Per NUREG-0711 criteria 8.4.6.1 and 8.4.6.2, trade-off studies are performed to evaluate the HSI design. The goal of the trade-off study is to optimize the balance of safety

performance, engineering and human factors development. This study includes operator training and procedure development based on the design. Testing and evaluation efforts consider safety implications and the potential for mitigating human error or of improving human performance associated with the equipment, system, or facility.

3. The selection of HSI design tests is based on the nature of the questions being addressed in test procedures and the level of design maturity. The selection of tests chosen are based on the results of the safety analysis, human reliability analysis, lessons learned, and operating experience from predecessor designs, the uncertainty of new design and technology and the indeterminate outcome of operator's response to it.

   The statement in U.S. EPR FSAR Tier 2, Section 18.7.7, "The criteria used to decide which type of testing or evaluation technique is applicable are described in a verification and validation (V&V) implementation plan (see Section 18.10)." will be revised to say the following: "The criteria used to decide which type of testing or evaluation technique is applicable are described in a V&V implementation plan."

FSAR Impact:

U.S. EPR FSAR, Tier 2, Section 18.7.7 will be revised as described in the response and indicated on the enclosed markup.

Question 18-14:

NUREG-0711 section 8.4.7 (1)

The HSI design should document the following features:

- *the detailed HSI description, including the format and performance characteristics*
- *the basis for the HSI design characteristics with respect to operating experience and literature analyses, trade-off studies, engineering evaluations and experiments, and benchmark evaluations*
- *records of the basis of the design changes*

The DC FSAR addresses all of the criterion guidance with the exception of recording design basis changes. The DC FSAR references ANP 10266, "Areva NP Inc. Quality Assurance Manual for the Design Certification of the US EPR," which specifies that design records include the final design output and revisions to the final output, important design steps (e.g., calculations, analyses, and computer programs) and the sources of input that support the final output. This document does not explicitly address recording design basis changes.

Please explain how the basis for design changes is documented.

Response to Question 18-14:

Configuration management and design control is maintained while changes are being processed by the Design Change Control (DCC) process. The DCC process is described in a U.S. EPR procedure, which is available for inspection at AREVA NP offices. This procedure complies with ANP-10266, "AREVA NP Quality Assurance Manual for the Design Certification of the U.S. EPR." The DCC procedure defines the actions and responsibilities necessary to propose, assess, review, approve, and document design changes to a design configuration. The process is performed in five sequential parts:

- Change Identification.
- Change Assessment.
- Identification of Affected Documents.
- Change Implementation.
- Design Change Closeout.

The design change is initiated by a Design Change Request (DCR) or change identification. The change is assessed by management at multiple levels to determine priority level and project impacts. DCRs are review by appropriate personnel to assess project impacts and level of importance. Appropriate personnel including all potentially impacted engineering disciplines (i.e., electrical, instrumentation and controls, human factors engineering, civil engineering), review the DCR for potential impacts. Changes are implemented to engineering documentation and reviews are performed independently to provide a quality review with appropriate checks and balances. Lastly, the DCR is closed out. Engineering documents, DCRs, and documents

associated with the DCC process are maintained in the AREVA NP records management system.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 18-15:

NUREG-0711, Element 12 for Design Implementation, states that the applicant should provide for staff review an implementation plan. After staff's review of the EPR FSAR and the topical report (ANP-10279, Rev. 0), AREVA provided to the staff a programmatic description of the design implementation process. However, the staff could not determine how the design implementation process will be executed.

Please provide the implementation plan for the design implementation process for staff review. If this is not available, please provide detailed information as to how AREVA will execute the design implementation process.

Response to Question 18-15:

U.S. EPR FSAR Tier 2, Sections 18.11.2 through 18.11.4 describe the methodology and activities that will be performed during the U.S. EPR human factors engineering (HFE) Design Implementation. The design implementation process will verify aspects of the design not addressed during the V&V process, the "As-Built" human system interface, Plant-Specific Procedures, Plant-Specific Training, and that HFE issues in the Tracking Database have been addressed. An HFE Design Implementation Plan that describes in more detail the process has been completed and is available for inspection at AREVA NP offices.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 18-16:

NUREG-0711 section 11.4.2.1.2 (2)
The inventory should describe the characteristics of each HSI component within the scope of the review, including the unique identification code number or name, associated plant system and subsystem, associated personnel functions/subfunctions, type of HSI component, display characteristics and functionality, control characteristics and functionality, user-system interaction and dialog type, location in the data management system, and physical location of the HSI, if applicable. The inventory should also include photos, copies of video display unit screens, and samples of HSI components.

In DC FSAR section 18.10.3.1, the applicant states that the HSI inventory provides an accurate and complete description of the HSI components. The list of description attributes included in the text contains all the elements in this criterion except “associated personnel functions/subfunctions.”

Please explain how "associated personnel functions/subfunctions" is addressed.

Response to Question 18-16:

Personnel functions and sub-functions that are associated with human system interfaces are documented during the Inventory and Characterization of design verification. The "associated personnel functions/subfunctions" will be added to U.S. EPR FSAR Tier 2, Section 18.10.3.1.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Section 18.10.3.1 will be revised as described in the response and indicated on the enclosed markup.

Question 18-17:

NUREG-0711 section 11.4.2.1.2 (3):
The HSI inventory should be based on the best available sources (e.g., equipment lists, design specifications, and drawings). These descriptions should be compared by directly observing the components, both hardwired and computer-generated, to verify that the inventory accurately reflects their current state

The V&V plan as outlined in DC FSAR section 18.10 does not address the verification of field components.

Please explain how the V&V program will address verification of the HSI inventory against field components.

If this action is not planned, please explain why not performing this part of the criterion is acceptable.

Response to Question 18-17:

U.S. EPR FSAR Tier 2, Section 18.10.2 states, “The HFE V&V process applies to HSIs (i.e., controls, displays, and alarms) in the MCR, the RSS, and appropriate local control stations (LCS). Functions considered critical to plant safety (i.e., risk-important HAs are specific targets to require sample V&V activities).” Verification of field components would fall under the “appropriate LCS” category. AREVA NP’s definition of “field components” includes LCS, human system interface (HSI) outside the control stations, and operational equipment within the plant (e.g. valve hand wheel). LCS deemed critical to plant safety and meeting the criteria defined in the U.S. EPR V&V implementation plan will be in scope when performing V&V of the human factors engineering HSI.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 18-18:

NUREG-0711 Section 7.4, Review Criteria 1 – 4, describes the review for the Human Reliability Analysis (HRA).

The Final Safety Analysis Report (FSAR) states that "an output report identifies the list of risk-important HAs and summarizes how those HAs and the associated tasks and scenarios were addressed during the various parts of the HFE design process." The level of detail provided is insufficient to verify that the HRA criteria have been implemented.

Please submit the HRA results for review or provide sufficient descriptions and examples that demonstrate how the criteria in Element 7 of NUREG-0711 have been addressed. If the HRA analysis has not been competed, please provide the estimated completion date.

Response to Question 18-18:

The Standardized Plant Analysis Risk-Human Reliability Analysis (SPAR-H) human reliability analysis (HRA) methodology was chosen for the U.S. EPR because it is a conservative methodology and because it is an appropriate methodology for a design for which the development of emergency procedure guideline (EPG) and final human machine interface (HMI) designs are at an early stage. The HRA will continue to be refined in parallel with the EPG and HMI designs as they mature.

One product of the cooperation discussed above is an implementation plan for the integration of HRA into the human factors engineering (HFE) program. The HFE Program Topical Report (ANP-10279 Section 5.2) and U.S. EPR FSAR Tier 2, Section 18.6 describe the iterative process by which the HRA, HMI, and EPG designs will be refined through detailed design. Through this process, the HRA and HFE will support each other and the EPG by providing the design team with feedback that assists in minimizing personnel errors, and improving operator recovery from human errors and plant system failures. Risk-significant human actions identified by the PRA team, and the associated tasks and accident scenarios, are addressed during HFE activities such as function allocation analyses, task analyses, procedure development, and training.

As described in U.S EPR FSAR Tier 2 Section 18.10, the HFE verification and validation (V&V) process includes validation of HRA assumptions for dominant sequences by walkthrough analyses with operationally experienced personnel using a plant-specific control room mockup or simulator. Incorporation of feedback from these activities and updates to the HRA are performed in accordance with the HFE/HRA integration plan described in U.S. EPR FSAR Tier 2, Section 18.6 and the PRA maintenance and upgrade process described in U.S. EPR FSAR Tier 2, Section 19.1.2.4.

U.S. EPR FSAR Tier 2 Section 19.1 addresses the risks associated with nominal full-power operation, low-power operation, and shutdown conditions. Tables in U.S. EPR FSAR Tier 2, Section 19.1 list several example risk important actions and associated analysis. COL item 19.1-9 listed in U.S. EPR FSAR Tier 2, Table 1.8-2 is provided to confirm that assumptions used in the PRA remain valid for the as-to-be-operated plant.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 18-19:

NUREG-0711 section 11.4.2.2.2 (4):
An HED should be identified for HSIs that are available in the HSI but are not needed for any task.

In DC FSAR section 18.10.3.2, the applicant states that HSI elements that do not support personnel tasks are identified during the HSI design. The number of HSI elements or screens is reduced if the HFE and Control Room Design Team determines that an excessive number of display elements or screens interfere with operator awareness or leads to information overload issues. This addresses the case where the HSI element is unneeded but not the case where there is an incomplete task or function analysis, or the element is outside the scope of the analyses. Also, there is no information provided on documenting the discrepancy on an HED.

For an HSI element without a corresponding task, Please address how causes other than an unnecessary element will be addressed. Please include HED requirements within this discussion.

Response to Question 18-19:

The U.S. EPR Verification and Validation (V&V) implementation plan describe in detail the human system interface (HSI) Task Support review criterion, which is utilized to determine if HSI are adequate or deficient. The following questions are used to verify HSI Tasks:

- Does the operator have excessive or unnecessary HSIs that could take away from the operators understanding of plant conditions or cause a distraction (e.g., flashing alarms of control or monitoring aspects that are unnecessary for the operator to perform the required task)?
- Are HSIs missing that are needed for monitoring and control that are required to perform operator tasks (e.g., procedure step that can not be performed due to lack of access to control or monitoring point)?
- Does the HSI monitoring and control action require excessive operation actions to perform the task. (e.g., the operator is required to navigate through too many screens to operator a valve)?
- Do the HSI characteristics align with the operator task requirement, component functional requirement, or the system functional requirement for the task to be performed (e.g., the valve control does not function as required because the valve either operates too fast, too slow, or requires additional steps)?

A “yes” to any of these questions would mean an HSI task issue has been found and a procedure or design change may be necessary. The HSI task deficiency shall be documented in the HED process. The HED process is described in U.S. EPR FSAR Tier 2, Section 18.10.3.6 and in the response to RAI 18-28.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 18-20:

NUREG-0711 section 11.4.3.1:
Plant personnel should perform operational events (for integrated system testing) using a simulator or other suitable representation of the system to determine its adequacy to support safety operation. This should be undertaken after significant HEDs that were identified in verification reviews have been resolved.

The applicant takes a more general strategy with respect to HEDs stating in DC FSAR section 18.10.3.5.5 that they will verify that previously generated HEDs have been addressed or are tracked for further consideration. While the applicant states in section 18.10.3. that HED resolution is performed iteratively throughout the HSI design process so that issues are identified and corrected early and that some HEDs identified during verification are resolved prior to proceeding with validation of the HSI design, this does not specifically reflect the element of the criterion stating all significant HEDs have been resolved.

Please explain how significant HEDs will be managed relative to the ISV.

Response to Question 18-20:

The human factors engineering (HFE) verification and validation (V&V) process is organized such that HEDs are identified as early as possible during the design process. As described in U.S. EPR FSAR Tier 2, Section 18.10.3.5, initial design ISV activities such as evaluation of display navigation are conducted throughout the design phases without operating procedures via techniques such as interviews, walk-throughs, and laboratory simulators. One of the key goals of initial design ISV activities is to identify HEDs. Initial TSV is performed early in the human system interface (HSI) design process to provide information for HSI screen layout and to ensure significant HED are identified. However, if latent or unidentified HEDs are not detected during Initial ISV they are likely to be detected during Formal ISV.

Formal ISV tests are performed using the plant simulator with a representative set of realistic scenarios selected from OCS input to confirm that the HSIs, the procedures, the function allocation, and the task design also supports the operator during task performance. Formal TSV is performed when the HSI and simulator designs have evolved to the point that the simulator represents the complete HSI inventory. Task requirements, performance requirements, or functional requirement are measure using the following objectives:

- Adequacy of the entire HSI configuration for achievement of the HFE goals.
- Confirmation of allocation of functions and the structure of tasks assigned personnel and machine.
- Adequacy of staffing and HSI that support tasks.
- Adequacy of procedures and operating instructions.
- Validation of the dynamic response aspect of HSI for task accomplishment.

HEDs, which are not identified in initial design ISV, should be identified in the formal ISV and documented just like other HEDs. The HED is tracked using the HED tacking database and processed using the HED Procedure. The HED Procedure can be found in the V&V

Implementation Plan. The V&V Implementation Plan is available for inspection at AREVA NP offices. For additional details on the HED process, see U.S. EPR FSAR Tier 2, Section 10.10.3.6 and the response to RAI 18-28.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 18-21:

NUREG-0711 section 11.4.3.2.1 (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 objectives should be to:

- *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 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.*

In DC FSAR section 18.10.3.5.4, the applicant describes ISV test objective. These objectives restate the criteria above with 2 exceptions.

- The objective to validate shift staffing does not include the concept of validating crew coordination between the control room and local control stations and support centers. It also does not include the concept of validating performance during shift turnover.
- The objective to validate that specific personnel tasks can be accomplished within time and performance criteria is not directly correlated to any of the criteria in the DC FSAR section. The closest ISV objective is to validate that the functional requirements are met for the major HSI features. The objective loses some of the intent of the criterion in that it could be applied with limited focus on equipment functionality and potentially miss the human elements described in the criterion.

Please explain how the following ISV test objectives will be addressed

1. Coordination between the MCR and local control stations
2. performance during shift turnover
3. the validation of personnel tasks with focus on crew situation awareness, balanced workloads supporting vigilance, minimization of operator error, error detection and recovery.

Response to Question 18-21:

AREVA NP agrees that the objectives described in items 1-3 above should be included in the U.S. EPR FSAR and will be added to Tier 2, Section 18.10.3.5.4. Therefore, the validation of those objectives in NUREG-0711 will be addressed in the same fashion as the other objectives in ISV. ISV test objective are considered when determining the validation test objectives. The Verification and Validation (V&V) Implementation Plan describes in more detail how the ISV test objectives are addressed and are incorporated into the test procedures. The V&V Implementation Plan is available for inspection at AREVA NP offices.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Section 18.10.3.5.4 will be revised as described in the response and indicated on the enclosed markup.

Question 18-22:

NUREG-0711 section 11.4.3.2.2
Validation should be performed by evaluating dynamic task performance using tools that are appropriate to the accomplishment of this objective. The primary tool for this purpose is a simulator. One approach to identifying a validation testbed that is consistent with the following review criteria, is to use the American National Standard "Nuclear power plant simulators for use in operator training," (ANSI/ANS 3.5-1998) as a guide

- *Interface Completeness*
- *Interface Physical Fidelity*
- *Interface Functional Fidelity*
- *Environment Fidelity*
- *Data Completeness Fidelity*
- *Data Content Fidelity*
- *Data Dynamics Fidelity-*
- *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.)*
- *The testbeds should be verified for conformance to the testbed characteristics identified above before validations are conducted.*

In DC FSAR section18.10.3.5.5, the applicant states that the ISV will be performed on a high-fidelity simulator meeting the requirements in 10CFR 50.34(f)(2)(i). There is no discussion of validation methods that will be applied at the non-control room locations. Also the 10CFR reference is incorrect(34.f.2.i verses 34.f.2.xii.C.2.i).

Response to Question 18-22:

The human factors engineering (HFE) verification and validation (V&V) implementation plan applies to the non-control room locations that are deemed critical to plant safety. HFE principles are applied during design installation via the U.S. EPR HSI Style Guide. During ISV, operator actions that are in the non-control room locations are simulated through representative operation actions. Representative operation actions utilize conservative time values associated with the location and actions simulated. The in-scope locations are verified during the design implementation.

The paragraph in U.S. EPR FSAR Tier 2, Section 18.10.3.5 “Verify that the test bed meets the requirements in 10 CFR 50.34.f.2.xii.C.2.i.” will be changed to “Verify that the test bed meets the requirements in 10 CFR 50.34.f.2.i.”

AREVA NP agrees that the ISV methods applicable to non-control room locations are not presented in the U.S. EPR FSAR at this time. AREVA NP will add the following to U.S. EPR FSAR Tier 2, Section 18.10.3.5:

"The RSS human system interface (HSI) testbed is simulated using a subset of the MCR or a separate HSI mockup since the HSI platform (i.e. PICS) in the MCR is the same. This will enable the V&V activities for the RSS to achieve a high fidelity of simulation."

FSAR Impact:

U.S. EPR FSAR, Tier 2, Section 18.10.3.5 will be revised as described in the response and indicated on the enclosed markup.

Question 18-23:

NUREG -0711 section 11.4.3.2.4
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:

- *task support needs*
- *staffing objectives*

In DC FSAR section 18.10.3.4.4, the applicant provides a set of criteria used to fully define the scenarios to be validated. All elements for the NUREG criterion are included in this set with the exception of "task support needs" and "staffing objectives."

Please explain how task support needs and staffing objectives are included in the V&V scenarios documentation.

Response to Question 18-23:

Task support needs and staffing objective are parts of the criteria used to define the scenarios to be validated. Task Support needs and staffing objectives will be added to U.S. EPR FSAR Tier 2, Section 18.10.3.4.4. The U.S. EPR verification and validation implementation plan has a detailed list of procedures and operator scenarios that are used during ISV.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Section 18.10.3.4.4 will be revised as described in the response and indicated on the enclosed markup.

Question 18-24:

NUREG-0711 section 11.4.3.2.4 (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.

In DC FSAR section 18.10.3.5, the applicant states that Formal ISV tests are performed using the plant simulator with a representative set of realistic scenarios selected from OCS input to confirm that the HSIs, the procedures, the function allocation, and the task design also supports the operator during task performance. There are no additional details on how task fidelity is maintained within scenarios.

Please explain how task fidelity is maintained within scenarios.

Response to Question 18-24:

The full scope simulator will utilize the same human system interface (HSI) layout, structure, content and functionality as the HSI used in the control room. In addition, the simulator environment will be closely mimicked to the environment of the main control room (MCR). Appropriate task fidelity will be ensured through the use of the suitable procedures as used during real scenarios in the control room. U.S. EPR FSAR Tier 2, Section 18.10.3.5 states the evaluation of the ISV shall include the identification of problems of unproven procedures. In addition, realistic scenarios in accordance with ANSI/ANS-3.5-1998 for the primary and secondary loop will be implemented in the thermo-hydraulic model of the simulator.

The simulator software will be designed to properly emulate plant and system real time responses. Operators can manipulate controls on operator workstations to initiate changes in plant or system variables.

Furthermore, the full scope simulator will be designed with the following objectives in mind:

- Interface physical fidelity – A high degree of physical fidelity in the HSIs and procedures is represented, which include alarms, displays, controls, job aids, procedures, communications, interface management tools, layout, and spatial relationships.
- Interface functional fidelity – A high degree of functional fidelity is represented. HSIs are functionally available. Highly 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).
- Environmental fidelity - A high degree of environmental fidelity is represented. The lighting, noise, temperature, and humidity characteristics will be reasonably reflected.
- Data completeness fidelity – Information and data provided to personnel will represent the plant systems monitored and controlled from that facility.
- Data content fidelity – The information and control presented is based on an underlying thermodynamic model that accurately reflects the U.S. EPR.

- Data dynamic fidelity – The process model is capable of providing input to the HSI allowing information flow and control response to occur accurately and timely (e.g., information should be provided to personnel with the same delay as would occur in the plant).

Task fidelity will be best maintained by sound configuration management of the plant simulator and the human factors engineering (HFE) program elements. Therefore, tasks performed can be judged against a known baseline and assessed accordingly.

Although some of these objectives are difficult to measure, the best judgment of the human factors engineers will be used to determine conformance to the test bed objectives. Areas that are not designed to conform to these fidelity objectives will be documented in the HED database. The HFE team utilizes engineering best judgment to create and maintain the highest level of fidelity.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 18-25:

NUREG-0711 section 11.4.3.2.5:
The review criteria for performance measurement are divided into three sections. Section 11.4.3.2.5.1 addresses the measurement characteristics that effect the quality of the performance measures, Section 11.4.3.2.5.2 addresses the identification and selection of variables to represent measures of performance, and Section 11.4.3.2.5.3 addresses the development of performance criteria.

DC FSAR section 18.10.3.5.5 states that human performance measure will be developed as part of the ISV strategy. However, the design certification does not address the performance measurement criterion in this section of the NUREG in any further detail.

Please address the criterion contained in section 11.4.3.2.5 of NUREG-0711.

Response to Question 18-25:

NUREG-0711 Performance Criteria 11.4.3.2.5.3, human performance measures are developed as part of the ISV operator testing strategy. The ISV process procedure is developed to govern how tests are conducted. To conduct non-bias testing, performance measurement and monitoring techniques will be used to record performance data. The performance measurements are developed from the performance criteria (e.g., requirements referenced, HRA assumptions, benchmarks referenced, normative referenced and expert-judgment referenced), measurement characteristics (e.g. construct validity, diagnosticity, reliability, resolution, sensitivity, and simplicity), and focus variable selection (e.g., plant performance measure, personnel task measure, work load, operator errors, physical/physiological factors, or situational awareness). As part of test development, performance measures are selected and documented to understand how personnel are performing.

Performance measure characteristics are considered when selecting the ISV test performance measure. The performance measure that is tested will often have several performance measure characteristics associated.

Testing variables (i.e., focus variables) are selected and the tests are developed to measure the selected variable. Variable selections can range from many to a few for a specific test. A detailed list of performance measure characteristics and testing variables can be found in the U.S. EPR V&V implementation plan available for inspection at AREVA NP offices.

The performance criterion for the performance measurement is evaluated and established as part of the test development. The approach to establishing criteria is based on the comparisons between the measurement and criteria that are performed. Performance criteria are non-biased and recordable with data to quantify operator and system performance.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 18-26:

NUREG-0711 section 11.4.3.2.6
The review criteria for test design are divided into five sections. Section 11.4.3.2.6.1 addresses coupling crews and scenarios, Section 11.4.3.2.6.2 addresses test procedures, Section 11.4.3.2.6.3 addresses the training of test conductors, Section 11.4.3.2.6.4 addresses the training of test participants, and Section 11.4.3.2.6.5 addresses the conduct of pilot studies.

The Design Certification FSAR did not contain information addressing test design related criteria from NUREG-0711 section 11.4.3.2.6 with the exception of subsection 11.4.3.2.6.4, “Pilot testing”.

Please address all "test design" related criteria from NUREG-0711 section 11.4.3.2.6 with the exception of those relating to Pilot Testing (subsection 11.4.3.2.6.4.)

Response to Question 18-26:

NUREG-0711 subsection reference to Pilot Testing should be subsection 11.4.3.2.6.5.

The test procedure section is not in U.S. EPR FSAR Tier 2, Section 18.10. The following will be added:

“18.10.3.5.6 Test Procedure

As part of the validation, a procedure is developed to govern how tests are conducted. Test procedures describe how tests are to be conducted. It is important that validation testing is conducted without bias performance data. It is necessary that test procedures are detailed, clear, and easily understandable. When possible, test procedures minimize the opportunity of tester expectancy bias or participant response bias. Procedures that describe how tests are to be conducted are developed to meet the following objectives:

- Identify the crew that will receive the scenario and the order the scenario is to be presented.
- Detailed and standardized instructions for briefing the participants. This source of bias is minimized by developing standard instructions.
- Specific criteria for scenarios, such as when to start and stop the scenario, and when events are introduced.
- Guidance on when and how to interact with participants when simulator or testing difficulties occur.
- Detailed information for personnel outside of the control room as to what information they can provide, as well as a script with acceptable responses to likely questions. There are limits to preplanning communications because personnel may ask questions or make requests that were not anticipated.
- Procedures for documentation (i.e., identify and maintain test record files including staff and scenario details, data collected, and test conductor logs).
- Instructions regarding when and how to collect and store data. The instructions identify which data are to be recorded by one or more of the following:

- Simulator computers.
- Special purpose data collection devices.
- Video recorders (location and views).
- Test personnel in real time (observation checklist).
- Subjective rating scales and questionnaires."

U.S. EPR FSAR 2, Tier Section 18.10.3.5.5 describes the steps that will be preformed during ISV. Test personnel training and participation training are covered in the bulleted list. Under select participants, the first bullet describes the test participants and the associated credentials. The second bullet describes the test conductors and the associated credentials. The fourth bullet describes additional requirement associated with the test participants.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Section 18.10.3.5.6 will be added as described in the response and indicated on the enclosed markup.

Question 18-27:

NUREG-0711 section 11.4.3.2.7 contains performance criteria associated with ISV data analysis and interpretation. NUREG-0711 section 11.4.3.2.8 contains criteria associate with ISV validation conclusions.

The design certification does not address these two sections of NUREG-0711.

Please explain how the criteria in NUREG-0711 sections 11.4.3.2.7 and 11.4.3.2.8 will be addressed within the V&V program

Response to Question 18-27:

U.S. EPR FSAR Tier 2, Section 18.10.3.5.5 outlines the ISV strategy. ISV data analysis, interpretation and validation conclusions are the last two steps of this strategy. Additional details are in the U.S. EPR human factors engineering (HFE) verification and validation implementation plan and the following will be added to the U.S. EPR FSAR Tier 2:

"18.10.3.5.7 Data Analysis, Interpretation and Validation Conclusions

ISV test data is analyzed though the use of quantitative and qualitative methods. Analysis will determine whether performance measures are pass/fail. Conservatism is built into the data analysis and interpretation to allow real-world performance differences and the margin of error associated with testing. Failed performance measures are tracked by the Human Engineering Deficiency (HED) process. Prior to formal ISV, pilot testing HEDs resulting from failed performance measures are resolved. The data analysis and the validation of converging performance measures are independently verified to be in conformance with the HFE program elements in accordance with the AREVA NP Design Control QA process.

The logical basis for performance measures validation and associated testing is documented and defined in engineering documentation. Performance measure validation also considers additional factors that could potentially invalidate results. For example, aspects of the test not well controlled, and differences between the ISV simulator and actual As-Built control station under real operating plant conditions are areas that require additional consideration prior to forming validation conclusions. Validation conclusions will be iteratively documented in validation output reports throughout the design process. HED will be created whenever HSI issues or personnel deficiencies are identified. The appropriate design or procedure changes will then be initiated as required."

FSAR Impact:

U.S. EPR FSAR, Tier 2, Section 18.10.3.5.7 will be added as described in the response and indicated on the enclosed markup.

Question 18-28:

NUREG-0711 section 11.4.4.2:
This criterion describes elements that should be contained in and HED evaluation.

In DC FSAR section 18.10.3.6, the applicant provides documentation requirements for an HED. The description includes categories that cover all the NUREG criterion concepts but without the details addressed within the criterion.

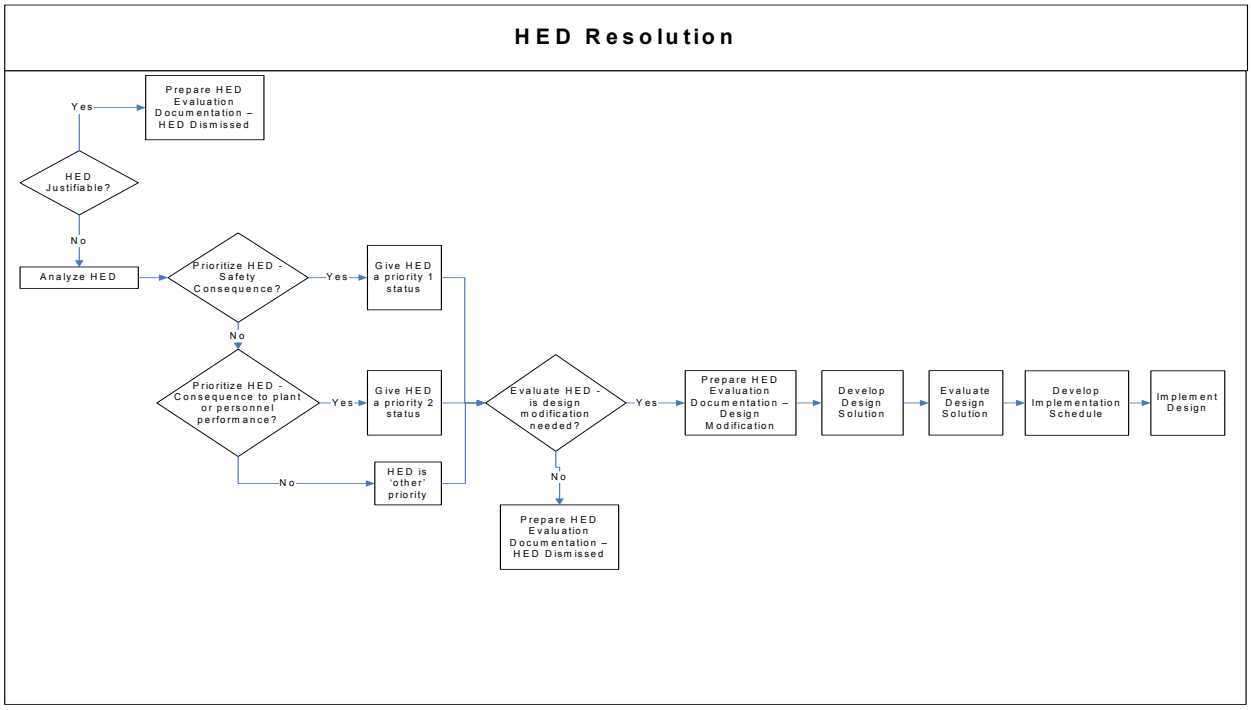
Please explain how and when the the additional detail in NUREG-0711 section 11.4.4.2 will be addressed.

Response to Question 18-28:

The Human Engineering Deficiency (HED) resolution procedure can be found in the U.S. EPR verification and validation (V&V) implementation plan. The HED resolution process, outlined by Figure 18-28-1—HED Resolution Process, includes HED Justification, HED Analysis, HED prioritization, HED Evaluation Documentation, Development of Design Solution, and Design Solution Evaluation. The HED resolution procedure is utilized for the V&V of the human factors engineering (HFE) program.

The detailed steps as described in NUREG-0711 for HED review criteria can be found in the U.S. EPR V&V implementation plan. The U.S. EPR V&V implementation plan has been developed and is available for inspection at AREVA NP offices. Additional details regarding human engineering discrepancy evaluations for the U.S. EPR are provided in this document.

Figure 18-28-1—HED Resolution Process



FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 18-29:

10 CFR 50.34(f)(2)(iv): Provide a plant safety parameter display console that will display to operators a minimum set of parameters defining the safety status of the plant, important plant parameter and data trends on demand, and capable of indication when process limits are being approached or exceeded.

As described in DC FSAR, Tier 2, Section 18.7.1.3.3 , "Safety Parameter Display System," the applicant addressed the SPDS requirement with an integrated design, rather than a stand-alone, add-on system as is used at most currently operating plants. The EPR design will address the regulatory requirements by integrating the SPDS requirements into the design requirements for the Plant Information Control and Safety Information Control systems. In NUREG-0800, the staff indicated that for applicants who are in the early stages of the control room design, the "function of a separate SPDS may be integrated into the overall control room design."

However, because the 10 CFR 50.34 regulation specifies a safety parameter display console, the staff has determined that an exemption must be processed. The exemption must conform to the special circumstances described in 10 CFR 50.12(a)(2)(ii).

To support the staffs review of an exemption from the requirements of 10 CFR 50.34(f)(2)(iv) for an SPDS console and instead the accomplishment of the SPDS console by integration of its functions into the overall design, the following information is requested.

Please explain how the SPDS related criteria contained in 50.34(f)(2)(iv), NUREG-0737 supplement 1, and NUREG-1342 are addressed within the integrated control room design.

Response to Question 18-29:

AREVA NP is seeking an exemption from the requirements of 10 CFR 50.34(f)(2)(iv) regarding a dedicated stand alone safety parameter display system (SPDS) console in accordance with 10 CFR 50.12 (a)(2)ii, "Application of the regulation in the particular circumstances would not serve the underlying purpose of the rule or is not necessary to achieve the underlying purpose of the rule; …".

The SPDS criteria contained in 50.34(f)(2)(iv) to display to operators a minimum set of parameters defining the safety status of the plant, a full range of important plant parameters and data trends on demand, and indicate when process limits are being approached or exceeded are provided as a specially designed display on the process information and control system (PICS) and the safety information and control system (SICS). The SPDS display can be viewed on the PICS and SICS workstations as well as on the Plant Overview Panel (POP) (driven by the PICS) in the Main Control Room (MCR). Additionally, the SPDS display can be viewed on the PICS workstations in the Technical Support Center and the Remote Shutdown Station.

The display navigation and hierarchy is designed such that the operator does not have to search through plant operating displays to find the SPDS display. By integrating the SPDS display into the PICS and SICS workstations, as well as the POP, a convenient location is provided for personnel to readily view the SPDS display. Having the SPDS implemented in this manner makes it an integral part of day to day plant safety oversight and operations. AREVA

NP is confident that an integrated approach is more effective and is consistent with new digital technologies and human factors best practices.

The U.S. EPR human system interface provides the status of the SPDS functions. The SPDS functions include:

- Reactivity control
- Reactor core cooling and heat removal from the primary system
- Reactor coolant system integrity
- Radioactivity control
- Containment conditions

The integrated U.S. EPR alarm system provides overview alarms addressing the five SPDS functions.

In the MCR, the SPDS display is provided on both the PICS and the SICS workstations, which provides redundancy and equal accuracy in both systems. The response time of both the PICS and SICS are equal to or better than the response times recommended in NUREG-1342. The response times will be verified during equipment Factory Acceptance Testing, initial, and final ISV.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 18-30:

NUREG-0711 section 2.4.1 (3)
The HFE Program should address the Main Control Room (MCR), remote shutdown facility, technical support center (TSC), emergency operations facility (EOF), and local control stations (LCSs).

The applicant states that the EOF is a COL responsibility. The TSC remains a responsibility of the DC applicant.

Please explain how the HFE program will be applied to the Technical Support Center. Will all program elements be applied? If yes, please explain how differences between MCR and TSC will be addressed. For example, will there be a function and task analysis specific to the TSC and how will the V&V be conducted?

Response to Question 18-30:

A response to this question will be provided by October 3, 2008.

Question 18-31:

NUREG-0711 section 4.4 (1)
The applicant should perform the functional requirements analysis and function allocation using a structured, documented process reflecting HFE principles.

In support of a completed element review, please submit the function analysis results. If the the function analysis has not been completed please provide and estimated completion date.

Response to Question 18-31:

The U.S. EPR functional analysis has not been completed. The U.S. EPR is an evolutionary design based on predecessor designs. An implementation plan describing how information inherited from predecessor designs will be integrated into the U.S. EPR design process is in progress. At that time, the Inheritance Implementation plan will be available for inspection at AREVA NP offices. This implementation will address activities that satisfy the intent of function analysis.

The Functional Allocation Implementation Plan has been developed for the U.S. EPR human factors engineering (HFE) detail design. The Functional Allocation Implementation Plan defines the automation criteria. The automation criteria is applied to the instrumentation and controls (I&C) functional requirements to perform, in part, functional analysis. The Functional Allocation Implementation Plan is available for inspection at AREVA NP offices.

The I&C functional requirements process has been developed for the U.S. EPR detail design. This process describes the method that will be used to define plant system functional requirements. The results of this process provides approximately three quarters of the input to the Functional Requirements Analysis (FRA) that is performed by the Integrated HFE team. The I&C functional requirements process is available for inspection at AREVA NP offices.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

U.S. EPR Final Safety Analysis Report Markups

When a set of OER data is collected, it is classified with respect to its relevance and importance. Classification of OER data is important because it is only useful if it is accessible to members of the design team engaged in the relevant activities. Section 5.4.3 of the AREVA Human Factors Topical Report (Reference 2) describes how OER information is screened. OER items classified as highly relevant to the U.S. EPR HSI design are captured in the HFE Issues Tracking Database. Issues not resolved in the current iteration of the HSI design are placed in the HFE issue tracking system to alert the applicable design organization of the relevant OER information. A review of the HSI design implementation plan ~~(see Section 18.11)~~ and the HSI style guide (see Section 18.7.5) is performed so that the HFE principles cited in the OER event are applied to HSIs in the HSI design process. The HSI style guide documents how HFE principles from OER events are included in the HSI design and justifies the application of those principles.

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18.7.1.1.2 Functional Requirement Analysis and Function Allocation

FRA and FA are performed as described in Section 18.3. These analyses determine which operational functions are to be performed by automatic systems, by plant personnel, or by some combination of the two. The allocation is made based on the FRA after determining what is required to perform the function. FA evolves from FRA and results in allocating functions for the best overall accomplishment for that function.

A function is a process or activity required to achieve a desired operational goal. The term, function, may refer to those critical to plant safety (e.g., initiation of emergency feedwater) or to non-safety support equipment (e.g., a valve or information display). Functions are essentially hierarchical; for example, pressurized water reactors have evolved a natural hierarchical structure of functions, processes, systems, and components. High-level functions may be accomplished through a combination of lower-level system functions and may require human action (HA). Allocation of functions to humans may be appropriate at any level of the functional structure.

Operational requirements related to a given process function are better defined by breaking the function down into more basic components. At a low level, a function can and must be explicitly assigned to an available resource (i.e., hardware, software, human, or some combination thereof). The overall goal of FRA and FA is to define the requirements in detail so that the allocation can take advantage of human strengths and avoid human limitations to maximize overall function accomplishment.

Inputs to the FRA include the overall plant design and operational concept, HSI concept definition (i.e., accomplished via the U.S. EPR predecessor designs), and OER identified tasks associated with a high workload that would be more efficient if automated. The FRA inputs lead to the definition of concept of operations (see Section 18.7.2) with respect to the role of personnel. The inputs define potential

18.7.4.5 Remote Shutdown Workstation Alarms, Displays, and Controls

The MCR provides the capability for safe shutdown, even assuming a safe-shutdown earthquake (SSE), a loss of offsite power, and the most limiting single failure. Localized emergencies which make the environment unsuitable for the operators and require evacuation of the MCR are not postulated concurrent with other design basis events. If evacuation of the MCR is required, the operators can establish and maintain a safe shutdown from outside the MCR through the use of the PICS and SICS in the RSS.

The minimum inventory of alarms, displays, and controls in the RSS meets criteria similar to that in the MCR, but consists of only those functions necessary to attain safe shutdown following an MCR evacuation. The RSS minimum inventory includes the readily accessible HSIs that the operator needs to:

- Perform and confirm a reactor trip.
- Place and maintain the reactor in a safe condition using the normal or preferred safety means.

Section 7.4.1.3 describes safe shutdown from outside the MCR by use of the RSS.

Table 7.4-1 shows the displays, alarms, and controls available in the RSS. A list of the minimum inventory on the RSS SICS is included in Table 18.7-2—Minimum Inventory of Remote Shutdown Station Fixed Alarms, Displays, and Controls. The methodology for selecting the final minimum inventory for the RSS is similar to that described in Section 18.7.4.4.

18.7.5 Human Factors Design for the Non-Human System Interface Portion of the Plant

A style guide provided by the HFE and Control Room Design Team is used in the design of HSI features. It also provides guidance on such issues as general plant layout design, equipment accessibility requirements, coding and labeling, and environmental issues such as lighting, acoustics, personnel protection equipment, and ambient conditions suitable for personnel. The style guide is a design guideline applicable to engineering disciplines (e.g., structural engineers) who are required to follow the style guide for plant and equipment layout decisions.

18.7.5.1 Plant Layout Design and Equipment Accessibility

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System engineers specify space requirements for their equipment during the plant layout phase taking into account maintenance, testing, and component replacement. The ~~HSI~~HFE style guide provides guidance for these space requirements. Location of interfaces also considers the general physical layout of the system. HSIs are placed in

easy to access locations (e.g., manual valve operators will not be located where access requires the use of a portable ladder or scaffold).

18.7.5.2 Coding, Language, and Information Presentation

Rules for coding, labeling, and presenting information on HSIs, local control stations, and on most equipment are specified in the HSI style guide. The nomenclature and terminology used in operating procedures and design documentation (e.g., system manuals and plant drawings) shall be consistent with those used for operator interfaces.

Unique equipment identifiers shall be established in the equipment database early in the design phase, and those identifiers shall be maintained throughout the design, manufacture, construction, testing, procedure development, and operational staff training. In conformance with NUREG-0711 (Reference 4) and consistent with NUREG-0700 (Reference 6), the HSI style guide specifies requirements for the use of symbols, abbreviations, syntax, and color schemes.

18.7.5.3 Lighting of the HMI Rooms and Workspaces

The lighting in the control rooms and workstations, including local control stations, provides suitable working conditions for personnel by:

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- Providing adequate lighting for performance of their tasks (e.g., good contrast for easy discrimination of required information, good minimum lighting level for the preservation of alertness).
- Avoiding glare and reflection.

18.7.5.4 Acoustic Environment

The acoustic environment and the mean noise level in the MCR aids operator alertness so that the monitoring and controlling of processes and the associated mental activities are performed in comfort, and communication between the members of the operating staff is not disrupted.

18.7.5.5 Personnel Protection Equipment

Though the use of personnel protection equipment such as hearing, eye, and head protection, anticontamination clothing, and self-contained air breathing apparatus is not postulated in the MCR; it is placed in locations providing easy access. The placement of this equipment is considered in the plant layout design.

18-11

18.7.5.6 Ambient Conditions ~~in the Control Rooms~~

During normal operation at basic atmospheric conditions, the temperature and humidity in the MCR and associated HSI rooms are controlled to normal comfort

Testing and evaluation is conducted throughout the HSI design at various stages of development so that the complex HSI design functions properly before the design process is resolved and validation occurs (see Figure 18.1-2).

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Activities such as concept testing, mock-up activities, trade-off evaluations, and performance-based tests are utilized at various stages of the design. The criteria used to decide which type of testing or evaluation technique is applicable are described in a V&V implementation plan ~~(see Section 18.10)~~.

18.7.8 HSI Design Results and Documentation

As described in Section 5.4.8.7 of Reference 2, the HSI designs are documented using specific design control process requirements. The various configuration management, design change controls, design verification, and design quality control tools are also described in Reference 1.

18.7.9 References

1. ANP-10266NPA, Revision 1, "AREVA NP Inc. Quality Assurance Plan (QAP) for Design Certification of the U.S. EPR," AREVA NP Inc., April 2007.

2. ANP-10279, Revision 0, “U.S. EPR Human Factors Engineering Program,” AREVA NP Inc., January 2007.

3. NUREG-0737, “Clarification of TMI Action Plan Requirements,” U.S. Nuclear Regulatory Commission, November 1980.

4. NUREG-0711, “Human Factors Engineering Program Review Model,” Rev. 2, U.S. Nuclear Regulatory Commission, February 2004.

5. ANP-10284, Revision 0, “U.S. EPR Instrumentation and Controls Diversity and Defense-in-Depth Methodology,” AREVA NP Inc., June 2007.

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

7. NUREG/CR-6633, “Advanced Information Systems: Technical Basis and Human Factors Review Guidance,” U.S. Nuclear Regulatory Commission, March 2000.

8. NUREG/CR-6634, “Computer-Based Procedure Systems: Technical Basis and Human Factors Review Guidance,” U.S. Nuclear Regulatory Commission, March 2000.

9. NUREG/CR-6635, “Soft Controls: Technical Basis and Human Factors Review Guidance,” U.S. Nuclear Regulatory Commission, March 2000.

10. NUREG/CR-6636, “Maintainability of Digital Systems: Technical Basis and Human Factors Review Guidance,” U.S. Nuclear Regulatory Commission, March 2000.

design that can not be assessed analytically. The goal is to test the integration of personnel and plant systems and to validate the integration of the design with personnel actions, plant response, HSIs, and procedures. ISV is performed using a high-fidelity simulator. Generally, ISV participants are operators with training and qualifications consistent with the description in Section 13.2. Multiple groups of operators are used for ISV scenarios so that results are not biased towards well-qualified crews. Details on ISV are provided in Section 18.10.3.5.

Human engineering discrepancy (HED) resolution is performed iteratively throughout the HSI design process so that issues are identified and corrected early. Some HEDs identified during verification are resolved prior to proceeding with validation of the HSI design. HEDs are not considered in isolation and, to the extent possible, their potential interactions are considered when developing and implementing solutions. More details on HED resolution are provided in Section 18.10.3.6.

The final step in verification is the design implementation activity, which confirms that the design description and documentation match the installed configuration and completes any V&V activities that could not be performed prior to installation. Any discrepancies identified at this stage are resolved by updating the appropriate documentation before the design is ready for operation. Design implementation is described in Section 18.11.

18.10.3.1 HSI Inventory and Characterization

The HSI inventory and characterization activity describes HSI components and related equipment associated with personnel tasks that are within the scope of the HSI design to be verified. The complete inventory is created by filtering certain portions of the instrumentation and controls (I&C) input/output (I/O) database which receives information from sources such as system description documents, design specifications, equipments lists, and process and instrumentation drawings. The accuracy of the inventory is confirmed by comparing it with the HSI elements described in the design specifications for the HSIs. The inventory includes aspects of the HSI that are used for interface management such as navigation and display retrieval in addition to those that control the plant.

The inventory provides an accurate and complete description of the HSI components and includes the following information:

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- A unique component identification code, which includes the associated plant system and subsystem.
- Associated personnel function/subfunction.
- The type of component.

18.10.3.4.4 Identification of Scenarios

When the complete set of operational condition samples is developed, the results are combined to identify a set of scenarios for ISV. The following criteria are used to fully define the scenarios to be validated.

- A given scenario identified for ISV that combines multiple characteristics of each dimension.
- A scenario defined to allow, where practicable, repetition with multiple ISV participants to establish consistency of results. The scenario definition includes, as a minimum:
  - A description of the scenario mission and any pertinent situational history necessary for operators to understand the state of the plant upon scenario startup.
  - Specific start conditions.
  - Events (e.g., failures) that will occur and their initiating condition(s).
  - Precise definition of workspace factors such as environmental conditions.
  - Communication requirements with remote personnel.
  - Crew behavior requirements.
  - Data to be collected by the operators including how they were collected and where they were captured and stored.
  - Criteria required for terminating the scenario.
  - Task support needs.
  - Staffing objectives.
- The scenarios selected are not biased towards:
  - Positive outcomes.
  - ISV that is administratively easy to conduct scenarios.
  - ISV that is familiar and well-structured scenarios (i.e., textbook design basis accidents).
- Random scenario selection and sequencing is used to keep the testing unbiased. The easy scenarios are not always conducted first and testing participants get random assignments.

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- 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 includes validation of the nominal shift levels, minimal shift levels, and shift turnover.

- 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.

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- Validate that the functional requirements are met for the major HSI features such as group-view displays, alarm systems, safety parameter display system functions, general display systems, procedures, controls, communication system, and EOP-related LCSs.

- Validate that the control room operators can make effective transitions between the HSI features (e.g., group-view display, alarm systems, SICS, PICS, procedures, controls, communication systems) in the accomplishment of their task and that interface management tasks such as display configuration and navigation are not a distraction or cause undue burden.

- Validate that the integrated system performance is tolerant of failures of individual HSI features.

- Identify aspects of the integrated system (e.g., staffing, communication, and training) that may negatively impact integrated system performance.

18.10.3.5.5 Strategy

ISV is performed on a high-fidelity simulator and includes the following steps:

- Develop detailed test objectives.

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- Verify that the test bed meets the requirements in 10 CFR 50.34(f)(2)~~(xii)(C)(2)(i)~~(i).

- Verify that previously generated HEDs have been addressed or are tracked for further consideration.

- Select participants:

  – Test participants are qualified operators that represent plant personnel who will interact with the HSI (e.g., operators currently licensed on similar plant designs rather than training or engineering personnel).

  – Test conductors are trained and qualified in the usage of test procedures, error introduction by inaccurate testing procedures, and importance of testing documentation.

- Normal crew configuration is present for the test (see Section 18.7.2).
- Sample participants for the validation test are randomly chosen to avoid significant overlap with regard to:
  - Operator license and qualification.
  - Age.
  - Skill and experience.
  - General demographics.
  - Test participants:
    - Are not a part of the design organization.
    - Have not been involved in prior evaluations.
    - Were not selected based on a specific characteristic.

- Select and define scenarios from OCS.
- Develop test procedures.
- Develop human performance measures.
- Establish that test personnel and test participants have been properly trained.
- Conduct a pilot study to assess test design, performance measures, and data collection methods.
- Initiate simulation and conduct study.
- Analyze data, validate HRA assumptions, make appropriate design changes, as required.
- Create validation output reports.

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18.10.3.5.6 Test Procedure

As part of the validation, a procedure is developed to govern how tests are conducted. Test procedures describe how tests are to be conducted. It is important that validation testing is conducted without bias performance data. It is necessary that test procedures are detailed, clear, and easily understandable. When possible, test procedures minimize the opportunity of tester expectancy bias or participant response bias. Procedures that describe how tests are to be conducted are developed to meet the following objectives:

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- Identify the crew that will receive the scenario and the order the scenario is to be presented.
- Detailed and standardized instructions for briefing the participants. This source of bias is minimized by developing standard instructions.
- Specific criteria for scenarios, such as when to start and stop the scenario, and when events are introduced.
- Guidance on when and how to interact with participants when simulator or testing difficulties occur.
- Detailed information for personnel outside of the control room as to what information they can provide, as well as a script with acceptable responses to likely questions. There are limits to preplanning communications because personnel may ask questions or make requests that were not anticipated.
- Procedures for documentation (i.e., identify and maintain test record files including staff and scenario details, data collected, and test conductor logs).
- Instructions regarding when and how to collect and store data. The instructions identify which data are to be recorded by one or more of the following:
  - Simulator computers.
  - Special purpose data collection devices.
  - Video recorders (location and views).
  - Test personnel in real time (observation checklist).
  - Subjective rating scales and questionnaires.

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18.10.3.5.7 Data Analysis, Interpretation and Validation Conclusions

ISV test data is analyzed though the use of quantitative and qualitative methods. Analysis will determine whether performance measures are pass/fail. Conservatism is built into the data analysis and interpretation to allow real-world performance differences and the margin of error associated with testing. Failed performance measures are tracked by the HED process. Prior to formal ISV, pilot testing Human Engineering Deficiency (HED)s resulting from failed performance measures are resolved. The data analysis and the validation of converging performance measures are independently verified to be in conformance with the HFE program elements in accordance with the AREVA NP Design Control QA process.

The logical basis for performance measures validation and associated testing is documented and defined in engineering documentation. Performance measure validation also considers additional factors that could potentially invalidate results. For example, aspects of the test not well controlled, and differences between the ISV

simulator and actual As-Built control station under real operating plant conditions are areas that require additional consideration prior to forming validation conclusions. Validation conclusions will be iteratively documented in validation output reports throughout the design process. HED will be created whenever HSI issues or personnel deficiencies are identified. The appropriate design or procedure changes will then be initiated as required.

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18.10.3.6 Human Engineering Discrepancy Resolution

HEDs refer to deficiencies in the HSI design with respect to HFE issues. During the design phases, HEDs are captured in the HFE Issues Tracking Database (see Section 18.1.4). When the U.S. EPR operator has assumed responsibility for maintaining design documentation, HEDs are tracked via the site-specific corrective actions program (see Section 18.12.3).

HEDs are documented throughout the HFE design process, including the HFE analyses, informal design reviews and iterations, and in each of the V&V steps. To identify an HED, designers document the relevant HSI, task criterion, an explanation of the basis for the deficiency, and a recommendation for correcting the problem, if applicable. The documentation completely describes the HED including, as a minimum:

- Priority categorization.
- Associated plant system.
- Associated personnel function.
- Associated HSI or procedure.
- Whether the HED was corrected or justified as needing no correction and the bases for this determination in terms of consequences to plant safety or operations.
- Possible impact of similar areas of design.
- Impact on plant design.
- Impact on schedule.

Some HEDs are evaluated as acceptable; a justification of acceptability allows the HED to be closed with concurrence of the HFE verifiers. After resolution for the discrepancy has been established, the task or HSI component is re-evaluated to establish that it was adequately resolved and the HED records are updated to show the changes. HEDs also track HFE issues. Where possible, these issues are satisfactorily resolved by the completion of the final design (see Section 18.11). Some HEDs are not resolved due to design constraints on HSI equipment or other factors.