Attachment 1

Sections 18.1 through 18.8 and Appendices 18E and 18F
of the
SBWR SSAR Amendment 1 Draft

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18.0 Human Factors Engineering

18.1 Introduction

This chapter describes the SBWR human-system ~~man-machine~~ interface (HSI) ~~(MMIS)~~ design goals and bases, the standard HSI ~~MMIS~~ design features and the detailed HSI ~~MMIS~~ design and implementation process, with embedded design acceptance criteria, for the SBWR standard plant operator interface. The SBWR Emergency Procedure Guidelines and the inventory of instrumentation and controls needed by the control room staff for the performance of Emergency Operating Procedures are also described. The incorporation of human factors engineering (HFE) principles into all phases of the design of these interfaces is provided for as described in this chapter.

Design goals and design bases for the HSI ~~instrumentation and control systems and operator interfaces~~ in the main control room and in remote locations are established in Section 18.2. The overall design and implementation process is described in Section 18.3. Section 18.4 contains a description of the main control room standard HSI ~~operator interface~~ design features and HSI technologies. The Remote Shutdown System is described in Section 18.5. Section 18.6 discusses how the systems which make up the HSI ~~operator interface~~ are integrated together and with the other systems of the plant. Section 18.7 discusses the detailed design implementation process. The SBWR Emergency Procedure Guidelines, which provide the basis for human factors evaluations of emergency operations, are contained in Appendix 18A. Appendix 18B discusses the differences between the SBWR Emergency Procedure Guidelines and the U.S. Boiling Water Reactor Owners Group (BWROG) Emergency Procedure Guidelines, Revision 4. The input data and results of calculations performed during the preparation of the SBWR Emergency Procedure Guidelines are contained in Appendix 18C. Appendix 18D presents a characterization of a main control room HSI ~~operator interface~~ equipment implementation that incorporates the SBWR standard design features discussed in Section 18.4. A general description of the design and implementation process for the SBWR HSI ~~operator interface and supporting plant systems~~ is presented in Appendix 18E. Appendix 18F contains the results of an analysis of the information and control needs of the main control room operators during emergency operations.

18.2 Design Goals and Design Bases

The primary goal for HSI ~~operator interface~~ designs is to facilitate safe, efficient and reliable operator performance during all phases of normal plant operation, abnormal events and accident conditions. To achieve this goal, information displays, controls and other interface devices in the control room and other plant areas are designed and shall be implemented in a manner consistent with good human factors engineering practices. Further, the following specific design bases are adopted:

- During all phases of normal plant operation, abnormal events and emergency conditions, the SBWR shall be operable by two reactor operators. In addition, the operating crew will include one assistant control room shift supervisor, one control room shift supervisor, and auxiliary equipment operators as required by task analysis. During accidents, technical assistance is available to the operating crew from personnel in the technical support center. Four licensed operators shall be on shift at all times, consistent with the staffing requirements of 10CFR50.54m. The main control room staff size and roles shall be evaluated by the COL applicant as an action item (Subsection 18.8.2).
- The HSI ~~SBWR operator interface~~ design shall promote efficient and reliable operation through expanded application of automated operation capabilities.
- The HSI ~~operator interface~~ design shall utilize only proven technology.
- Safety-related systems monitoring and control capability shall be provided in full compliance with pertinent regulations regarding divisional separation and independence.
- The HSI ~~operator interface~~ design shall be highly reliable and provide functional redundancy such that sufficient displays and control will be available in the main control room and remote locations to conduct an orderly reactor shutdown and to cool the reactor to cold shutdown conditions, ~~for safe operation~~, even during design basis equipment failures.
- The principal functions of the Safety Parameter Display System (SPDS) as required by Supplement 1 to NUREG-0737, will be integrated into the HSI ~~operator interface~~ design.
- Accepted human factors engineering principles shall be utilized for the HSI ~~operator interface~~ design in meeting the relevant requirements of General Design Criterion 19.
- The design bases for the Remote Shutdown System shall be as specified in Section 7.4.

18.3 Planning, Development, and Design

18.3.1 Introduction

An integrated program plan to incorporate HFE ~~human factors engineering~~ principles and to achieve an integrated design of the control and instrumentation systems and HSI ~~operator interfaces~~ of the SBWR was prepared and implemented. The program plan, entitled "Design of Controls, Instrumentation and Man-Machine Interfaces", presents a comprehensive, synergistic design approach with provisions for task analyses and human factors evaluations. Also included are formal decision analysis procedures to facilitate selection of design features which satisfy top level requirements and goals of individual systems and the overall plant. Procedures developed as part of the program plan address the following areas:

- development of system functional and performance requirements,
- analysis of tasks and allocation of functions,
- evaluation of human factors and man-machine interfaces,
- design of hardware and software, and
- verification and validation of hardware and software.

The program plan and the associated procedures provided guidance for the conduct of the SBWR HSI ~~control and instrumentation and MMIS~~ design development activities, including (1) definition of the standard design features of the control room HSI ~~MMIS. (Refer to~~ (Subsections 18.3.2 and 18.4.2), and (2) definition of the inventory of controls and instrumentation necessary for the control room crew to follow the operation strategies given in the SBWR Emergency Procedure Guidelines and to complete the important operator actions described in the Probabilistic Risk Assessment (Subsection 18.3.3 and Appendix 18F).

~~In addition, the program and associated procedures will be transmitted to multidisciplinary team which is responsible for the definition and supervision of the detailed process by which the control room man machine interface and control and instrumentation systems are implemented. This process includes provisions for Nuclear Regulatory Commission (NRC) conformance reviews where the process or equipment specific design will be tested against specific acceptance criteria and is discussed further in Subsection 18.3.3, Section 18.7 and Appendix 18E.~~

18.3.2 Standard Design Features

The SBWR control room HSI ~~man-machine interface~~ design contains a group of standard features which form the foundation for the detailed HSI ~~MMIS~~ design. These features are described in Subsection 18.4.2.

The development of the control room HSI ~~MMIS~~ standard design features was accomplished through consideration of existing control room operating experience; a review of trends in control room designs and existing control room data presentation methods; evaluation of new HSI ~~man-machine interface (MMI)~~ technologies, alarm reduction and presentation methods; and validation testing of two dynamic control room prototypes. The prototypes were evaluated under simulated normal and abnormal reactor operating conditions and utilized experienced nuclear plant control room operators. Following the completion of the prototype tests and employing their results, the standard control room HSI ~~MMIS~~ design features were finalized.

18.3.3 Inventory of Controls and Instrumentation

The SBWR Emergency Procedure Guidelines (EPGs), presented in Appendix 18A, and the important operator actions identified in the Probabilistic Risk Assessment (PRA), presented in Chapter 19, provided the bases for an analysis of the information and control capability needs of the main control room operators based upon the operation strategies. This analysis defines a minimum set of controls, displays, and alarms which will enable the operating crew to perform the actions that would be specified in the Emergency Operating Procedures and the important operator actions identified in the PRA. Appendix 18F contains the tabulated results of this analysis. The controls, displays and alarms needed by the operators to perform and validate the completion of those steps and important actions are listed in Tables 18F-1 through 18F-3, respectively.

18.3.4 Detailed Design Implementation Process

The process by which the detailed equipment design implementation of the SBWR HSI ~~control and instrumentation and man-machine interface~~ will be completed ~~implemented~~ is discussed in Section 18.7 and in Appendix 18E. This process builds upon the standard HSI ~~MMIS~~ design features which are discussed in Subsection 18.4.2. Embedded in the process~~, which is illustrated in~~ (Figure ~~21.~~18E-1), are a number of NRC conformance reviews in which various aspects and outputs of the process are evaluated against established acceptance criteria presented in Tables 18E-1 through 18E-4.

18.4 Control Room Standard Design Features

18.4.1 Introduction

This section presents the standard design features of the HSI ~~operator interface~~ in the control room (Subsection 18.4.2). These standard design features are based upon proven technologies and have been demonstrated, through broad scope control room dynamic simulation tests and evaluation, to satisfy the SBWR HSI ~~operator interface~~ design goals and design bases as given in Section 18.2. Appendix 18D presents an example of a control room HSI ~~operator interface~~ design implementation which incorporates these design features. ~~Final~~ Validation of the implemented MCR design will include evaluation of the standard design features and will be performed as part of the design implementation process as defined by the acceptance criteria presented in Tables 18E-1 through 18E-4. ~~All of the standard design features will be done as part of the design implementation process as defined by the process description provided in Appendix 18E.~~

18.4.2 Standard Design Feature Descriptions

18.4.2.1 Listing of Features

The SBWR control room HSI ~~operator interface~~ design incorporates the following standard features:

(1) A single, integrated control console staffed by two operators; the console has a low profile such that the operators can see over the console from a seated position.

(2) The use of plant process computer system driven on-screen control video display units (VDUs) for safety-related system monitoring and non-safety-related system control and monitoring. ~~which are driven by the plant process computer system.~~

(3) The use of a separate set of on-screen control VDUs for safety-related system control and monitoring and separate on-screen control VDUs for non-safety-related system control and monitoring; the operation of these two sets of VDUs is entirely independent of the process computer system. Further, the first set of VDUs and all equipment associated with their functions of safety-related system control and monitoring are divisionally separated and qualified to Class 1E standards.

(4) The use of dedicated function switches on the control console.

(5) Operator selectable automation of pre-defined plant operation sequences.

(6) The incorporation of an operator selectable semi-automated mode of plant operations, which provides procedural guidance on the main control console VDUs but does not control plant systems ~~system~~ and equipment.

(7) The capability to conduct all plant operations in an operator manual mode.

(8) The incorporation of a large display panel that presents information for use by the entire control room operating staff.

(9) The inclusion on the large display panel of fixed-position displays of key plant parameters and major equipment status.

(10) The inclusion in the fixed-position displays of both Class1E-qualified and non-1E display elements.

(11) The independence of the fixed-position displays from the plant process computer.

(12) The inclusion within the large display panel of a large VDU which is driven by the plant process computer system.

(13) The incorporation of a "monitoring only" supervisor's console which includes VDUs on which display formats available to the operators on the main control console are also available to the supervisors.

(14) The incorporation of the SPDS function as part of the plant status summary information which is continuously displayed on the fixed-position displays on the large display panel.

(15) A spatial arrangement between the large display panel, the main control console and the shift supervisor's console, which allows the entire control room operating crew to conveniently view the information presented on the large display panel.

(16) The use of fixed-position alarm tiles on the large display panel.

(17) The application of alarm processing logic to prioritize alarm indications and to filter unnecessary alarms.

(18) The use of VDUs to provide alarm information in addition to the alarm information provided through the fixed-position alarm tiles on the large display panel.

Validation of the design of each of the main control room standard design features is a COL action item (Subsection 18.8.5).

The remainder of this subsection provides further descriptions of these standard design features.

18.4.2.2 Main Control Console

The main control console comprises the work stations for the two control room plant operators. It is configured such that each operator is provided with controls and monitoring information necessary to perform their assigned tasks and allows the operators to view all of the displays on the large display panel (Subsection 18.4.2.7) from a seated position.

The main control console, in concert with the large display panel, provides the controls and displays required to operate the plant during normal plant operations, abnormal events and emergencies. These main control console controls and displays include the following:

- On-screen control VDUs for safety-related system monitoring and non-safety-related system control and monitoring which are driven by the plant process computer system (Subsection 18.4.2.3).
- A separate set of on-screen control VDUs for safety-related system control and monitoring and separate on-screen control VDUs for non-safety-related system control and monitoring; the operation of these two sets of VDUs is entirely independent of the process computer system. Further, the first set of VDUs and all equipment associated with their functions of safety-related system control and monitoring are divisionally separated and qualified to Class 1E standards (Subsection 18.4.2.4).
- Dedicated function switches (Subsection 18.4.2.5).

The main control console is also equipped with a limited set of dedicated displays for selected functions (e.g., the Standby Liquid Control System and the synchronization of the main generator to the electrical grid).

In addition to the above equipment, the main control console is equipped with both intra-plant and external communications equipment and a laydown space is provided for hard copies of procedures and other documents required by the operators during the performance of their duties.

18.4.2.3 Process Computer System Driven VDUs

A set of on-screen control VDUs is incorporated into the main control console design to support the following activities:

- monitoring of plant systems, both safety-related and non-safety-related;

- control of non-safety-related system components; and
- presentation of system and equipment alarm information.

This set of VDUs is driven by the plant process computer system. Thus, data collected by the process computer system is available for monitoring on these VDUs. All available display formats can be displayed on any of these VDUs.

18.4.2.4 Process Computer System Independent VDUs

A set of VDUs which are independent of the process computer system are also installed on the main control console. These VDUs are driven by independent processors. They are divided into two subsets:

(1) The first subset consists of those VDUs which are dedicated, divisionally separated devices. The VDUs in this group can only be used for monitoring and control of equipment within a given safety division. The VDUs are qualified, along with their supporting display processing equipment, to Class 1E standards.

(2) The second subset of process computer system independent VDUs is used for monitoring and control of non-safety-related plant systems. The VDUs in this subset are not qualified. to Class 1E standards.

18.4.2.5 Dedicated Function Switches

Dedicated function switches are installed on the main control console. These devices provide faster access and feedback compared to that obtainable with soft controls. These dedicated switches are implemented in hardware, so that they are located in a fixed position and are dedicated in the sense that each individual switch is used only for a single function, or for two very closely related functions (e.g., valve open/close).

The dedicated function switches on the main control console are used to support such functions as initiation of automated sequences of safety-related and non-safety-related system operations, manual scram and reactor operating mode changes.

18.4.2.6 Automation Design

The SBWR incorporates selected automation of the operations required during a normal plant startup/shutdown and during normal power range maneuvers. Subsection 7.7.1.5 describes the Power Generation Control ~~System~~ (PGC ~~PGCS~~) function which is the primary SBWR function ~~system~~ for implementing the automation features for normal SBWR plant operations.

18.4.2.6.1 Automatic Operation

When placed in automatic mode, the PGC ~~PGCS~~ performs sequences of automated plant operations by sending mode change commands and setpoint changes to lower-level, non safety-related plant system controllers. The PGC ~~PGCS~~ cannot directly change the status of a safety-related system. When a change in the status of a safety-related system is required to complete the selected operation sequence, the PGC ~~PGCS~~ provides prompts to guide the operator in manually performing the change using the appropriate safety-related operator interface controls provided on the main control console.

The operator can stop an automatic operation at any time. The PGC ~~PGCS~~ logic also monitors plant status, and will automatically revert to manual operating mode when a major change in plant status occurs (e.g., reactor scram or turbine trip). When such abnormal plant conditions occur, PGC ~~PGCS~~ automatic operation is suspended and the logic in the individual plant systems and equipment directs the automatic response to the plant conditions. Similarly, in the event that the operational status of the PGC ~~PGCS~~ or interfacing systems changes (e.g., equipment failures), operation reverts to manual operating mode. When conditions permit, the operator may manually reinitiate PGC ~~PGCS~~ automatic operation.

Evaluation of the effects of automation strategies on operator reliability and the appropriateness of the SBWR automation design is a COL action item (Subsection 18.8.3). Also, a consideration of malfunctions of the PGC is a COL action item (Subsection 18.8.10).

18.4.2.6.2 Semi-Automated Operation

The PGC ~~PGCS~~ also includes a semi-automatic operational mode which provides automatic operator guidance for accomplishing the desired normal changes in plant status; however, in this mode, the PGC ~~PGCS~~ performs no control actions. The operator must activate all necessary system and equipment controls for the semi-automatic sequence ~~plant operations~~ to proceed. The PGC ~~PGCS~~ monitors the plant status during the semi-automatic mode in order to check the progression of the semi-automatic sequence ~~plant operations~~ and to determine the appropriate operator guidance to be activated.

18.4.2.6.3 Manual Operation

The manual mode of operation in the SBWR corresponds to the manual operations of conventional BWR designs in which the operator determines and executes the appropriate plant control actions without the benefit of computer-based operator aids. The manual mode provides a default operating mode in the event of an abnormal condition in the plant. The operator can completely stop an automated operation at any time by simply selecting the manual operating mode. The PGC ~~PGCS~~ logic will also automatically revert to manual mode when abnormal conditions occur.

18.4.2.7 Large Display Panel

The large display panel provides information on overall plant status with real-time data during all phases of plant operation. The information on the large display panel can be viewed from the main control console and the supervisor's console. The large display panel includes fixed-position displays (Subsection 18.4.2.8), a variable display (Subsection 18.4.2.9) and spatially dedicated alarm windows (Subsection 18.4.2.12).

18.4.2.8 Fixed-Position Display

The fixed-position portion of the large display panel provides key plant information for viewing by the entire control room staff. The dynamic display elements of the fixed-position displays are driven by dedicated microprocessor-based controllers which are independent of the plant process computer system.

Those portions of the large display panel which present safety-related information are qualified to Class 1E standards. The COL applicant shall address the human factors aspects of TMI Item I.E.3, Safety System Status Monitoring, as an action item (Subsection 18.8.9).

The information presented in the fixed-position displays includes the critical plant parameter information, as defined by the SPDS requirements of NUREG–0737, Supplement 1, and the Type A post-accident monitoring (PAM) instrumentation required by Regulation Guide 1.97. (Refer to Subsection 18.4.2.11 for a discussion of the SPDS and to Section 7.5 for a discussion of the PAM variables.)

18.4.2.9 Large Variable Display

The large variable display which is included on the large display panel is a VDU which is driven by the plant process computer system. Any screen format resident in the process computer system can be shown on this large variable display.

18.4.2.10 Supervisors' Console

A console provided for the control room supervisors ~~which~~ is equipped with VDUs on which any screen format resident in the process computer system and available to the operators at the main control console is also available to the supervisors. The location of this console in the control room is discussed in Subsection 18.4.2.15.

18.4.2.11 Safety Parameter Display System

NUREG–0737 provides guidance for implementing Three Mile Island (TMI) action items. NUREG–0737, Supplement 1, clarifies the TMI action items related to emergency response capability, including item I.D.2, "Safety Parameter Display System". The principal purpose of the SPDS is to aid control room personnel during abnormal and emergency conditions in determining the safety status of the plant and in assessing whether abnormal conditions warrant corrective action by operators to prevent core damage. During emergencies, the SPDS serves as an aid in evaluating the current safety status of the plant, in executing symptom–based emergency operating procedures, and in monitoring the impact of engineered safeguards or mitigation activities. Selection of the parameters for inclusion in the SPDS display is based upon the SBWR Emergency Procedure Guidelines (Appendix 18A). The SPDS also operates during normal operation, continuously displaying information from which the plant safety status can be readily and reliably assessed. The SBWR does not provide a separate SPDS, but rather, the principal functions of the SPDS (as required by NUREG–0737, Supplement 1) are integrated into the overall control room display capabilities. Displays of critical plant variables sufficient to provide information to plant operators about the following critical safety functions are provided on the large display panel as an integral part of the fixed-position displays:

- reactivity control;
- reactor core cooling and heat removal from the primary system;
- reactor coolant system integrity;
- radioactivity control; and
- containment conditions.

Displays to assist the plant operator in execution of symptom–based emergency operating procedures are available at the main control console VDUs. Examples of these VDU displays are trend plots and operator guidance. Information regarding entry conditions to the symptomatic emergency procedures is provided through the fixed-position display of the critical plant parameters on the large display panel. The critical plant parameters on the large display panel are also viewable from the control room supervisor's monitoring station. The supplemental SPDS displays on the VDUs on the main control console are also accessible at the control room supervisor's monitoring station and may be provided in the technical support center (TSC) and, optionally, in the emergency operations facility (EOF). (Refer to Section 13.3 for the requirements on the TSC and EOF.)

Entry conditions to the symptomatic emergency operating procedures (EOPs) are annunciated on the dedicated hardware alarm windows on the large display panel. The large display panel also displays the containment isolation status, safety-related systems status, and the following critical parameters:

(1) reactor pressure vessel (RPV) pressure;

(2) RPV water level;

(3) core neutron flux (startup range and power range instruments);

(4) suppression pool temperature;

(5) suppression pool water level;

(6) drywell temperature;

(7) drywell pressure;

(8) drywell water level;

(9) control rod scram status;

(10) drywell ~~containment~~ oxygen concentration; (when monitors are in operation);

(11) drywell ~~containment~~ hydrogen concentration (when monitors are in operation);

(12) wetwell oxygen concentration (when monitors are in operation);

(13) wetwell hydrogen concentration (when monitors are in operation); and

(14) containment radiation levels.

The oxygen monitoring instrumentation system is normally in continuous operation and hence the large display panel also includes continuous fixed-position display of wetwell and drywell oxygen concentrations. The hydrogen monitoring instrumentation is automatically started on a loss-of-coolant accident (LOCA) signal and, hence, continuous display is not required. Additional post-accident monitoring parameters, such as effluent stack radioactivity release (refer to Section 7.5 for a list of post-accident monitoring parameters), may be displayed at the large variable display or at the main control console VDUs on demand by the operator.

The SPDS is required to be designed so that the displayed information can be readily perceived and comprehended by the control room operating crew. Compliance with this requirement is assured because of the incorporation of accepted human factors engineering principles into the overall control room design implementation process (refer to Subsection 18.7 for a discussion of the design implementation process).

All of the continuously displayed information necessary to satisfy the requirements for the SPDS, as defined in NUREG-0737, Supplement 1, is included in the fixed-position display list in Table 18F-2. Table 18F-2 also includes other displays, beyond those required for the SPDS.

The evaluation of the SPDS against the requirements of Paragraph 3.8a of NUREG-0737, Supplement 1, and confirmation that the design meets all applicable criteria is a COL license information requirement.

18.4.2.12 Fixed-Position Alarms

Specially dedicated fixed-position alarm tiles on the large display panel annunciate the key, plant-level alarm conditions that indicate entry into the emergency operating procedures or otherwise potentially affect plant availability or plant safety, or indicate the need of immediate operator action.

18.4.2.13 Alarm Processing Logic

Alarm prioritization and filtering logic is employed in the SBWR design to enhance the presentation of meaningful alarm information to the operator and reduce the amount of information which the operators must absorb and process during abnormal events.

Alarm prioritizing is accomplished in the SBWR through the designation of three categories of alarm signals. The first of these is the important ~~plant level~~ alarms. These are defined as those alarms which notify the operators of changes in plant status regarding safety and include those items which are to be checked in the event of accidents, principal events or transients. The important ~~plant level~~ alarms are displayed on the fixed-position tiles discussed in Subsection 18.4.2.12.

The second category is the system-specific alarms which are provided to notify the operators of system-level abnormalities or non-normal system statuses. Examples of these are as follows:

- main pump trips caused by system process, power source or control abnormalities;
- valve closures in cooling or supply lines;
- decreases in supply process values;
- loss of a backup system;
- system isolation;

- by passing safety-related systems; and

- systems are undergoing testing.

The system-specific alarms are also shown on the fixed-position tiles discussed in Subsection 18.4.2.12.

Equipment alarms make up the third category of alarms in the prioritizing scheme and are discussed in Subsection 18.4.2.14.

Alarm suppression in the SBWR is based upon the following concepts:

- Suppression based on the operating mode. The plant operating mode is defined on the basis of the hardware or process status, and alarms which are not relevant to the current operating mode are suppressed. For example, alarms which are needed in the "RUN" mode but are unnecessary in the "SHUTDOWN" mode are suppressed.

- Suppression of subsidiary alarms. Alarms are suppressed if they are logically consequent to the state of operation of the hardware or to the process status. For example, scram initiation (a plant-level alarm condition announced with a fixed-position alarm tile on the large display panel) will logically lead to a fine motion control rod drive (FMCRD) hydraulic control unit scram accumulator low pressure (also an alarm condition). Such subsidiary alarms are suppressed if they simply signify logical consequences of the systems operation.

- Suppression of redundant alarms. When there are overlapping alarms, such as "high" and "high-high" or "low" and "low-low", only the most severe of the conditions is alarmed and the others are suppressed.

Operators may activate or deactivate the alarm suppression logic at any time.

18.4.2.14 Equipment Alarms

Alarms which are not indicated by fixed-position alarm tiles on the large display panel (i.e., those alarms of nominally lower level importance such as those related to specific equipment status) are displayed to the control room operating staff through the main control console VDUs. The supplemental alarm indications and supporting information regarding the plant-level alarms which are presented on the large display panel are also presented on the VDUs.

18.4.2.15 Control Room Arrangement

In the SBWR main control room arrangement, the main control console is located directly in front of the large display panel for optimum viewing efficiency by the plant operators seated at the main console. The shift supervisor's console is also placed in front of the large display panel, but at a somewhat greater distance than the main control console. The shift supervisor is, thus, in a position behind the control console operators. This arrangement allows all control room personnel to view the contents of the large panel displays.

18.4.3 Control Room HSI ~~MMI~~ Technology

The SBWR main control room standard design features described in the preceding subsections include, in their design, equipment that utilizes a variety of technologies to control and monitor the plant processes. This subsection provides a summary listing and description of the technologies which are utilized in these control and monitoring functions. For this purpose, the term "technology" is taken to have the following definition: "the equipment, including both hardware and software, employed to directly accomplish the functions of control and monitoring of the plant processes."

Hardware such as consoles, panels, cabinets, control room lighting and HVAC and plant communication equipment which has ~~have~~ a supporting role but is ~~are~~ not directly involved in the control and monitoring processes is excluded. ~~, such as consoles, panels, cabinets, control room lighting and HVAC and plant communication equipment~~

The scope of this section is limited to the main control room and the remote shutdown station areas of the plant and includes all technology, regardless of use in prior designs.

The list format includes a brief description of each item of equipment:

(1) Hardware switches such as multi-position rotary, pushbutton, rocker, toggle and pull-to-lock types.

(2) Soft switch, the functions of which may be changed through the execution of software functions.

(3) Continuous adjustment controls, such as rotary controls and thumbwheels.

(4) Visual display units with full color screens, including large reverse projection screens, cathode ray tubes and flat panel display screens.

(5) On-screen control utilized with the units in 3 and 4, above.

(6) VDU screen format such as large screen optical projection display formats; text displays, including menus and tabular information and graphical displays, including trend plots, 2-D Plots, P&IDs and other diagrams and pictorial information.

(7) Analog meters which employ a hardware medium to pictorially or graphically present quantitative and qualitative information concerning plant process parameters This includes analog meters using digitally controlled LEDs and digital readouts.

(8) Fixed-position digital displays which present alphanumeric information in a hardware medium. These can be back-lit.

(9) Fixed-position hardware mimic displays which schematically represent plant systems and components and their relationships utilizing pictorial elements, labels and indicator lights.

(10) Fixed-position alarm tiles which use light to indicate the alarm state.

(11) An audio signal system which is coordinated to the alarm tiles in #10, above, and utilizes prioritization and alarm reduction logic and pre-defined set points to alert operators to plant status changes.

(12) Printers and printer/plotters used to provide hard copy output in the form of plots, logs and text.

(13) Keyboards which are composed of alphanumeric and/or assignable function keys and function as computer input devices.

18.5 Remote Shutdown System

The Remote Shutdown System (RSS) provides a means to safely shut down the plant from outside the main control room. It provides control of the plant systems needed to bring the plant to hot shutdown, with the subsequent capability to attain cold shutdown, in the event that the control room becomes uninhabitable.

The RSS design is described in ~~Subsections 7.4.1.4 and 7.4.2.4~~ Section 7.4.2. All of the controls and instrumentation required for RSS operation are identified in ~~Subsection 7.4.1.4.4~~ Section 7.4.2 and in Figure 21.7.4-2.

The RSS uses conventional, hardwired controls and indicators to maintain diversity from the main control room. These dedicated devices are arranged in a mimic of the interfacing systems process loops.

Evaluation of alternate design approaches for reliability and confirmation of the adequacy of the RSS design is a COL action item (Subsection 18.8.6).

18.6 Systems Integration

18.6.1 Safety-Related Systems

The operator interfaces with the safety-related systems through a variety of methods. Dedicated hardware switches are used for system initiation and logic reset, while system mode changes are made with other hardware switches. Safety-related VDUs provide capability for individual safety equipment control, status display and monitoring; non-safety-related VDUs are used for additional safety-related system monitoring. The large fix. d-position display provides plant overview information. Instrumentation and control aspects of the microprocessor-based safety system logic and control (SSLC) are described in Subsection 7.3.4.

Divisional separation for control, alarm and display equipment is maintained. The SSLC processors provide alarms signals to their respective safety-related alarm processors and provide display information to the divisionally dedicated VDUs. The SSLC microprocessors communicate with their respective divisional VDU controllers through the essential multiplexing system (EMS). The divisional VDUs have on-screen control capability and are classified as safety-related equipment. These VDUs provide control and display capabilities for individual safety systems if control of a system component is required. Normally, such control actions are performed for equipment surveillance purposes only, as the normal method of system control is through the mode-oriented master sequence switches.

~~Divisional isolation devices are provided between the safety related systems and non-safety related communication networks so that failures in the non safety related equipment will have no impact on the ability of the safety related systems to perform their design functions. A complete discussion of instrumentation to control systems architecture is contained in Chapter 7.~~

Divisional isolation devices are provided between the safety-related systems and non-safety-related communication networks so that failures in the non-safety-related equipment will have no impact on the ability of the safety-related systems to perform their design functions. The non-safety-related communication network is part of the Non-Essential Multiplex System (NEMS) described in Subsection 7.7.7.

Operation controls through dedicated hardware switches and master sequential switches communicate with the SSLC logic units through conventional hardwire signal transmission (i.e., not multiplexed). Communications between the SSLC logic units and alarm panels and the safety-related fixed-position displays is through multiplex data links.

Safety-related system process parameters, alarms and system status information from the SSLC are communicated to the NEMS through isolation devices for use by other equipment connected to the communication network. Selected operator control functions are performed through dedicated hardware control switches which are Class 1E qualified and divisionally separated on the main control console. These hardware switches communicate with the safety-related systems logic units through hardwire transmission lines.

The divisionally dedicated VDUs are classified as safety-related equipment. These VDUs provide control and display capabilities for individual safety-related systems if control of a system component is required. Normally, such control actions are performed for equipment surveillance purposes only, as the normal method of system control is through the mode-oriented master sequence switches.

18.6.2 Non-Safety-Related Systems

For non-safety-related systems, operation control is accomplished using master sequence switches, and on-screen control through the non-safety-related VDUs. The hardware switches for non-safety-related equipment on the main control console communicate with the non-safety-related systems logic units through hardwire transmission lines.

The non-safety-related systems communicate with other equipment in the operator interface through the NEMS network. The non-safety-related portion of the large display panel fixed-position displays is driven by a controller separate from the process computer system. Alarm processing microprocessor units separate from the process computer system perform alarm filtering and suppression and also drive dedicated alarm tiles on the large display panel. The alarms for entry conditions into the symptomatic emergency operating procedures are provided by the alarm processing units, both safety and non-safety-related. Equipment level alarm information is presented by the process computer system on the main control console VDUs.

An additional set of non-safety-related on-screen control VDUs is provided on the main control console for control and display of non-safety-related systems. These VDUs are independent of the process computer system. In the unlikely event of loss of the process computer system, these independent VDUs, in conjunction with the large display panel safety-related displays, have sufficient information and control capability to allow the following operations to be performed:

- steady-state power operation,
- power decrease,
- plant shutdown to hot standby conditions, and
- plant shutdown to cold shutdown conditions.

Without the plant process computer system, control is carried out through the master sequential switches and the process computer-independent, on-screen control VDUs. Monitoring is accomplished with the independent VDUs and the fixed-position display on the large display panel. Power increases cannot be performed in the absence of the process computer system because core thermal margin limit information provided by the process computer to the automatic thermal limit monitor (described in Subsection 7.7.2.2) would not be available.

18.7 Detailed Design of the Operator Interface System

The standard design features of the SBWR main control room HSI ~~MMIS~~, discussed in Subsection 18.4.2, provide the framework for the detailed equipment hardware and software designs that will be developed following ~~a~~ the design and implementation process ~~such as that typically~~ described in Appendix 18E. This ~~typical design and implementation~~ process is made up of eight major elements, as illustrated in Figure 18E-1. ~~presented in flow chart form in Figure 21.18E-1 and described in more detail in Section 18E.3.~~

~~As part of the detailed design implementation process described in Appendix 18E, operator task analyses will be performed as a basis for evaluating details of the design implementation and MMIS requirements will be specified. The evaluation of the integrated control room design will include the confirmation of the SBWR main control room standard design features.~~

As part of the Appendix 18E discussion of the HSI design and implementation plan elements, detailed acceptance criteria are specified that shall be used to govern and direct all SBWR HSI design implementations which reference the Certified Design. These detailed acceptance criteria, presented in Section 18E.2 of Appendix 18E, encompass the set of necessary and sufficient design implementation related activities required to maintain the implemented HSI design in compliance with accepted HFE principles and accepted digital electronics equipment and software development methods.

Also, as part of the detailed design implementation process described in Appendix 18E, operator task analyses will be performed as a basis for evaluating details of the design implementation and HSI requirements will be specified. These HSI requirements will include the instrumentation and controls listed in Tables 18F-1 through 18F-3 as a subset. The evaluation of the integrated control room design will include the confirmation of the SBWR main control room standard design features.

18.8 COL License Information

18.8.1 HSI Design Implementation Process

The HSI Design Implementation Process is described in Appendix 18E is the responsibility of the COL applicant and is to be considered general COL license information. In addition, the following specific COL action items are in effect.

18.8.2 Number of Operators Needing Controls Access

The number of operators needing access to the controls on the main control panel shall be evaluated and the ABWR control room staffing arrangement (Subsection 18.2, Item 1) shall be confirmed as adequate. In addition, the roles and responsibilities of the shift supervisor and assistant shift supervisor shall be specified. The results of the evaluation shall be placed in the HFE Issue Tracking System (Subsection II.2 of Table 18E-1).

18.8.3 Automation Strategies and Their Effect on Operator Reliability

Automation strategies for plant operation shall be evaluated for effects on operator reliability and the appropriateness of the SBWR ~~ABWR~~ automation design (Subsection 18.4.2.6.1) shall be confirmed. This evaluation shall be performed according to the criteria of Subsection II of Table 18E-1 and the results of the evaluation shall be placed in the HFE Issue Tracking System.

18.8.4 SPDS Integration With Related Emergency Response Capabilities

The design of the SPDS (Subsection 18.4.2.11) shall be evaluated against the requirements of Paragraph 3.8a of NUREG-0737, Supplement 1, and confirmed to be in compliance with all applicable criteria. The results of the evaluation shall be placed in the HFE Issue Tracking System.

18.8.5 Standard Design Features Design Validation.

The design of each of the main control room standard design features (Subsection 18.4.2.1) shall be validated using the applicable criteria in Subsection VIII of Table 18E-1. The results of the validation shall be placed in the HFE Issue Tracking System.

18.8.6 Remote Shutdown System Design Evaluation

Digital versus analog design approaches for the Remote Shutdown System (RSS) shall be evaluated for reliability and the adequacy of the SBWR ~~ABWR~~ RSS design (Subsection 18.5) shall be confirmed. The results of the evaluation shall be placed in the HFE Issue Tracking System.

18.8.7 Local Valve Position Indication

The necessity for providing local valve position indication (VPI) for each valve in any of the following categories shall be evaluated:

(1) All power-operated valves (e.g., motor, hydraulic and pneumatic).

(2) All large manual valves (i.e., 5 cm or larger).

(3) Small manual valves (i.e., less than 5 cm) which are important to safe plant operations.

These evaluation records shall be placed in the HFE Issue Tracking System.

18.8.8 Operator Training

An operator training program which meets the requirements of 10CFR50 shall be established (Subsection II.1.c of Table 18E-1).

18.8.9 Safety System Status Monitoring

The COL applicant shall address the human factors aspects of TMI Item I.E.3, "Safety System Status Monitoring", as part of the detailed design implementation process (Subsection 18.4.2.8).

18.8.10 PGCS Malfunction

As part of the verification and validation effort, the COL applicant shall consider malfunctions of the Power Generation Control function of the process computer system (Subsection 18.4.2.6.1).

18.8.11 Local Control Stations

The COL applicant shall evaluate all operations at local control stations which are critical to plant safety, as defined in Paragraph V.1.c of Table 18E-1. The results of these evaluations shall be incorporated into the HFE Issue Tracking System.

18.8.12 As-Built Evaluation of MCR and RSS

The COL applicant shall prepare a report which documents that the as-built main control room (MCR) and remote shutdown station (RSS) conform to the certified and validated main control room and remote shutdown station configurations. Aspects of the as-built MCR and RSS to be considered in this report are the area and panel layouts, operator environment, alarms, displays, controls and general human-system interface characteristics.

18.8.13 Accident Monitoring Instrumentation

The COL applicant shall evaluate the instrumentation described in TMI Item II.F.1, "Additional Accident-Monitoring Instrumentation", with regard to the impact of the inclusion of that instrumentation in the MCR HSI on the potential for operator error. The results of this evaluation shall be placed in the HFE Issue Tracking System.

18.8.14 In-Core Cooling Instrumentation

The COL applicant shall evaluate the instrumentation described in TMI Item II.F.2, "Instrumentation For Detection of Inadequate Core-Cooling", with regard to the impact of the inclusion of that instrumentation in the MCR HSI on the potential for operator error. The results of this evaluation shall be placed in the HFE Issue Tracking System.

18.8.15 Performance of Critical Tasks

The COL applicant shall evaluate the adequacy of the HSI with respect to providing the controls, displays and alarms necessary for timely performance of critical tasks. Critical tasks shall include, as a minimum, those operator actions which have significant impact on the PRA results, as presented in Section 19D.7, and the operator actions isolate the reactor and inject water for the postulated event scenarios of a common-mode failure of the Safety System Logic and Control System and/or the Essential Multiplexing System concurrent with the design basis main steamline, feedwater line or shutdown cooling line break LOCA (Paragraph V.2.d of Table 18E-1). The results of this evaluation shall be placed in the HFE Issue Tracking System.

18.8.16 Plant Status and Post-Accident Monitoring

The main control instrumentation described in TMI Item I.D.5 (2), "Plant Status and Post-Accident Monitoring", shall be evaluated with regard to the impact of the inclusion of that instrumentation in the MCR HSI on the potential for operator error and the results of the evaluation shall be placed in the HFE Issue Tracking System.

18E SBWR ~~ABWR~~ Human-System Interface Design Implementation Process

18E.1 Introduction

Section 18.3 discusses the program of human factors related activities conducted throughout the development of the SBWR ~~ABWR~~ plant system designs, including the development of the Main Control Room (MCR) and Remote Shutdown System (RSS) designs. Appendix 18E describes the process through which the MCR and RSS human system interface (HSI) design implementations will be conducted and evaluated through the application of accepted human factors engineering (HFE) practices and principles. Section 18E.2 discusses the basic elements of this HFE design implementation process and includes identification of where in the process the results are planned to be made available for NRC review. The criteria to be used by the NRC in their review of the design implementation (i.e., the Design Acceptance Criteria (DAC)) are presented in Section 18E.3

18E.2 HSI Design Implementation Process

The designs of the MCR and RSS areas of operator interface, for the execution of normal plant operation and emergency operation, will be implemented and evaluated in accordance with the process illustrated in Figure 18E-1. As shown in Figure 18E-1, the implementation process begins with the establishment of the Human Factors Engineering (HFE) Design Team which prepares the HFE Program and Implementation Plans and guides the process through the remaining steps to the final validation of the implemented design. Figure 18E-1 also identifies the relative timing of the planned NRC conformance reviews along with the corresponding table in Section 18E.3 that defines the acceptance criteria applicable to the individual reviews.

18E.2.1 The HFE Design Team

The HFE Design Team will be composed of experienced individuals whose collective expertise cover a broad range of disciplines relevant to the design and implementation process. These disciplines will include technical project management, control and instrument engineering, plant operations and architect engineering, as well as human factors engineering.

The duties of the HFE Design Team will be to establish the HFE Program and Implementation Plans, to guide and oversee the design implementation process and to assure that the execution and documentation of each step in the process is carried out in accordance with the established program and procedures. The team will have the authority to insure that all its areas of responsibility are accomplished and to identify problems in the implementation of the HSI design. The team will have the authority to determine where its input is required and to access work areas and design documentation. The team will also have the authority to control further processing, delivery, installation or use of HFE/HSI products until the disposition of a non-conformance, deficiency or unsatisfactory condition has been achieved.

18E.2.2 The HFE Program and Implementation Plans

The HFE Design Team will establish the HFE Program and Implementation Plans that provide overall direction and integration of the HFE-related design implementation and evaluation activities for the specific HSI scope which includes the RSS and MCR areas of operational interface. The HFE Program Plan will identify the individuals who comprise the HFE Design Team and establish the processes through which the HFE Design Team will perform its functions. Included in the HFE Program Plan will be a system for documenting human factors issues, that may be identified throughout the implementation of the designs, and the actions taken to resolve those issues. The HFE Design Team will also establish the Implementation Plans for conductin, each of the following HFE-related activities:

(a) System functional requirements analysis

(b) Allocation of functions

(c) Task analysis

(d) Human-system interface design

(e) Human factors verification and validation

The Implementation Plans will establish methods and criteria, for the conduct of each of these HFE-related activities, which are consistent with accepted HFE practices and principles. (For additional detailed information regarding the scope and content of the HFE Program and Implementation Plans, refer to the acceptance criteria presented in Table 18E-1.)

18E.2.3 System Functional Requirements Analysis

Analyses of the system functional requirements will be conducted through application of the methods and criteria established by the HFE Design Team in the System Functional Requirements Analysis Implementation Plan. The system functional analysis will determine the performance requirements and constraints of the HSI design and establish the functions which must be accomplished to meet these requirements. Safety functions will be specifically identified along with any functional interrelationship that those safety functions may have with non-safety systems. In addition, critical functions (i.e., functions required to achieve major system performance requirements or functions which, if failed, could degrade system performance or pose a safety hazard to plant personnel or the general public) will be identified. Detailed narrative descriptions will be developed for each of the identified functions.

18E.2.4 Allocation of Functions

The functions defined through the function analysis will then be allocated (i.e., defined as a function to be performed by the human, the system equipment or by a combination of the human and system equipment) per the methods and criteria established by the HFE Design Team in the Allocation of Functions Implementation Plan. The allocation of functions will be done to take advantage of areas of human strengths and avoid allocating functions to personnel which would be impacted by human limitations. The allocation of functions to personnel, systems or personnel-system combinations will be made to reflect: sensitivity, precision, time and safety requirements, required reliability of system performance, and the number and level of skills of personnel required to operate and maintain the system.

As alternative allocation concepts are developed, analyses and trade-off studies shall be conducted to determine adequate configurations of personnel and system-performed functions. Analyses will be done to confirm that the personnel elements can properly perform tasks that are allocated to them while maintaining proper operator situational awareness, workload and vigilance.

18E.2.5 Task Analyses

Following completion of the function allocation step, task analyses will be performed on those functions which have been allocated to personnel. These task analyses will be performed per the methods and criteria established by the HFE Design Team Task Analysis Implementation Plan. The task analyses will identify the behavioral requirements of the tasks associated with individual functions. Tasks are defined as groups of activities that have a common purpose, often occurring in temporal proximity, and which utilize the same displays and controls. The task analyses will: (1) provide one of the bases for making design decisions (e.g., determining before hardware fabrication, to the extent practicable, whether system performance requirements can be met by combinations of anticipated equipment, software and personnel); (2) assure that human performance requirements do not exceed human capabilities; (3) be used as basic information for developing manning, skill, training and communications requirements of the system; and (4) form the basis for specifying the requirements for the displays, data processing and controls needed to carry out the tasks.

The scope of the task analyses shall include all operations performed at the operator interface in the main control room and at the Remote Shutdown System. The analysis shall be directed to the full range of plant operating modes, including startup, normal operations, abnormal operations, transient conditions, low power and shutdown conditions. The analysis shall also address operator interface operations during periods of maintenance test and inspection of plant systems and equipment and of the HSI equipment.

18E.2.6 Human-System Interface Design

As established by the HFE Design Team in their development of the HSI Design Implementation Plan, human engineering criteria will be applied along with all other design requirements to select and design the particular equipment for application to the MCR and RSS HSI. The HSI design will implement the information and control requirements that have been developed in the task analysis, including the displays, control and alarms necessary for the execution of those tasks identified in the task analyses as being critical tasks. The equipment design configuration will satisfy the functional and technical design requirements and insure that the HSI is consistent with applicable HFE principles.

18E.2.7 Procedure Development

Plant and emergency operating procedures will be developed to support and guide human interactions with plant systems and to control plant-related events and activities. Plant procedure development is discussed in Section 13.5.

18E.2.8 Human Factors Verification and Validation

Following the methods and criteria established by the HFE Design Team in the Human Factors Verification and Validation Plan, the successful incorporation of human factors engineering into the implemented HSI design and the acceptability of the resulting HSI will be thoroughly evaluated as an integrated system.

The evaluations will include consideration of the HSI, the plant and emergency operating technical procedures and the overall work environment (e.g., lighting, ventilation, etc.). Individual HSI elements will be evaluated in a static mode to assure that all controls, displays and data processing that were identified in the task analyses are available and that they are designed according to accepted HFE principles, practices, and criteria. In addition, the integration of HSI elements with each other and with personnel will be evaluated and validated through dynamic task performance evaluation using evaluation tools such as a dynamic HSI prototype driven by real-time plant simulation models. The dynamic task performance evaluation will be conducted over the full range of operational conditions and plant maintenance activities including: normal plant operation; plant system and equipment failures; HSI equipment failures; plant transients and postulated plant emergency conditions.

18E.3 HSI Implementation Requirements

Section 18E.2 describes the process through which the SBWR ~~ABWR~~ Main Control Room (MCR) and Remote Shutdown System (RSS) areas of operator interface will be implemented and evaluated. Figure 18E-1 presents the relative timing of the NRC conformance reviews which are planned throughout the MCR and RSS Human-System Interface (HSI) design implementation. Tables 18E-1 through 18E-4 of this section define the requirements that are to be met by the HSI design implementation activities that are to be made available for review by the NRC. The HSI design implementation-related Design Acceptance Criteria (DAC) which are established through Rulemaking, (refer to Section 3.1 of the Tier 1 Design Certification material for the GE SBWR ~~ABWR~~ design), are defined such that there exists a direct correspondence between the DAC entries and requirements imposed herein on those design activities whose results are to be made available for the NRC conformance reviews, as identified in Figure 18E-1. Those requirements presented in Tables 18E-1 through 18E-4 which correspond to individual Tier 1 DAC acceptance criteria are specifically identified. Therefore, satisfaction of those specific requirements shall result in full compliance with the Certified Design Commitment and the corresponding Acceptance Criteria presented in the Tier 1 (Rulemaking) DAC established for the HSI design implementation.

Table 18E-1

Human Factors Engineering Design Team and Plans

(I) HFE Design Team Composition

(Satisfaction of the requirements presented herein shall result in the creation of an HFE Design Team which is in full compliance with the Item 1a Acceptance Criteria presented in Table 3.1 of the Tier 1 Design Certification Material for the GE SBWR ~~ABWR~~ design)

(1) The composition of the Human Factor Engineering (HFE) Design Team shall include, as a minimum, the technical skills presented in Article (4), below.

(2) The education and related professional experience of the HFE Design Team personnel shall satisfy the minimum personal qualification requirements specified in Article (4), below, for each of the areas of required skills. In those skill areas where related professional experience is specified, qualifying experience of the individual HFE Design Team personnel shall include experience in the SBWR ~~ABWR~~ main control room and Remote Shutdown System (RSS) Human System Interface (HSI) designs and design implementation activities. The required professional experience presented in those personal qualifications of Article (4) are to be satisfied by the HFE Design Team as a collective whole. Therefore, satisfaction of the professional experience requirements associated with a particular skill area may be realized through the combination of the professional experience of two or more members of the HFE Design Team who each, individually, satisfy the other defined credentials of the particular skill area but who do not possess all of the specified professional experience. Similarly, an individual member of the HFE Design Team may possess all of the credentials sufficient to satisfy the HFE Design Team qualification requirements for two or more of the defined skill areas.

(3) Alternative personal credentials may be accepted as the basis for satisfying the minimum personal qualification requirements specified in Article (4), below. Acceptance of such alternative personal credentials shall be evaluated on a case-by-case basis and approved, documented and retained in auditable plant construction files by the COL applicant. The following factors are examples of alternative credentials which are considered acceptable:

(a) A Professional Engineer's license in the required skill area may be substituted for the required Bachelor's degree.

(b) Related experience may substitute for education at the rate of six semester credit hours for each year of experience up to a maximum of 60 hours credit.

Table 18E-1
Human Factors Engineering Design Team and Plans (Continued)

	(c)	Where course work is related to job assignments, post-secondary education may be substituted for experience at the rate of two years of education for one year experience. Total credit for post-secondary education shall not exceed two years experience credit.	
(4)	Required Skill Area		Personal Qualification
	(a)	Technical Project Management	Bachelor of Science degree, and five years experience in nuclear power plant design operations, and three years management experience
	(b)	Systems Engineering	Bachelor of Science degree, and four years cumulative experience in at least three of the following areas of systems engineering; design, development, integration, operation, and test and evaluation
	(c)	Nuclear Engineering	Bachelor of Science degree, and four years nuclear design, development, test or operations experience
	(d)	Instrumentation and Control (I&C) Engineering	Bachelor of Science degree, and four years experience in design of process control systems, and experience in at least one of the following areas of I&C engineering; development, power plant operations, and test and evaluation
	(e)	Architect Engineering	Bachelor of Science degree, and four years power plant control room design experience

Table 18E-1
Human Factors Engineering Design Team and Plans (Continued)

(f)	Human Factors	Bachelor of Science degree in human factors engineering, engineering psychology or related science, and four years cumulative experience related to the human factors aspects of human-computer interfaces. Qualifying experience shall include experience in at least two of the following human factors related activities; design, development, and test and evaluation, and four years cumulative experience related to the human factors field of ergonomics. Again, qualifying experience shall include experience in at least two of the following areas of human factors activities; design, development, and test and evaluation
(g)	Plant Operations	Have or have held a Senior Reactor Operator license; two years experience in BWR nuclear power plant operations
(h)	Computer System Engineering	Bachelor of Science degree in Electrical Engineering or Computer Science, or graduate degree in other engineering discipline (e.g., Mechanical Engineering or Chemical Engineering), and four years experience in the design of digital computer systems and real time systems applications
(i)	Plant Procedure Development	Bachelor of Science degree, and four years experience in developing nuclear power plant operating procedures
(j)	Personnel Trainng	Bachelor of Science degree, and four years experience in the development of personnel training programs for power plants, and experience in the application of systematic training development methods

Table 18E-1
Human Factors Engineering Design Team and Plans (Continued)

(II) Human Factors Engineering Program Plan

(1) (Satisfaction of the requirements presented herein shall result in the creation of a Human Factors Engineering Program Plan which is in full compliance with the Item 1.b. Acceptance Criteria presented in Table 3.1 of the Tier 1 Design Certification material for the GE SBWR ~~ABWR~~ design.) The Human Factors Engineering (HFE) Program Plan shall establish:

(a) Methods and criteria, for the development and evaluation of the Main Control Room (MCR) and Remote Shutdown System (RSS) HSI which are consistent with accepted HFE practices and principles. Within the defined scope and content of the HFE Program Plan, accepted HFE methods and criteria are presented in the following documents:

(i) AR 602-1, Human Factors Engineering Program, (Dept. of Defense)

(ii) DI-HFAC-80740, Human Engineering Program Plan, (Dept. of Defense)

(iii) DOD-HDBK-763, Human Engineering Procedures Guide, Chapters 5-7 and Appendices A and B, (Dept. of Defense)

(iv) EPRI NP-3659, Human Factors Guide for Nuclear Power Plant Control Room Development, 1984, (Electric Power Research Institute)

(v) IEEE-1023, IEEE Guide to the Application of Human Factors Engineering to Systems, Equipment and Facilities of Nuclear Power Generating Stations, (IEEE)

(vi) MIL-H-46855B, Human Engineering Requirements for Military Systems, Equipment and Facilities, (Dept. of Defense)

(vii) NUREG-0700, Guidelines for Control Room Design Reviews, 1981, (US Nuclear Regulatory Commission)

(viii) NUREG-0737, Clarification of TMI Action Plan Requirements (Item I.C.5, "Feedback of Operating Experience to Plant Staff"), 1983, (US Nuclear Regulatory Commission)

(ix) NUREG-0899, Guidelines for the Preparation of Emergency Operating Procedures, 1982, (US Nuclear Regulatory Commission)

(x) NUREG/CR-3331, A Methodology for Allocating Nuclear Power Plant Control Functions to Human and Automated Control, 1983, (US Nuclear Regulatory Commission)

Table 18E-1
Human Factors Engineering Design Team and Plans (Continued)

(xi) TOP 1-2-610, Test Operating Procedure Part 1, (Dept. of Defense)

Note that within the set of documents listed above, differences may exist regarding specific methods and criteria applicable to the HFE Program Plan. In situations that such differences exist, for a particular issue, all of the methods and criteria presented within those documents which address that particular issue are considered to be equally appropriate and valid and, therefore, any of those documents may be selected as the basis for how that particular issue is addressed in the HFE Program.

(b) The methods for addressing:

(i) The ability of the operating personnel to accomplish assigned tasks

(ii) Operator workload levels and vigilance

(iii) Operating personnel "situation awareness"

(iv) The operator's information processing requirements

(v) Operator memory requirements

(vi) The potential for operator error

(c) HSI design and evaluation scope which applies to the Main Control Room (MCR) and Remote Shutdown System (RSS).

The HSI scope shall address normal, abnormal and emergency plant operations and test and maintenance interfaces that impact the function of the operations personnel. The HSI scope shall also address the development of operating technical procedures for normal, abnormal and emergency plant operations and the identification of personnel training needs applicable to the HSI design. The development of operating technical procedures are a COL action item (see Section 13.5). The establishment of an operator training program which meets the requirements of 10CFR50 is also a COL license information requirement (see Subsection 18.8.8).

Table 18E-1
Human Factors Engineering Design Team and Plans (Continued)

(d) The HFE Design Team as being responsible for:

(i) The development of HFE plans and procedures

(ii) The oversight and review of HFE design, development, test, and evaluation activities

(iii) The initiation, recommendation, and provision of solutions through designated channels for problems identified in the implementation of the HFE activities

(iv) Verification of implementation of solutions to problems

(v) Assurance that HFE activities comply to the HFE plans and procedures

(vi) Phasing of activities

(e) The methods for identification, closure and documentation of human factors issues.

(f) The HSI design configuration control procedures.

(2) The HFE Program Plan shall also establish:

(a) That each HFE issue/concern shall be entered on the HFE Issue Tracking System log when first identified, and each action taken to eliminate or reduce the issue/concern should be documented. The final resolution of the issue/concern, as accepted by the HFE Design Team, shall be documented along with information regarding HFE Design Team acceptance (e.g., person accepting, date, etc.) the individual responsibilities of the HFE Design Team members when an HFE issue/concern is identified, including definition of who should log the item, who is responsible for tracking the resolution efforts, who is responsible for acceptance of a resolution, and who shall enter the necessary closeout data.

(b) That the HFE Issue Tracking System shall address human factors issues that are identified throughout the development and evaluations of the Main Control Room and Remote Shutdown System HSI design implementation.

(c) That the MCR and RSS designs shall be implemented using HSI equipment technologies which are consistent with those defined in Section 18.4.3.

(d) That in the event other HSI equipment technologies are alternatively selected for application in the MCR and RSS design implementations:

Table 18E-1

Human Factors Engineering Design Team and Plans (Continued)

(i) A review of the industry experience with the operation of those selected new HSI equipment technologies shall be conducted.

(ii) The Operating Experience Review (OER) of those new HSI equipment technologies shall include both a review of literature pertaining to the human factors issues related to similar system applications of those new HSI equipment technologies and interviews with personnel experienced with the operation of those systems.

(iii) Any relevant HFE issues/concerns associated with those selected new HSI equipment technologies, identified through the conduct of the OER, shall be entered into the HFE Issue Tracking System for closure.

(e) That a review of HSI operating experience shall be conducted as follows:

(i) For the first implementation of the SBWR ~~ABWR~~ Certified Design:

(a) That the lessons learned from the review of previous nuclear plant HSI designs, as defined by Attachment 1 to this Table 18E-1, shall be entered into the HFE Issue Tracking System to assure that problems observed in previous designs have been adequately addressed in the SBWR ~~ABWR~~ design implementation.

(b) Reviews of operating experience with the following SBWR ~~ABWR~~ HSI design areas, in which further development of the industry's experience base can be expected, shall be completed:

— Use of flat panel and CRT displays
— Use of electronic on-screen controls
— Use of wide display panels
— Use of prioritized alarm systems
— Automation of process systems
— Operator workstation design integration

Table 18E-1

Human Factors Engineering Design Team and Plans (Continued)

Those operating experience reviews shall include review of reports provided by industry organizations (i.e., EPRI, etc.); review of applicable research in these design areas, as may be documented in reports from universities, national laboratories and the NRC, and in proceedings published by HFE professional societies; and review of applicable research and experience reports published by the HSI equipment vendors. Further, the review of operating experience in each of the six above identified areas shall include feedback obtained from actual users. Therefore, if the documents selected for the conduct of the operating experience review for a particular area do not include the results of user feedback, then interviews with users of at least two applications of that particular technology area shall also be conducted. Finally, the results from all these operating experience review activities shall be entered into the HFE Issue Tracking System to assure that the SBWR ~~ABWR~~ implementation reflects the experience gained by the resolution of design problems in operating plants.

(ii) For all subsequent implementations of the SBWR ~~ABWR~~ design:

(a) If a previously implemented SBWR ~~ABWR~~ HSI design is utilized directly and without change, then no further review of operating experience is required.

(b) If a previously implemented SBWR ~~ABWR~~ HSI design is not being utilized directly, then the operating experience of the most recent implementations, up to three, shall be reviewed through the conduct of operator interviews and surveys and the evaluation of Licensing Event Reports and the results of these reviews shall be entered into the HFE Issue Tracking System to assure that previous design problems have been adequately addressed in the SBWR ~~ABWR~~ design implementation.

(3) The HFE Program Management Plan document shall include:

(a) The purpose and organization of the plan.

(b) The relationship between the HFE program and the overall plant equipment procurement and construction program (organization and phasing).

(c) Definition of the HFE Design Team and their activities, including:

Table 18E-1

Human Factors Engineering Design Team and Plans (Continued)

(i) Description of the HFE Design Team function within the broader scope of the plant equipment procurement and construction program, including charts to show organizational and functional relationships, reporting relationships, and lines of communication.

(ii) Description of the responsibility, authority and accountability of the HFE Design Team organization.

(iii) Description of the process through which management decisions will be made regarding HFE.

(iv) Description of the process through which technical decisions will be made by the HFE Design Team.

(v) Description of the tools and techniques (e.g., review forms, documentation) to be utilized by the HFE Design Team in fulfilling their responsibilities.

(vi) Description of the HFE Design Team staffing, job descriptions of the individual HFE Design Team personnel and their personal qualifications.

(vii) Definition of the procedures that will govern the internal management of the HFE Design Team.

(d) Definition of the HFE Issue Tracking System and its implementation, including:

(i) Individual HFE Design Team member responsibilities regarding HFE issue identification, logging, issue resolution, and issue closeout.

(ii) Procedures and documentation requirements regarding HFE issue identification.

These shall include description of the HFE issue, effects of the issue if no design change action is taken and an assessment of the criticality and likelihood of the identified HFE issue manifesting itself into unacceptable HSI performance.

Table 18E-1
Human Factors Engineering Design Team and Plans (Continued)

(iii) Procedures and documentation requirements regarding HFE issue resolution.

These procedures shall include evaluation and documentation of proposed solutions, implemented solutions, evaluated residual effects of the implemented solution and the evaluated criticality and likelihood of the implemented resolution of the HFE issue manifesting itself into unacceptable HSI performance.

(e) Identification and description of the following implementation plans to be developed:

(i) System Functional Requirements Development

(ii) Allocation of Function

(iii) Task Analysis

(iv) Human-System Interface Design

(v) Human Factors Verification and Validation

(f) Definition of the phasing of HFE program activities, including:

(i) The plan for completion of HFE tasks which addresses the relationships between HFE elements and activities, the development of HFE reports and the conduct of HFE reviews

(ii) Identification of other plant equipment procurement and construction activities which are related to HFE Design Team activities but outside the scope of the team (e.g., I&C equipment manufacture)

(g) Definition of HFE documentation requirements and procedures for retention and retrieval.

(h) Description of the manner in which HFE Program requirements will be communicated to applicable personnel and organizations, including those which may be subcontracted, who are responsible for the performance of work associated with the Main Control Room and Remote Shutdown System design implementation.

Table 18E-1
Human Factors Engineering Design Team and Plans (Continued)

(III) System Functional Requirements Analysis Implementation Plan

(1) (Satisfaction of the requirements presented herein shall result in the creation of a System Functional Requirements Analysis Implementation Plan which is in full compliance with the Item 2.a acceptance criteria presented in Table 3.1 of the Tier 1 Design Certification material for the GE SBWR ABWR design). The System Functional Requirements Analysis Implementation Plan shall establish:

(a) Methods and criteria for conducting the System Functional Requirements Analysis which are consistent with accepted HFE practices and principles. Within the context of system functional requirements analysis, accepted HFE methods and criteria are presented in the following documents:

(i) AD/A233 168, System Engineering Management Guide, (Dept. of Defense, Defense Systems Management College, Kockler, F., et al)

(ii) AR602-1, Human Factors Engineering Program, (Dept. of Defense)

(iii) EPRI NP-3659, Human Factors Guide for Nuclear Power Plant Control Room Development, 1984, (Electric Power Research Institute)

(iv) IEC 964, Design for Control Rooms of Nuclear Power Plants, 1989, (Bureau Central de la Commission Electrotechnique Internationale)

(v) IEEE-1023, IEEE Guide to the Application of Human Factors Engineering to Systems, Equipment and Facilities of Nuclear Power Generating Stations, 1988, (IEEE)

(vi) MIL-H-46855B, Human Engineering Requirements for Military Systems, Equipment and Facilities, (Dept. of Defense)

(vii) NUREG-0700, Guidelines for Control Room Design Reviews, 1981, (US Nuclear Regulatory Commission)

(viii) NUREG/CR-3331, A Methodology for Allocating Nuclear Power Plant Control Functions to Human and Automated Control, 1983, (US Nuclear Regulatory Commission)

Table 18E-1

Human Factors Engineering Design Team and Plans (Continued)

Note that within the set of documents listed above, differences may exist regarding the specific methods and criteria applicable to the conduct of system functional requirements analysis. In situations that such differences exist, for a particular issue, all of the methods and criteria presented within those document which address that particular issue are considered to be equally appropriate and valid and, therefore, any of those documents may be selected as the basis for defining how that particular issue is addressed in the system functional requirements analysis.

(b) That system requirements shall define the system functions and those system functions shall provide the basis for determining the associated HSI performance requirements.

(c) That functions critical to safety shall be defined (i.e., those functions required to achieve safety system performance requirements; or those functions which, if failed, could pose a safety hazard to plant personnel or to the general public).

(d) That descriptions shall be developed for each of the identified functions and for the overall system configuration design itself. Each function shall be identified and described in terms of inputs (observable parameters which will indicate systems status) functional processing (control process and performance measures required to achieve the function), functional operations (including detecting signals, measuring information, comparing one measurement with another, processing information, and acting upon decisions to produce a desired condition or result such as a system or component operation actuation or trip) outputs, feedback (how to determine correct discharge of function), and interface requirements so that subfunctions are related to larger functional elements.

(2) The System Functional Requirements Analysis Implementation Plan shall include:

(a) The methods for identification of system level functions based upon system performance requirements. The functions shall be defined as the most general, yet differentiable means whereby the system requirements are met, discharged, or satisfied. Functions shall be arranged in a logical sequence so that any specified operational usage of the system can be traced in an end-to-end path.

Table 18E-1

Human Factors Engineering Design Team and Plans (Continued)

(b) The methods for developing graphic function descriptions (e.g., Functional Flow Block Diagrams and Time Line Diagrams). The functions shall be described initially in graphic form. Function diagramming shall be done starting at a "top level", where major functions are described, and continuing to decompose major functions to lower levels until a specific critical end-item requirement emerges (e.g., a piece of equipment, software, or an operator).

(c) The method for developing detailed function narrative descriptions which encompass:

- (i) Observable parameters that indicate system status
- (ii) Control process and data required to achieve the function
- (iii) How to determine the manner in which proper discharge of function is to be determined

(d) Analysis methods which define the integration of closely-related subfunctions so that they can be treated as a unit.

(e) Analysis methods which divide identified subfunctions into two groups according to whether:

- (i) Common achievement of the subfunction is an essential condition for the accomplishment of a higher level function.
- (ii) The subfunction is an alternative supporting function to a higher level function or the subfunction's accomplishment is not necessarily a requisite for a higher level function.

(f) Requirements to identify for each integrated subfunction:

- (i) The basis for why accomplishment of the subfunction is required
- (ii) The control actions necessary for accomplishment of the subfunctions
- (iii) The parameters necessary for the subfunction control actions
- (iv) The criteria for evaluating the results of the subfunction control actions
- (v) The parameters necessary for evaluation of the subfunction
- (vi) The criteria to be used to evaluate the subfunction
- (vii) The criteria for selecting alternative function assignments if the evaluation criteria b is not satisfied

Table 18E-1

Human Factors Engineering Design Team and Plans (Continued)

(IV) Allocation of Function Implementation Plan

(1) (Satisfaction of the requirements presented herein shall result in the creation of an Allocation of Function Implementation Plan which is in full compliance with the Item 3.a Acceptance Criteria presented in Table 3.1 of the Tier 1 Design Certification material for the GE SBWR ~~ABWR~~ design). The Allocation of Function Implementation Plan shall establish:

(a) The methods and criteria for the execution of function allocation which are consistent with accepted HFE practices and principles. Within the context of function allocation, accepted HFE practices and principles are presented in the following documents:

(i) AD/A223 168, System Engineering Management Guide, (Dept. of Defense, Defense Systems Management College, Kockler, F., et al)

(ii) AR 602-1, Human Factors Engineering Program , (Dept. of Defense)

(iii) EPRI NP-3659, Human Factors Guide for Nuclear Power Plant Control Room Development, 1984, (Electric Power Research Institute)

(iv) IEC 964, Design for Control Rooms of Nuclear Power Plants, (Bureau Central de la Commission Electrotechnique Internationale)

(v) NUREG-0700, Guidelines for Control Room Design Reviews, 1981, (US Nuclear Regulatory Commission)

(vi) NUREG/CR-3331, A Methodology for Allocating Nuclear Power Plant Control Functions to Human and Automated Control, 1983, (US Nuclear Regulatory Commission)

Note that within the set of documents listed above, differences may exist regarding the specific methods and criteria applicable to the conduct and analysis of function allocation. In situations that such differences exist, for a particular issue, all of the methods and criteria presented within those documents which address that particular issue are considered to be equally appropriate and valid and, therefore, any of those documents may be selected as the basis for defining how the particular issue is to be addressed in the conduct of the function allocation and analysis.

Table 18E-1

Human Factors Engineering Design Team and Plans (Continued)

(b) That aspects of system and functions definition shall be analyzed in terms of resulting human performance requirements based on the expected user population.

(c) That the allocation of functions to personnel, system elements, and personnel system combinations shall reflect:

(i) Areas of human strengths and limitations

(ii) Sensitivity, precision, time, and safety requirements

(iii) Reliability of system performance

(iv) The number and the necessary skills of the personnel required to operate and maintain the system

(d) That the allocation criteria, rationale, analyses, and procedures shall be documented.

(e) Analyses shall confirm that the personnel can perform tasks allocated to them while maintaining operator situation awareness, acceptable personnel workload, and personnel vigilance.

(2) The Allocation of Function Implementation Plan shall include:

(a) Establishment of a structured basis and criteria for function allocation.

(b) Definition of function allocation analyses requirements, including:

(i) Definition of the objectives and requirements for the evaluation of function allocations

(ii) Development of alternative function allocations for use in the conduct of comparative evaluations

(iii) Development of criteria to be used as the basis for selecting between alternative function allocations

(iv) Development of evaluation criteria weighing factors

(v) Development of test and analysis methods for evaluating function allocation alternatives

(vi) Definition of the methods to be used in conducting assessments of the sensitivity of the comparative function allocation alternatives analyses results to the individual analysis inputs and criteria

(vii) Definition of the methods to be employed in selecting individual function allocation for incorporation into the implemented design

Table 18E-1

Human Factors Engineering Design Team and Plans (Continued)

(V) Task Analysis Implementation Plan

(1) (Satisfaction of the requirements presented herein shall result in the creation of a Task Analysis Implementation Plan which is in full compliance with the Item 4.a Acceptance Criteria presented in Table 3.1 of the Tier 1 Design Certification material for the GE SBWR ~~ABWR~~ design). The Task Analysis Implementation Plan shall establish:

(a) The methods and criteria for conduct of the task analyses which are consistent with accepted HFE practices and principles. Within the context of performing task analysis, accepted HFE methods and criteria are presented in the following documents:

(i) AD/A223 168, System Engineering Management Guide, (Dept. of Defense, Defense Systems Management College, Kockler, F., et al)

(i) DOD-HDBK-763, Human Engineering Procedures Guide, Chapters 5-7 and Appendices A and B, 1991, (Dept. of Defense)

(ii) EPRI NP-3659, Human Factors Guide for Nuclear Power Plant Control Room Development, 1984, (Electric Power Research Institute)

(iii) IEC 964, Design for Control Rooms of Nuclear Power Plants, (Bureau Central de la Commission Electrotechnique Internationale)

(iv) IEEE-1023, IEEE Guide to the Application of Human Factors Engineering to Systems, Equipment and Facilities of Nuclear Power Generating Stations, (IEEE)

(v) MIL-H-46855B, Human Engineering Requirements for Military Systems, Equipment and Facilities, (Dept. of Defense)

(vi) MIL-STD-1478, Task Performance Analysis, (Dept. of Defense)

(vii) NUREG-0700, Guidelines for Control Room Design Reviews, 1981, (US Nuclear Regulatory Commission)

(viii) NUREG/CR-3331, A Methodology for Allocating Nuclear Power Plant Control Functions to Human and Automated Control, 1983, (US Nuclear Regulatory Commission)

(ix) NUREG/CR-3371, Task Analysis of Nuclear Power Plant Control Room Crews (Vol. 1), 1983, (US Nuclear Regulatory Commission)

Table 18E-1

Human Factors Engineering Design Team and Plans (Continued)

Note that within the set of documents listed above, differences may exist regarding the specific methods and criteria applicable to the conduct of HFE task analysis. In situations that such differences exist, for a particular issue, all of the methods and criteria presented within those documents which address that particular issue are considered to be equally appropriate and valid and, therefore, any of those documents may be selected as the basis for defining how that particular issue is addressed in the task analysis.
(b) The scope of the task analysis, which shall include operations performed at the operator interface in the Main Control Room and at the Remote Shutdown System. The analyses shall be directed to the full range of plant operating modes, including startup, normal operations, abnormal operations, transient conditions, low power and shutdown conditions. The analyses shall also address operator interface operations during periods of maintenance, test and inspection of plant systems and equipment, including the HSI equipment
(c) That the analysis shall link the identified and described tasks in operational sequence diagrams. The task descriptions and operational sequence diagrams shall be used to identify which tasks are critical to safety in terms of importance for function achievement, potential for human error, and impact of task failure. Human actions which are identified through PRA sensitivity analyses to have significant impact on safety shall also be considered "critical" tasks. Where critical functions are automated, the analyses shall address the associated human tasks including the monitoring of the automated function and the backup manual actions which may be required if the automated function fails.
(d) Task analysis shall develop narrative descriptions of the personnel activities required for successful completion of the task. A task shall be a group of activities, often occurring in temporal proximity, which utilize a common set of displays and controls. Task analyses shall define the input, process, and output required by and of personnel.
(e) The task analysis shall identify requirements for alarms, displays, data processing, and controls.
(f) The task analysis results shall be made available as input to the personnel training programs.

Table 18E-1

Human Factors Engineering Design Team and Plans (Continued)

(2) The Task Analysis Implementation Plan shall include:

(a) The methods and data sources to be used in the conduct of the task analysis.

(b) The methods for conducting the initial (high level) task analysis, including:

(i) Converting functions to tasks

(ii) Developing narrative task descriptions

(iii) Developing the basic statement of the task functions

(iv) Decomposition of tasks to individual activities

(v) Development of operational sequence diagrams

(c) The methods for developing detailed task descriptions that address:

(i) Information requirements (i.e., information required to execute a task, including cues for task initiation)

(ii) Decision-making requirements (i.e., decisions that are probably based on the evaluations, description of the decisions to be made and the evaluations to be performed)

(iii) Response requirements (i.e., actions to be taken, frequency of action, speed/time line requirements, any tolerance/accuracy requirements associated with the action, consideration of any operational limits of personnel performance or of equipment body movements required by an action taken, and any overlap of task requirements such as serial vs. parallel task elements)

(iv) Feedback requirements (i.e., feedback required to indicate adequacy of actions taken)

(v) Personnel workload (i.e., both cognitive and physical workload and the estimation of the level of difficulty associated with a particular workload condition)

(vi) Any associated task support requirements (i.e., special/protective clothing, job aids or reference materials required; any tools and equipment required, or any computer processing support aids)

(vii) Workplace factors (i.e., the workspace envelope required by the action taken, workspace environmental conditions, location that the work is to be performed, the physical/mental attributes of the work)

Table 18E-1

Human Factors Engineering Design Team and Plans (Continued)

(viii) Staffing and communication requirements (i.e., the number of personnel, their technical specialty, and specific skills, the form and content of communications and other personnel interaction required when more than one person is involved)

(ix) The identification of any hazards involved in execution of the task

(d) The methods for identification of critical tasks. The identified critical tasks shall include, at the minimum, those operator actions which have significant impact on the PRA results, as presented in Section 19D.7, and the operator actions to isolate the reactor and inject water for the postulated event scenarios of a common mode failure of the Safety System Logic and Control System and/or the essential Multiplexing System concurrent with a design basis main steamline, feedwater line or shutdown cooling line break LOCA.

(e) The methods for establishing information and control requirements.

(f) The methods for conducting alarm, display, processing, and control requirements analysis.

(g) The methods through which the application of task analysis results are assembled and documented to provide input to the development of personnel training programs.

(h) The methods to be used to evaluate the results of the task analysis.

(VI) HSI Design Implementation Plan

(1) (Satisfaction of the requirements presented herein shall result in the creation of an HSI Design Implementation Plan which is in full compliance with the Item 5.a Acceptance Criteria presented in Table 3.1 of the Tier 1 Design Certification material for the GE SBWR ~~ABWR~~ design). The HSI Design Implementation Plan shall establish:

(a) The methods and criteria for HSI equipment design and evaluation of HSI human performance, equipment design and associated work place factors, such as illumination in the MCR and in the RSS area, which are consistent with accepted HFE practices and principles. Within the context of performing these HSI design evaluations, accepted HFE methods and criteria are presented in the following documents:

(i) AD/A223 168, System Engineering Management Guide, (Dept. of Defense, Defense Systems Management College, Kockler, F., et al)

Table 18E-1

Human Factors Engineering Design Team and Plans (Continued)

(ii) ANSI HFS-100, American National Standard for Human Factors Engineering of Visual Display Terminal Workstations, (Am. Nat'l. Standards Institute)

(iii) EPRI NP-3659, Human Factors Guide for Nuclear Power Plant Control Room Development, 1984, (Electric Power Research Institute)

(iv) EPRI NP-3701, Computer-Generated Display System Guidelines, 1984, (Electric Power Research Institute)

(v) ESD-TR-86-278, Guidelines for Designing User Interface Software, (Department of Defense)

(vi) IEC 964, Design for Control Rooms of Nuclear Power Plants, (Bureau Central de la Commission Electrotechnique Internationale)

(vii) MIL-H-46855B, Human Engineering Requirements for Military Systems, Equipment and Facilities, (Dept. of Defense)

(viii) MIL-HDBK-759A, Human Factors Engineering Design for Army, Material (Dept. of Defense)

(ix) DOD-HDBK-761A, Human Engineering Guidelines for Management Information Systems, (Dept. of Defense)

(x) MIL-STD-1472D, Human Engineering Design Criteria for Military Systems, Equipment and Facilities, (Dept. of Defense)

(xi) NUREG-0696, Functional Criteria for Emergency Response Facilities, 1980, (US Nuclear Regulatory Commission)

(xii) NUREG-0700, Guidelines for Control Room Design Reviews, 1981, (US Nuclear Regulatory Commission)

(xiii) NUREG-0800, Standard Review Plan, (US Nuclear Regulatory Commission)

(xiv) NUREG-0899, Guidelines for the Preparation of Emergency Operating Procedures, 1982, (US Nuclear Regulatory Commission)

(xv) NUREG/CR-5228, Techniques for Preparing Flowchart Format Emergency Operating Procedures (Vols. 1 & 2), 1989, (US Nuclear Regulatory Commission)

Table 18E-1

Human Factors Engineering Design Team and Plans (Continued)

(xvi) NUREG/CR-4227, Human Engineering Guidelines for the Evaluation and Assessment of Video Display Units, 1985, (US Nuclear Regulatory Commission)

(xvii) Gilmore, et. al. (1989), *User-Computer interface in process control: A human factors engineering handbook.* San Diego, CA: Academic Press, Inc.

Note that within the set of documents listed above, differences may exist regarding the specific methods and criteria applicable to the conduct of HSI design evaluations. In situations that such differences exist, for a particular issue, all of the methods and criteria presented within those documents which address that particular issue are considered to be equally appropriate and valid and, therefore, any of those documents may be selected as the basis for defining how that particular issue is addressed in the HSI design evaluations.

(b) That the HSI design shall implement the information and control requirements developed through the task analyses, including the displays, controls and alarms necessary for the execution of those tasks identified in the task analyses as being critical tasks (see paragraph V.2.d of this table).

(c) The methods for comparing the consistency of the HSI human performance equipment, design and associated workplace factors with that modeled and evaluated in the completed task analysis.

(d) That the HSI design shall not incorporate equipment (i.e., hardware or software function) which has not been specifically evaluated in the task analysis.

(e) The HSI design criteria and guidance for control room operations during periods of maintenance, test and inspection of control room HSI equipment and of other plant equipment which has control room personnel interface.

(f) The test and evaluation methods for resolving HFE/HSI design issues. These test and evaluation methods shall include the criteria to be used in selecting HFE/HSI design and evaluation tools which:

(i) May incorporate the use of static mockups and models for evaluating access and workspace-related HFE issues

(ii) Shall require dynamic simulations and HSI prototypes for conducting evaluations of the human performance associated with the activities in the critical tasks identified in the task analysis

Table 18E-1

Human Factors Engineering Design Team and Plans (Continued)

(2) The Human System Interface Design Implementation Plan shall include:

(a) Identification of the specific HFE standards and guidelines documents which substantiate that the selected HSI Design Evaluation Methods and Criteria are based upon accepted HFE practices and principles.

(b) Definition of standardized HFE design conventions.

(c) Definition that the standard design features (Section 18.4.2), the standard HSI equipment technologies (Section 18.4.3), and the displays, controls and alarms (Tables 18F-1, 18F-2 and 18F-3) shall be incorporated as requirements on the HSI design.

(d) Definition of the design/evaluation tools (e.g., prototypes) which are to be used in the conduct of the HSI design analyses, the specific scope of evaluations for which those tools are to be applied and the rationale for the selection of those specific tools and their associated scope of application.

(VII) Human Factors Verification and Validation Implementation Plan

(1) (Satisfaction of the requirements presented herein shall result in the creation of a Human Factors Verification and Validation Implementation Plan which is in full compliance with the Item 7.a Acceptance Criteria presented in Table 3.1 of the Tier 1 Design Certification material for the SBWR ~~ABWR~~ design). The Human Factors Verification and Validation (V&V) Implementation Plan shall establish:

(a) Human factors V&V methods and criteria which are consistent with accepted HFE practices and principles. Within the context of performing human factors V&V, accepted HFE methods and criteria are presented in the following documents:

(i) AD/A223 168, System Engineering Management Guide, (Dept. of Defense, Defense Systems Management College, Kockler, F., et al)

(ii) DOD-HDBK-763, Human Engineering Procedures Guide, Chapters 5-7 and Appendices A and B, (Dept. of Defense)

(iii) DOD 5000.2, Defense Acquisition Management Policies and Procedures, (Dept. of Defense)

(iv) EPRI NP-3701, Computer-Generated Display System Guidelines, 1984, (Electric Power Research Institute)

Table 18E-1

Human Factors Engineering Design Team and Plans (Continued)

(v) IEC 964, Design for Control Rooms of Nuclear Power Plants, (Bureau Central de la Commission Electrotechnique Internationale)

(vi) IEEE-845, IEEE Guide to Evaluation of Man-Machine Performance in Nuclear Power Generating Station Control Rooms and Other Peripheries, (IEEE)

(vii) MIL-H-46855B, Human Engineering Requirements for Military Systems, Equipment and Facilities, (Dept. of Defense)

(viii) DOD-HDBK-761A, Human Engineering Guidelines for Management Information Systems, (Dept. of Defense)

(ix) NUREG-0700, Guidelines for Control Room Design Reviews, 1981, (US Nuclear Regulatory Commission)

(x) NUREG-0899, Guidelines for the Preparation of Emergency Operating Procedures, 1982, (US Nuclear Regulatory Commission)

(xi) TOP 1-2-610, Test Operating Procedure Part 1, (Dept. of Defense)

(xii) NSAC-39, Verification and Validation for Safety Parameter Display Systems, (Electric Power Research Institute)

(xiii) NUREG/CR-4227, Human Engineering Guidelines for the Evaluation and Assessment of Video Display Units, 1985, (US Nuclear Regulatory Commission)

Note that within the set of documents listed above, differences may exist regarding the specific methods and criteria applicable to the conduct of human factors V&V. In situations that such differences exist, for a particular issue, all of the methods and criteria presented within those documents which address that particular issue are considered to be equally appropriate and valid and, therefore, any of those documents may be selected as the basis for defining how that particular issue is addressed in the human factors V&V.

Table 18E-1

Human Factors Engineering Design Team and Plans (Continued)

(b) That the scope of the evaluations of the integrated HSI shall include: (i) The Human-System Interface (including both the interface of the operator with the HSI equipment hardware and the interface of the operator with the HSI equipment's software-driven functions) (ii) The plant and emergency operating technical procedures (iii) HSI work environment (c) That static and/or "part-task" mode evaluations of the HSI equipment shall be conducted to confirm that the controls, displays, and data processing functions identified in the task analyses are designed per accepted HFE guidelines and principles. (d) The integration of HSI equipment with each other, wi:' he operating personnel and with the plant and emergency operating technical procedures shall be evaluated through the conduct of dynamic task performance testing. The dynamic task performance testing and evaluations shall be performed over the full scope of the integrated HSI design using dynamic HSI prototypes (i.e., prototypical HSI equipment which is dynamically-driven using real time plant simulation computer models). In the event that the particular HSI design implementation under consideration is referenced to a previous HSI design for which dynamic task performance test and evaluation results are available, those existing results, along with the results of limited scope dynamic task performance tests which address the areas of difference between the two subject HSI designs, may be used to satisfy this requirement. The methods for defining the scope and application of the dynamic HSI prototype, past test results and other evaluation tools shall be documented in the implementation plan. The dynamic task performance tests and evaluations shall have as their objectives:

Table 18E-1
Human Factors Engineering Design Team and Plans (Continued)

(i) Confirmation that the identified critical functions can be achieved using integrated HSI design

(ii) Confirmation that the HSI design and configuration can be operated using the established main control room staffing levels

(iii) Confirmation that the plant and emergency operating technical procedures of the scope as defined in Section 18.5 provide direction for completing the identified tasks associated with normal, abnormal and emergency operations

(iv) Confirmation that the time dependent and interactive (e.g., display format selection) aspects of the HSI equipment performance allow for task accomplishment

(v) Confirmation that the allocation of functions are sufficient to enable task accomplishment

(vi) Confirmation that the integrated HSI design implementation is consistent with accepted HFE practices and principles

(e) That dynamic task performance test evaluations shall be conducted over the range of operational conditions and upsets, including:

(i) Normal plant operations, such as plant startup, shutdown, full power operations, and plant maintenance activities

(ii) Plant system and equipment failures (including instrumentation failures)

(iii) HSI equipment failures

(iv) Plant transients

(v) Postulated plant accidents conditions, as defined in paragraph V.2.d of this table

(f) The HFE performance measures to be used as the basis for evaluating the dynamic task performance test results. These performance measures shall include:

Table 18E-1

Human Factors Engineering Design Team and Plans (Continued)

(i) Operating crew primary task performance characteristics, such as task times and procedure compliance

(ii) Operating crew errors and error rates

(iii) Operating crew situation awareness

(iv) Operating crew workload

(v) Operating crew communications and coordination

(vi) Anthropometry evaluations

(vii) HSI equipment performance measures

(g) The methods to confirm that HFE issues identified and documented in the Human Factors Issue Tracking System have been resolved in the integrated HSI design.

(h) The methods and criteria to be used to confirm that critical human actions, as defined by the task analysis, have been addressed in the integrated HSI design.

(i) The methods and criteria to be used to evaluate the adequacy of the operating technical procedures.

(2) The Human Factors Verification and Validation Implementation Plan shall include:

(a) Definition of test objectives

(b) Definition of test methods and procedures

(c) Identification of the participants in the dynamic task performance testing, which shall include licensed operators as test subjects

(d) Definition of dynamic task performance test conditions which shall include:

(i) Plant startup operations

(ii) Plant power operations

(iii) Plant shutdown operations

(iv) Plant refueling and maintenance operations

(v) Individual plant system and equipment failures (including instrumentation failures)

(vi) Individual HSI equipment failure (e.g., loss of VDU functions)

(vii) Design basis transients (e.g., turbine trip, loss of feedwater)

Table 18E-1
Human Factors Engineering Design Team and Plans (Continued)

(viii) Design basis accidents (e.g., LOCAs)

(ix) Execution of symptom-based emergency procedures

(x) Execution of task scenarios which contain critical tasks as identified in the task analyses

(e) Methods for defining scope and configuration of the prototypical HSI required to support testing

(f) Methods for defining criteria and performance measures to be used in evaluating test results

(g) Method for conducting analysis of test data

(h) Requirement that the HSI design shall be reviewed and confirmed:

(i) To have incorporated the inventory of controls, displays and alarms presented in Tables 18F-1, 2 and 3

(ii) That the implemented design is consistent with the standard design features and technologies as presented in Sections 18.4.2 and 18.4.3, respectively

(i) Requirements for the development of documented test & evaluation plans and procedures

(j) Requirements for documenting test results

Table 18E-2

Attachment 1 to Table 18E-1
Results of Operating Experience Review of Previous Nuclear Power Plant HSI Designs

(A) Control Room Design

(1) The large size of the control room and console and their configuration contributed to operator dissatisfaction.

(2) Traffic flows should not be impeded by placement of consoles.

(3) Adequate levels of illumination are necessary to ensure that visual effectiveness is sufficient for task performance. Emergency lighting should be available.

(4) Noise levels in the main control room should be maintained within acceptable industry levels.

(5) The climate control system in the control room should be capable of continuously maintaining temperature and humidity within the human comfort zone.

(6) Convenient storage should be provided so that procedures, logs, and drawings needed for routine job performance are conveniently available. Storage should also be provided for equipment needed for emergency operation.

(B) Control Board Design

(1) Control boards should be optimized for minimum manning.

(2) Panels in the control rooms were observed to have large arrays of identical controls and displays and repetitive labels. The systems, subsystems, and components should be separated by appropriate demarcation methods.

(3) Controls and related displays should be located in close proximity so that the two items are readily associated and can be used conveniently with one another. Controls should be placed in an obvious and consistent order. The displays and controls used to monitor major system functions should be assigned to and arranged in functional groups.

(4) Flow arrangements between CRT display formats and controls on panels should not differ.

(5) Flow mimics should be used to aid (and not mislead) the operators.

(6) Panel arrangements for similar systems should be the same.

(7) Location of controls in areas and orientations that render them vulnerable to accidental contact and disturbance should be avoided.

Table 18E-2

Attachment 1 to Table 18E-1
Results of Operating Experience Review
of Previous Nuclear Power Plant HSI Designs (Continued)

(8) Unclear, illogical, overly complex, or mirror-imaged control board or panel layout arrangements have been observed to promote operational mishaps and should be avoided.

(C) Computer

(1) Computer data should be available on CRT and hard copy output.

(2) Computer audible alarms should not be distracting.

(D) CRT Displays

(1) The nomenclature, labeling, and arrangement of systems on the CRT displays should be similar to the panels.

(2) CRT display should be comprehensible with a minimum of visual search. When data is presented in lines and columns, the lines of data should be separated by a space (blank line), one character high, every 4-5 lines.

(3) Display access should be efficient and require a minimum of key strokes.

(4) CRT displays should have convenient brightness, focus, and degauss controls.

(5) The character height should be the appropriate height for the viewing distance during normal and emergency conditions.

(6) Visibility of CRT displays should not be affected by glare.

(E) Anthropometrics

(1) Panel dimensions should accommodate the 5 to 95 percentile range of the user population to ensure that personnel can see and reach the displays and controls or the front and back panels. Displays should not be placed beyond the visual range of the operators.

(2) Controls should not be located in the control panels that require the operator to lean into the panel. This is a potential health risk to the operator and to the equipment.

(F) Controls

(1) Large controls were observed to have been used in place of preferred smaller controls. Larger controls impact panel size and should be avoided.

(2) Labeling or coding techniques should be used to differentiate controls and indicator lights of similar appearance.

(3) Control configurations should not introduce parallax problems.

Table 18E-2
Attachment 1 to Table 18E-1
Results of Operating Experience Review of Previous Nuclear Power Plant HSI Designs (Continued)

(4) Control switches that must be held by the operator for operation should be avoided unless necessary.

(5) Projecting control handles should not cover or obstruct labels.

(6) Key lock switches require administrative control and should be avoided if possible.

(7) Control handles should not be difficult to operate and should not cause the operators to resort to using unauthorized mechanical leveraging devices (i.e., "cheaters") so as to achieve reduced difficulty in operation.

(8) Controls should be built and installed following standard conventions for OPEN/CLOSE and INCREASE/DECREASE. Setpoint scales should not move up in response to a downward movement of the controller thumbwheel.

(9) Inadvertent operation of adjacent controls may be reduced through the use of shape coding such as using similar shaped handles for similar functions (i.e., pistol grips for pumps and round handles for valves).

(G) Indicator Lights

(1) Instances of improper use of qualitative indicators were observed where quantitative displays such as meters would be more effective.

(2) Light status (on/off) should be visible to the operator. Extinguished bulbs should be obvious and a test method provided. Lamp designs should allow for easy access for lamp removal.

(3) The use of so-called negative indications (the absence of an indication) should not be used to convey information to the operator.

(4) Indicator design selection and layout should be standardized to conserve panel space.

(5) A color code standard should be established for indicating lights.

(H) Display and Information Processing

(1) Plant parameter validity should not have to be inferred. In addition to secondary information, the quality or validity of the displayed parameter should be available to allow operators to readily identify improper ESF or other safety equipment status under various operating modes.

Table 18E-2

Attachment 1 to Table 18E-1
Results of Operating Experience Review of Previous Nuclear Power Plant HSI Designs (Continued)

(2) Necessary information should be available during events such as SBO and LOOP. Systems and indications such as Neutron Monitoring System, control rod position indication, and drywell area radiation indication should all be available during these events.

(3) The main control room should contain an integrating overview display. The overview display should provide a limited number of key operating parameters.

(4) The same displays that are used during normal operation should be used by the operators during accident conditions to ensure their familiarity with the interface.

(I) Meters

(1) Proper use of minor, intermediate, and major scale markings in association with scale numerals should be made. Formats should be customized to take into account identification of normal operating values and limits. Scale numerical progressions and formats should be selected for the process parameter being presented.

(2) Placement of meters above and below eye level, making the upper and lower segment of the scale difficult to read (especially with curved scales), can present parallax problems.

(3) Meters were observed that fail with the pointer reading in the normal operating band of the scale. The instrument design should allow the operator to determine a valid indication from a failed indication.

(4) Placement of meters on panels should prevent glare and reflections caused by overhead illumination.

(5) Where redundant channels of instrumentation exist, software-based displays should provide for easy inspection of the source data and intermediate results without the need to display them continuously.

(6) Data presented to the operator should be in a usable form and not require the operator to calculate its value. Scale graduations should be consistent and easily readable. Zone markings should be provided to aid in data interpretation.

(7) Meter pointers should not obscure the scale on meters.

(8) Process units between the control room instruments and the operating procedures should be consistent.

Table 18E-2
Attachment 1 to Table 18E-1
Results of Operating Experience Review of Previous Nuclear Power Plant HSI Designs (Continued)

(J) Chart Recorders

(1) Recorders should not be used in place of meters. Recorders should be selected with consideration given to minimizing required maintenance and high reliability.

(2) A recorder designed to monitor 24 parameters was observed to have 42 parameters assigned to it. This makes it extremely difficult to read the numerical outputs on the chart paper. The inputs assigned should be consistent with the design of the recorder.

(3) Operational limits should be defined on recorders. Proper selection of recorder scales will eliminate the need for overlays. The units for the process should be labeled on the recorder.

(4) Monitored inputs should be assigned to recorder pens in alphabetical order. The correlation of pen color to input parameter should be clearly defined by multi-pen recorder labels.

(5) The change of chart speed should also be noted on the chart paper when the paper is changed. The paper scales should match the fixed scales.

(6) Recorders should have fast speed and point select capability.

(7) Proper placement of recorders and adequate illumination should prevent glare and parallax problems with recorder faces.

(8) The pointers should not cover the graduation marks.

(9) When upper and lower pens coincide, the printout of the upper scale should still be visible.

(K) Annunciator Warning Systems

(1) Annunciators should be located near the control board panel elements to which they are related. Divisional arrangements should be consistent. Annunciators should be functionally located near the applicable system.

(2) "Advisory alarms" reporting expected conditions should not be grouped with true alarms. The audio and visual warning system signal should be prioritized to reduce the audio and visual burden placed on the operators during an event.

(3) Some alarms were observed to lack specificity. Multi-input alarms (e.g. xyz pressure/levels, hi/lo) frustrate, rather than inform the operator.

Table 18E-2

Attachment 1 to Table 18E-1 Results of Operating Experience Review of Previous Nuclear Power Plant HSI Designs (Continued)

(4) Excessive alarms were observed during emergency conditions. Auditory signals should be coded to aid the operator in determining the panel location.

(5) Alarm operating sequence controls should be placed at specific locations to encourage operator acknowledgment.

(6) For standing and sit-down workstations, window size and lettering height should be consistent with the viewing distance.

(7) The labels should use consistent abbreviations and nomenclature and not be ambiguous.

(8) For traceability to response procedures, the windows should be identified with a location reference code.

(9) A consistent color coding convention should be employed.

(10) A "First Out" feature should be provided that presents prioritized parameters important to safety parameters for immediate operator response.

(11) Means should be provided for identification of out-of-service annunciators.

(12) Annunciators for conditions which signal an EOP entry condition should be located based on the functional analysis.

(L) Coding of Displays and Controls

(1) The color codes for the control boards should be systematically applied. Effective color coding should be used to aid in differentiating between identical controls placed in close proximity.

(2) The coding of indicators should inform the operator whether a valve is open or closed.

(3) Systematic approach to color and shape coding of controls should be taken.

(M) Labeling

(1) Label abbreviations, numbering, and nomenclature should be consistent. A label placement standard for the control room should be established. Labels should be placed consistently above or below the panel elements being identified and not placed between two components.

(2) Hierarchical labeling schemes, including size coding or differentiation of labels, should be used to identify major console panels, sub-panels, and panel elements. Hierarchical labeling will eliminate the need to place redundant labels on control or display devices.

Table 18E-2

Attachment 1 to Table 18E-1
Results of Operating Experience Review of Previous Nuclear Power Plant HSI Designs (Continued)

(3) The content of the labels should be consistent with the procedures used by the operators.

(4) The labels should meet the readability guidelines and should not be obscured by the equipment that they are mounted near. A control room standard for labels should be established that addresses label character size and font.

(5) Maintenance tags should not obscure labels or panel components such as displays.

(6) To minimize the mispositioning of valves and other equipment, the controls and displays should be labeled with the unique number or name of the valve or piece of equipment.

(N) Communications

(1) Communications in the control room should consider the ambient noise levels in the control room and plant. The control room operator should be able to communicate with necessary personnel in the plant. Communication equipment should also be provided at the remote shutdown panel.

(2) Communications equipment design should not limit the operator's access to the controls or displays.

(3) The communication system should be accessible from the operator's workstations.

(O) Task Analysis

(1) Controls and displays should be located for effective operator response to postulated events. Information needed by the operator in the control room should be readily available and not located at remote panels in the plant.

(2) In addition to normal and emergency conditions, plant displays and controls should also consider low power and shutdown scenario information requirements.

(P) Procedures

(1) The measurement units in the procedure and the values indicated on display scales should be consistent.

(2) Control board designs should make provisions for the operator's simultaneous referral to the procedures and the operation of the control boards.

Table 18E-2

Attachment 1 to Table 18E-1
Results of Operating Experience Review
of Previous Nuclear Power Plant HSI Designs (Continued)

(3) The parameters displayed on electronic information systems or on the control boards should be designed to support the EOPs as well as other required monitoring tasks.

(4) The safety function parameter status should be presented in an organized, readily accessible format compatible with the EOPs.

(5) A procedure should address operator action in the event of computer, CRT, or printer problems or complete failure.

(Q) Operator Errors

(1) Operator mishaps were observed to be caused by the absence of a timely, attention-getting indication (either qualitative or quantitative) that informs the operator that some element of the system is not operating properly.

(2) Operator mishaps were also observed to result from incorrect lineup of valves.

(R) Maintenance and Testing

(1) The main control room should be designed in such a way that minimizes the need for maintenance and test personnel to work, or at least limit their presence, in the control room.

(2) Control room displays should be designed and installed for easy calibration and replacement.

(3) Access for inspection, operation, and routine maintenance of components should not be restrictive.

Table 18E-3
HFE Analysis

(I) System Functional Requirements Analyses

(1) (Satisfaction of the requirements presented herein shall result in the conduct of system functional requirements analyses which are in full compliance with the Item 2.b Acceptance Criteria presented in Table 3.1 of the Tier 1 Design Certification material for the GE SBWR ~~ABWR~~ design). The system functional requirements analyses shall be conducted in accordance with the requirements of the Human Factors Engineering Program Plan and the System Functional Requirements Analysis Implementation Plan.

(2) The results of the system functional requirements analyses shall be documented in a report that includes the following:

- (a) Objectives of the system functional requirements analyses
- (b) Description of the methods employed in the conduct of system functional requirements analyses
- (c) Identification of deviations from the System Functional Requirements Analysis Implementation Plan
- (d) Presentation and discussion of the results of the system functional requirements analysis, including a discussion of design change recommendations derived from these analyses and/or negative implications that the current design may have on safe plant operations
- (e) Conclusions regarding the conduct of the analyses and the analyses results

(3) The results of the HFE Design Team's evaluation of the conduct and results of the system functional requirements analyses shall be documented in a report that includes the following:

- (a) The methods and procedures used by the HFE Design Team in their review of the system functional requirements analyses
- (b) The HFE Design Team's evaluation of the completed system functional requirements analyses, including an evaluation of the compliance with the System Functional Requirements Analysis Implementation Plan and the HFE Program Plan
- (c) Presentation and discussion of the HFE Design Team's Review findings

Table 18E-3

HFE Analysis (Continued)

(II) Function Allocation Analyses

(1) (Satisfaction of the requirements presented herein shall result in the conduct of function allocation analyses which are in full compliance with the Item 3.b Acceptance Criteria presented in Table 3.1 of the Tier 1 Design Certification material for the GE SBWR ~~ABWR~~ design). The function allocation analyses shall be conducted in accordance with the requirements of the Human Factors Engineering Program Plan and the Allocation of Functions Implementation Plan.

(2) The results of the function allocation analysis shall be documented in a report that includes the following:

(a) Objectives of the function allocation analyses

(b) Description of the methods employed in the conduct of the function allocation analyses

(c) Identification of deviations from the Allocation of Function Implementation Plan

(d) Presentation and discussion of the results of the function allocation analyses, including a discussion of design change recommendations derived from these analyses and/or negative implications that the current design may have on safe plant operations

(e) Conclusions regarding the conduct of the analyses and analysis results

(3) The results of the HFE Design Team's evaluation of the conduct and results of the function allocation analyses shall be documented in a report that includes the following:

(a) The methods and procedures used by the HFE Design Team in their review of the function allocation analyses

(b) The HFE Design Team's evaluation of the completed function allocation analyses, including an evaluation of the compliance with the Allocation of Function Implementation Plan and the HFE Program Plan

(c) Presentation and discussion of the HFE Design Team's review findings

Table 18E-3

HFE Analysis (Continued)

(III) Task Analyses

(1) (Satisfaction of the requirements presented herein shall result in the conduct of task analyses which are in full compliance with the Item 4.b Acceptance Criteria presented in Table 3.1 of the Tier 1 Design Certification material for the GE SBWR ~~ABWR~~ Design). The task analyses shall be conducted in accordance with the requirements of the Human Factors Engineering Program Plan and the Task Analysis Implementation Plan.

(2) The results of the task analyses shall be documented in a report that includes the following:

(a) Objectives of the task analyses

(b) Description of the methods employed in the conduct of the task analyses

(c) Identification of deviations from the Task Analyses Implementation Plan

(d) Presentation and discussion of the results of the task analyses, including discussion of design change recommendations derived from these analyses and/or negative implications that the current design may have on safe plant operations

(e) Conclusions regarding the conduct of the analyses and the analyses results

(3) The results of the HFE Design Team's evaluation of the conduct and results of the task analyses shall be documented in a report that includes the following:

(a) The methods and procedures used by the HFE Design Team in their review of the completed task analyses

(b) The HFE Design Team's evaluation of the completed task analyses including an evaluation of the compliance with the Task Analysis Implementation Plan and the HFE Program Plan

(c) Presentation and discussion of the HFE Design Team's review findings

Table 18E-4
Human System Interface Design

(I) HSI Design Analyses

(1) (Satisfaction of the requirements presented herein shall result in the conduct of HSI design analyses which are in full compliance with the Item 5.b Acceptance Criteria presented in Table 3.1 of the Tier 1 Design Certification material for the GE SBWR ~~ABWR~~ design). The Human System Interface (HSI) design implementation and analyses shall be conducted in accordance with the requirements of the Human Factors Engineering Program Plan and the HSI Design Implementation Plan.

(2) The results of the HSI design analyses shall be documented in a report that includes the following:

(a) Objectives of the HSI design analyses

(b) Description of the methods employed in the conduct of the HSI design analyses

(c) Identification of deviations from the HSI Design Implementation Plan

(d) Presentation and discussion of the results of the HSI design analyses, including discussion of design change recommendations derived from these analyses and/or negative implications that the current design may have on safe plant operations

(e) Conclusions regarding the conduct of the analyses and the analysis results

(3) The results of the HFE Design Team's evaluation of the conduct and results of the HSI design analyses shall be documented in a report that includes the following:

(a) The methods and procedures used by the HFE Design Team in their review of the HSI design analyses

(b) The HFE Design Team's evaluation of the completed HSI design analyses, including an evaluation of the compliance with the HSI Design Implementation Plan and HFE Program Plan

(c) Presentation and discussion of the HFE Design Team's review findings

Table 18E-5

Human Factors Verification and Validation

(I) Human Factors Verification and Validation

(1) (Satisfaction of the requirements presented herein shall result in the conduct of human factors verification and validation activities which are in full compliance with the Item 7.b Acceptance Criteria presented in Table 3.1 of the Tier 1 Design Certification material for the GE SBWR ~~ABWR~~ design). The human factors verification and validation (V&V) of the human system interface (HSI) design shall be conducted in accordance with the requirements of the Human Factors Engineering Program Plan and the Human Factors V&V Implementation Plan.

(2) The results of the human factor verification and validation (V&V) activities shall be documented in a report that includes the following:

(a) Objec es of the human factors V&V

(b) Description of the methods employed in the conduct of the human factors V&V

(c) Identification of deviations from the Human Factors V&V Implementation Plan

(d) Presentation and discussion of the human factors V&V results, including discussion of design change recommendations derived from the human factors V&V tests and evaluations and/or significant negative implications that the current HSI design may have on safe plant operations which may have been identified

(e) Conclusions regarding the conduct of the human factors V&V and the results

(3) The results of the HFE Design Team's evaluation of the conduct and results of the human factor verification and validation (V&V) shall be documented in a report that includes the following:

(a) The review methodology and procedures used by the HFE Design Team in their review of the human factor V&V

(b) The HFE Design Team's evaluation of the completed human factors V&V, including an evaluation of the compliance with the Human Factors V&V Implementation Plan and HFE Program Plan

(c) The HFE Design Team's evaluation of the completed human factors V&V, including an evaluation of the presentation and discussion of the HFE Design Team's Human Factors review findings

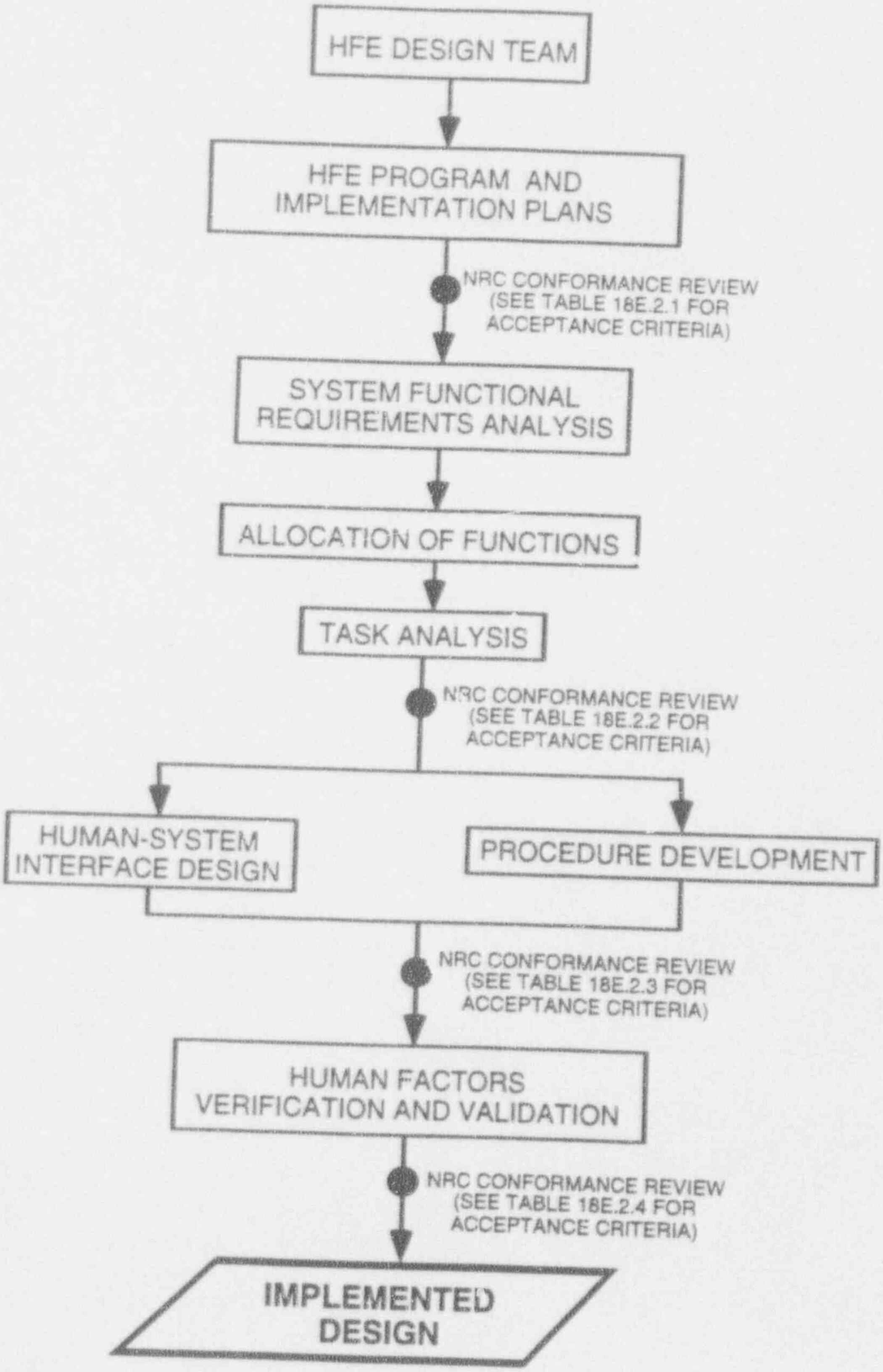

Figure 18E-1 SBWR ~~ABWR~~ Human-System Interface Design Implementation Process

18F Emergency Operation Information and Controls

18F.1 Introduction

This appendix contains the results of an analysis of information and control needs of the main control room operators. The analysis is based upon the operation strategies given in the SBWR ~~ABWR~~ Emergency Procedure Guidelines (EPGs) as presented in Appendix 18A. ~~and upon the significant operator actions determined by the Probabilistic Risk Assessment (PRA) as given in Appendix 19D.7.~~ The minimum inventory of controls, displays and alarms from this analysis are presented in Tables 18F-1 through 18F-3 of this appendix. The information and controls identified from this analysis do not necessarily include those from other design requirements (such as those from Section 18.4.2.11, SPDS).

Information and control needs for each operation instruction or action were developed through task analyses conducted in the following manner:

- Each specific step in the EPGs (referred to as the EPG step) ~~or specific operator action referenced in the PRA (herein referred to as the PRA step)~~ was individually identified.
- For each EPG step, ~~and PRA action~~, a summary description of the step or operator action was developed.
- Information needs of the operator to perform the specific EPG step ~~or PRA operator action~~ were then identified.
- Next, the control functions that the operators perform to execute the actions specified in the EPG step ~~or PRA operator action~~ were identified.
- The plant process parameters or other displays that are needed for execution of the individual EPG step ~~or PRA operator action~~, were then identified.
- Similarly, the controls needed for the execution of the step were identified.
- Annunciators necessary for the execution of the step were identified.
- Operator aids, such as supplementary procedures or other information needed for the execution of the step, were identified.
- Displays used to provide a feedback to the operators to confirm that the specified control functions have been initiated or accomplished were identified.
- Position of control devices that provide feedback to the operators to confirm that proper controls are manipulated to the correct positions were identified.

- Annunciators which provide feedback to the operators to confirm that proper control actions are initiated or accomplished were identified.

- Operator aids, which provide feedback to the operators to confirm that proper control actions are initiated or accomplished, were identified.

~~The following operator actions are considered to be important operator actions in the SBWR ABWR PRA (Subsection 19D.7):~~

- ~~Manual initiation of Fuel Pool & Aux Pool Cooling System in LPCI mode;~~

- ~~Manual initiation of Gravity Driven Cooling System;~~

- ~~Manual initiation of ADS;~~

  ~~(1) Backup manual initiation of HPCF~~

  ~~(2) Recovery of feedwater following a scram~~

  ~~(3) Use of condensate injection following scram with reactor depressurized~~

  ~~(4) Control of reactor water level in an ATWS~~

  ~~(5) Emergency depressurization of the reactor~~

  ~~(6) Alignment and initiation of firewater for RPV injection with ECCS failure~~

  ~~(7) Alignment and initiation of firewater for drywell spray~~

  ~~(8) Initiation of wetwell spray using RHR~~

  ~~(9) Isolation of water sources in an internal flooding~~

~~These actions are already specified in the EPGs and are included in the analyses.~~

Based upon the results of those operator task analyses, the listings of controls, displays and alarms that will be provided in the implemented SBWR ~~ABWR~~ design to support execution of the E Ps ~~and PRA significant operator actions~~ (as presented in Tables 18F-1, 18F-2, and 18F-3) were generated.

Table 18-F1

Inventory of Controls Based Upon the SBWR EPGs ~~and PRA Required Fixed Position Main Control Console~~

No.	Fixed Position Controls
1	Manual Scram Initiation Switch (A)
2	Manual Scram Initiation Switch (B)
3	Reactor Mode Switch
4	Main Steam Line Manual Isolation Switch Div. 1
5	Main Steam Line Manual Isolation Switch Div. 2
6	Main Steam Line Manual Isolation Switch Div. 3
7	Main Steam Line Manual Isolation Switch Div. 4
8	Containment Manual Isolation Switch (Inboard)
9	Containment Manual Isolation Switch (Outboard)
10	GDCS Logic (A) Initiation Switch
11	GDCS Logic (B) Initiation Switch
12	I C Logic (A) Initiation Switch
13	I C Logic (B) Initiation Switch
14	Condensate Pump Standby Mode Initiation Switches (3)*
15	Reactor Feedpump Standby Mode Initiation Switches (3)*
16	Condensate Pump Startup Mode Initiation Switches (3)*
17	Reactor Feedpump Startup Mode Initiation Switches (3)*
18	FAPCS Train (A) LPCI Mode Initiation Switch*
19	FAPCS Train (B) LPCI mode initiation Switch*
20	Div. 1 MSIV Isolation Reset Switch
21	Div. 2 MSIV Isolation Reset Switch
[illegible]	Div. 3 MSIV Isolation Reset Switch
23	Div. 4 MSIV Isolation Reset Switch
24	MSIV Control Switches (4)
25	SLC Logic (A) Initiation Switch
26	SLC Logic (B) Initiation Switch
27	ARI Manual Initiation Switch (A)*
28	ARI Manual Initiation Switch (B)*
29	ARI Reset Switch*
30	ARI Logic (A) Bypass Switch*

Table 18.F1

Inventory of Controls Based Upon the SBWR EPGs and PRA Required Fixed Position Main Control Console (Continued)

No.	Fixed Position Controls
31	ARI Logic (B) Bypass Switch*
32	CRD Charging Water Pressure Low Scram Bypass Switch (A)
33	CRD Charging Water Pressure Low Scram Bypass Switch (B)
34	CRD Charging Water Pressure Low Scram Bypass Switch (C)
35	CRD Charging Water Pressure Low Scram Bypass Switch (D)
36	Manual Scram Reset Switch
37	RPS Div. 1 Trip Reset Switch
38	RPS Div. 2 Trip Reset Switch
39	RPS Div. 3 Trip Reset Switch
40	RPS Div. 4 Trip Reset Switch
41	FAPCS (A) Suppression Pool Cooling Mode Initiation Switch
42	FAPCS (B) Suppression Pool Cooling Mode Initiation Switch
43	Containment Outboard Isolation Reset Switch
44	Containment Inboard Isolation Reset Switch
45	FAPCS (A) Drywell Spray Mode Initiation Switch
46	FAPCS (B) Drywell Spray Mode Initiation Switch
47	FAPCS (A) Mode Selection Reset Switch
48	FAPCS (B) Mode Selection Reset Switch
49	Turbine Trip Switch
50	ADS Logic (A) Manual Initiation Switch
51	ADS Logic (B) Manual Initiation Switch
52	FAPCS Manual Valve For Injection of Firewater (F-346)
53	Turbine Building HVAC System Controls
54	RPS Div. 1 Manual Trip Switch
55	RPS Div. 2 Manual Trip Switch
56	RPS Div. 3 Manual Trip Switch
57	RPS Div. 4 Manual Trip Switch
58	Fire Protection Motor Operated Pump Control Switch*
59	Fire Protection Diesel-Operated Pump Control Switch*
60	Fire Protection Jockey Pumps Control Switch

Table 18-F1

Inventory of Controls Based Upon the SBWR EPGs ~~and PRA Required Fixed Position Main Control Console~~ (Continued)

No.	Fixed Position Controls
61	Div. 1 MSIV and Main Steam Line Drain Isolation Logic Bypass Switch
62	Div. 2 MSIV and Main Steam Line Drain Isolation Logic Bypass Switch
63	Div. 3 MSIV and Main Steam Line Drain Isolation Logic Bypass Switch
64	Div. 4 MSIV and Main Steam Line Drain Isolation Logic Bypass Switch
65	RWCU Isolation Logic Bypass Switch (SLC Initiation, MSL Temperature, RPV Water Level 2)
66	Alternate Rod Insertion (ARI) Logic (A) Bypass Switch*
67	"A" Scram Solenoid Main Power Breaker CS
68	"B" Scram Solenoid Main Power Breaker CS
69	RPS Div. 1 Trip Inhibit Switch
70	RPS Div. 2 Trip Inhibit Switch
71	RPS Div. 3 Trip Inhibit Switch
72	RPS Div. 4 Trip Inhibit Switch
73	Control Rod Scram Test Switches*
74	Rod Worth Minimizer Bypass Switch
75	CAMS (A) Operating Mode Switch
76	CAMS (B) Operating Mode Switch
77	CAMS (A) Sample Select Switch
78	CAMS (B) Sample Select Switch
79	Bypass Switch of LOCA Interlocks on Drywell Cooling Fans and Associated Cooling Water (RCCW)*
80	FCS (A) Control Switch
81	FCS (B) Control Switch
82	FCS (C) Control Switch
83	FCS (D) Control Switch
84	Div. 1 Logic Bypass Switch for Controlled Area HVAC Isolation
85	Div. 2 Logic Bypass Switch for Controlled Area HVAC Isolation
86	Div. 3 Logic Bypass Switch for Controlled Area HVAC Isolation
87	Div. 4 Logic Bypass Switch for Controlled Area HVAC Isolation
88	High RPV Water Level (Level 8) Reactor Feedpumps Interlock Bypass Switch*
89	High RPV Water Level (Level 9) Reactor Feedpump Trip Logic Bypass Switch

Table 18-F1

Inventory of Controls Based Upon the SBWR EPGs ~~and PRA Required Fixed Position Main Control Console~~ (Continued)

No.	Fixed Position Controls
90	High RPV Water Level (Level 8) Reactor Feedpumps Interlock Bypass Switch*
91	High RPV Water Level (Level 9) Reactor Feedpumps Trip Logic Bypass Switch

* Provided outside the main control room.

Table 18F-1

Inventory of Controls Based Upon the SBWR EPGs ~~and PRA~~ (Continued) ~~Required Divisional VDU~~

No.	~~Divisional VDU~~ Other Control Functions*
1	RWCU Isolation Valves Control Switch
2	I C (A) System Controls
3	I C (B) System Controls
4	I C (C) System Controls
5	Main Steam Line Drain Inboard Isolation Valve Controls
6	Main Steam Line Drain Outboard Isolation Valve Controls
7	SRV Control Switches (8 Switches 4 per Division)
8	SLC Injection Line Shutoff Valve Control Switch
9	RBHVAC Isolation Valves Controls
10	Atmospheric Control System Isolation Valve Controls
11	CRD System Controls
12	Condensate and Feedwater System Controls
13	Feedwater Control System Control
14	FAPCS System Controls
15	Pressure Control System Controls
16	RWCU System Controls
17	Main Steam System Controls
18	Rod Control and Information System Controls
19	RWM Bypass Switch
20	Drywell Cooling System Controls
21	Nitrogen Vent And Purge Mode of ACS Controls
22	Containment Purge Mode of Containment Supply and Purge Subsystem of RBHVAC Controls
23	Drywell Cooling Coils Fans Controls
24	Atmospheric Control System Controls
25	RB HVAC System Controls
26	FAPCS Pump (A) Room Cooler Fan Control
27	FAPCS Pump (B) Room Cooler Fan Control
28	RCCW Pump (A) Room Cooler Fan Control
29	RCCW Pump (B) Room Cooler Fan Control

Table 18F-1

Inventory of Controls Based Upon the SBWR EPGs and PRA (Continued) Required Divisional VDU

No.	Divisional VDU Other Control Functions*
30	CRD Pump (A) Room Cooler Fan Control
31	CRD Pump (B) Room Cooler Fan Control
32	RWCU Pump (A) Room Cooler Fan Control
33	RWCU Pump (B) Room Cooler Fan Control
34	Main Steam Tunnel Cooler Fan Controls (A)
35	Main Steam Tunnel Cooler Fan Controls (B)
36	SJAE Steam Isolation Valve Control
37	Steam to Off-Gas Preheater Isolation Valve Controls
38	Steam to Radwaste Isolation Valve Control
39	Steam to Turbine HVS Isolation Valve Control
40	Turbine Extraction Steam Isolation Valve Control
41	Turbine Bypass Valves Controls
42	RPV Head Vent Valve Controls

* Not necessarily provided at fixed positions.

Table 18F-2

Inventory of Displays Based Upon the SBWR EPGs ~~and PRA Required Fixed-Position Display: Main Control Room~~

No.	Fixed Position Displays
1	RPV Water Level*
2	RPV Pressure*
3	Time†
4	Drywell Pressure*
5	Reactor Power Level (APRM)*
6	Reactor Power Level (SRNM)*
7	Reactor Simulated Thermal Power*
8	Neutron Flux Rate of Change (APRM)*
9	Neutron Flux Period (SRNM)*
10	MSIV Position Status*
11	Suppression Pool Bulk Temperature*
12	RPV Water Level 8*
13	Scram Solenoid Status Light Indication (8)
14	Manual Scram Switch (A) Status Indicating Light
15	Manual Scram Switch (B) Status Indicating Light
16	RPV Isolation Status*
17	SRV Valves Status (8)*
18	DPV Valves Status (6)*
19	GDCS (A) Pool Level*
20	GDCS (B) Pool Level*
21	GDCS (C) Pool Level*
22	GDCS (A) Injection Valve Status*
23	GDCS (B) Injection Valve Status*
24	GDCS (C) Injection Valve Statu *
25	I C (A) Condensate Return Valve Status*
26	I C (A) Condensate Return Bypass Valve Status*
27	I C (B) Condensate Return Valve Status*
28	I C (B) Condensate Return Bypass Valve Status*
29	I C (C) Condensate Return Valve Status*
30	I C (C) Condensate Return Bypass Valve Status*

Table 18F-2

Inventory of Displays Based Upon the SBWR EPGs and PRA Required Fixed-Position Display: Main Control Room (Continued)

No.	Fixed Position Displays
31	Containment Water Level*
32	Wetwell Pressure*
33	Condensate and Feedwater Pumps Operating Status
34	RPV Water Level 3 Indication*
35	RPV Water Level 8 Indication*
36	FAPCS System Injection Valve Status
37	FAPCS Injection Valve Status
38	FAPCS Pump (A) Discharge Pressure
39	FAPCS Pump (B) Discharge Pressure
40	FAPCS Pump (A) Discharge Flow
41	FAPCS Pump (B) Discharge Flow
42	FAPCS Pump (A) Operating Status
43	FAPCS Pump (B) Operating Status
44	RPV Water Level 1m Above TAF Indication*
45	Main Condenser Pressure
46	Main Steam Line Pressure
47	Turbine Bypass Valves Status
48	Suppression Pool Water Level*
49	Main Steam Line Flow
50	RWCU Isolation Valves Status*
51	RWCU Train (A) Inlet Valve Status
52	RWCU Train (B) Inlet Valve Status
53	RWCU Train (A) Flow*
54	RWCU Train (B) Flow*
55	RWCU Train (A) RHX Bypass Valve Status
56	RWCU Train (B) RHX Bypass Valve Status
57	RWCU Pump (A) Status
58	RWCU Pump (B) Status
59	RWCU Demin (A) Inlet Valve Status
60	RWCU Demin (B) Inlet Valve Status

Table 18F-2

Inventory of Displays Based Upon the SBWR EPGs ~~and PRA Required Fixed-Position Display: Main Control Room~~ (Continued)

No.	Fixed Position Displays
~~61~~	~~RWCU Demin (A) Bypass Valve Status~~
~~62~~	~~RWCU Demin (B) Bypass Valve Status~~
~~63~~	~~RWCU RHX (A) Inlet Valve Status~~
~~64~~	~~RWCU RHX (B)Inlet Valve Status~~
~~65~~	~~RWCU RHX (A) Bypass Valve Status~~
~~66~~	~~RWCU RHX (B)Bypass Valve Status~~
~~67~~	~~RWCU (A) Return to Feedwater Valve Status~~
~~68~~	~~RWCU (B) Return to Feedwater Valve Status~~
~~69~~	~~RWCU Train (A) RHX Inlet Temperature~~
~~70~~	~~RWCU Train (B) RHX Inlet Temperature~~
~~71~~	~~RWCU Train (A) NRHX Outlet Temperature*~~
~~72~~	~~RWCU Train (B) NRHX Outlet Temperature*~~
~~73~~	~~RWCU Train (A) Demin Outlet Valve Status~~
~~74~~	~~RWCU Train (b) Demin Outlet Valve Status~~
~~75~~	~~RWCU Discharge Line to Main Condenser Valve Status~~
~~76~~	~~RWCU Discharge Line to Radwaste Valve Status~~
~~77~~ 50	SLC Injection Valve (A) Status
~~78~~ 51	SLC Injection Line Shutoff Valve Status
~~79~~ 52	SLC Accumulator Level*
~~80~~ 53	SLC Accumulator Pressure*
~~81~~ 54	Average Upper Drywell Temperature*
~~82~~ 55	Average Lower Drywell Temperature*
~~83~~ 56	Wetwell Hydrogen Level*
~~84~~ 57	Drywell Hydrogen Level*
~~85~~ 58	FAPCS Drywell Spray Valve Status
~~86~~ 59	Containment Purge Exaust Radioactivity Level *
~~87~~ 60	Drywell Oxygen Concentration*
~~88~~ 61	Wetwell Oxygen Concentration*
~~89~~ 62	Safety Envelope HVAC Exaust Radiation Level*
~~90~~ 63	Refueling Area Air Ventilation Exaust Radiation Level*

Table 18F-2

Inventory of Displays Based Upon the SBWR EPGs and PRA Required Fixed Position Display: Main Control Room (Continued)

No.	Fixed Position Displays
91 64	Isolation Condenser (A) Pool Discharge Vent Radiation Level*
92 65	Isolation Condenser (B) Pool Discharge Vent Radiation Level*
93 66	Isolation Condenser (C) Pool Discharge Vent Radiation Level*
94 67	Reactor Building HVAC Exaust Radiation Level*
95 68	Stack Radioactivity Level*
96 69	RPV Water Level 9*
97 70	Fire Protection System Status Display†
98 71	Fire Line Header Pressure†
99 72	CAMS (A) System Lineup Display
100 73	CAMS (B) System Lineup Display
101 74	FCS (A) Operating Status
102 75	FCS (B) Operating Status
103 76	FCS (C) Operating Status
104 77	FCS (D) Operating Status
105 78	Containment Purge Exaust Radioactivity Level
106 79	Safety Envelope HVAC Exaust Radiation Level
107 80	Refuelling Area Air Ventilation Exaust Radiation Level
108 81	Isolation Condenser (A) Pool Discharge Vent Radiation Level*
109 82	Isolation Condenser (B) Pool Discharge Vent Radiation Level*
110 83	Isolation Condenser (C) Pool Discharge Vent Radiation Level*
111 84	Reactor Building HVAC Exhaust Radiation Level †
112 85	Area Radiation Monitors Levels*†
113 86	Stack Radiation Level†
114 87	RCCW System (A) Radiation†
115 88	RCCW System (B) Radiation†
116 89	Radwaste Effluent Radiation†
90	Reactor Mode Switch Mode Indications

* Reg. Guide 1.97 parameter.

† Not necessarily provided at fixed positions.

Table 18F-2

Inventory of Displays Based Upon the SBWR EPGs and PRA (Continued) Required Divisional VDU Displays

No.	Divisional VDU Other Displays
1	RPV Water Level Instrument Reference Leg Temperature
2	RPV Water Level Instrument Area Temperature
3	Narrow Range Water Level
4	CRD Charging Water Pressure
5	GDCS (A) System Lineup Display
6	GDCS (B) System Lineup Display
7	GDCS (C) System Lineup Display
8	I C (A) System Lineup Display
9	I C (B) System Lineup Display
10	I C (C) System Lineup Display
11	Main Steam Line Tunnel Area Temperature
12	Turbine Area Main Steam Line Temperature
13	SLC System Lineup Display
14	Controlled Area HVAC Isolation Valves Status Display
15	RWCU Isolation Valves Status*
16	RWCU Train (A) Inlet Valve Status
17	RWCU Train (B) Inlet Valve Status
18	RWCU Train (A) Flow*
19	RWCU Train (B) Flow*
20	RWCU Train (A) RHX Bypass Valve Status
21	RWCU Train (B) RHX Bypass Valve Status
22	RWCU Pump (A) Status
23	RWCU Pump (B) Status
24	RWCU Demin (A) Inlet Valve Status
25	RWCU Demin (B) Inlet Valve Status
26	RWCU Demin (A) Bypass Valve Status
27	RWCU Demin (B) Bypass Valve Status
28	RWCU RHX (A) Inlet Valve Status
29	RWCU RHX (B)Inlet Valve Status
30	RWCU RHX (A) Bypass Valve Status

Table 18F-2

Inventory of Displays Based Upon the SBWR EPGs ~~and PRA~~ (Continued) ~~Required Divisional VDU Displays~~

No.	~~Divisional VDU~~ Other Displays
31	RWCU RHX (B)Bypass Valve Status
32	RWCU (A) Return to Feedwater Valve Status
33	RWCU (B) Return to Feedwater Valve Status
34	RWCU Train (A) RHX Inlet Temperature
35	RWCU Train (B) RHX Inlet Temperature
36	RWCU Train (A) NRHX Outlet Temperature*
37	RWCU Train (B) NRHX Outlet Temperature*
38	RWCU Train (A) Demin Outlet Valve Status
39	RWCU Train (b) Demin Outlet Valve Status
40	RWCU Discharge Line to Main Condenser Valve Status
41	RWCU Discharge Line to Radwaste Valve Status

* Reg. Guide 1.97 parameter.

Table 18F-3

Inventory of Alarms Based Upon the SBWR EPGs ~~and PRA Required Fixed-Position Alarms~~

No.	Fixed Position Alarms
1	Indicated RPV Water Level Abnormal
2	RPV Water Level 3
3	RPV Pressure High
4	Drywell Pressure High
5	Neutron Flux High–High
6	Neutron Monitoring System Trouble
7	Neutron Flux Rapid Increase
8	Neutron Flux Short Period
9	CRD Charging Water Pressure Low
10	MSIV Closure
11	Suppression Pool Bulk Temperature High
12	RPV Water Level 8
13	Reactor Scram
14	RPV Water Level 2 Isolation Incomplete
15	RPV Level 1 Isolation Incomplete
16	RPV Water Level ≤ 1m Above TAF
17	SRV Open
18	ADS Logic (A) Initiated
19	ADS Logic (B) Initiated
20	GDCS Logic (A) Initiated
21	GDCS Logic (B) Initiated
22	GDCS POols Level Low
23	Control Rod Not Inserted To/Beyond MSBWP
24	Fire Protection System Trouble
25	RPV Water Level ≤ TAF
26	Main Steam Line Flow High
27	HPNSS Trouble
28	RWCU Trouble
29	SLC Trouble
30	ARI Actuated

Table 18F-3

Inventory of Alarms Based Upon the SBWR EPGs ~~and PRA Required Fixed-Position Alarms~~ (Continued)

No.	Fixed Position Alarms
31	ATWS Initiated
32	Rod Withdrawal Block
33	Drywell Average Temperature High
34	Suppression Pool Water Level High/Low
35	CAMS H_2/O_2 Level Highs
36	Suppression Pool Bulk Average Temperature High
37	Suppression Pool Water Level High/Low
38	CAMS H_2/O_2 Level High
39	CAMS (A) System Abnormal
40	CAMS (B) System Abnormal
41	Process Radiation Monitoring System Trouble
42	Controlled Area Differential Pressure Low
43	Area Temperature High
44	RBHVAC Exaust Radiation High
45	Controlled Areas Area Radiation High
46	Controlled Area Floor Drain Sump Level High
47	Reactor Building Control Room Envelope HVAC Trouble
48	Stack Radioactivity High
49	Reactor Component Cooling Water Activity High
50	Turbine Building Ventilation System Trouble
51	Radiation Monitors High (Common Alarm)
52	RPV Water Level 9
53	Main Turbine Trip
54	Main Generator Trip
55	Leak Detection Isolation

Table 18F-3

Inventory of Alarms Based Upon the SBWR EPGs ~~and PRA Required Divisional VDU Alarms~~ (Continued)

No.	~~Divisional VDU~~ Other Alarms
1	RWCU SLC Initiation Isolation Bypassed
2	RWCU RPV Water Level 2 Isolation Bypassed
3	RWCU Main Steam Line Tunnel Temperature High Isolation Bypassed
4	RPS Div. 1 Trip Inhibited
5	RPS Div. 2 Trip Inhibited
6	RPS Div. 3 Trip Inhibited
7	RPS Div. 4 Trip Inhibited
8	Wetwell Pressure Low
9	Controlled Area HVAC Isolated
10	Div. 1 Controlled Area HVAC Drywell Pressure Isolation Bypassed
11	Div. 2 Controlled Area HVAC Drywell Pressure Isolation Bypassed
12	Div. 3 Controlled Area HVAC Drywell Pressure Isolation Bypassed
13	Div. 4 Controlled Area HVAC Drywell Pressure Isolation Bypassed
14	Div. 1 Controlled Area HVAC RPV Water Level Isolation Bypassed
15	Div. 2 Controlled Area HVAC RPV Water Level Isolation Bypassed
16	Div. 3 Controlled Area HVAC RPV Water Level Isolation Bypassed
17	Div. 4 Controlled Area HVAC RPV Water Level Isolation Bypassed
18	Turbine Building MSL Tunnel Temperature High
19	Div. 1 MSIV & Main Steam Drain Isolation Logic Bypassed
20	Div. 2 MSIV & Main Steam Drain Isolation Logic Bypassed
21	Div. 3 MSIV & Main Steam Drain Isolation Logic Bypassed
22	Div. 4 MSIV & Main Steam Drain Isolation Logic Bypassed
23	Containment Water Level ~~0.0~~