18H Supporting Analysis for Emergency Operation Information and Controls

18H.1 Introduction

This appendix contains the supporting analysis of information and control needs of the main control room operators. The analysis is based upon the operation strategies given in the ABWR Emergency Procedure Guidelines (EPGs) as presented in Appendix 18A and the significant operator actions determined by the Probabilistic Risk Assessment (PRA) described in Section 19D.7. The minimum inventory of controls, displays and alarms from this analysis are presented in Appendix 18F.

Information and control needs for each operation instruction or action provided in Reference 18H-1.

The following guidelines, developed from a research program of advanced control panel designs, were used to specify the type of implementation device for controls, displays, and alarms:

(a) Fixed Position Controls
- Manual starting and resetting of safety systems,
- Manual starting of emergency backups,
- Mode switches for initiation of automation sequences.

(b) Divisional VDUs
- Individual controls of safety system components,
- Lineup displays of safety systems.

(c) Non-Divisional VDUs
- Monitoring of non-safety systems and control of individual controls of non-safety systems,
- Individual alarms.

(d) Fixed Position Alarms
- Important plant level and system level alarms.

(e) Fixed Position Display
- Monitoring of important plant parameters.

Operator actions that are considered to be important in the ABWR PRA (refer to Appendix 19D and Subsection 18F.1) are already specified in the EPGs and are included in the analyses.

18H.2 Presentation of Results

The results of the operational analysis of each step of the ABWR EPGs and PRA important operator actions and inventories of the controls, displays, and alarms which have been

identified in those operational analyses as being the minimum primary means of accomplishing a particular function of main control room operation are provided in Reference 18H-1. These inventories do not necessarily include controls, displays, and alarms from consideration of other design requirements.

In the ABWR human-system interface design (HSI), control, display and alarm indication functions are implemented through the use of divisional VDUs (referred to as "Div. VDUs"), non-divisional VDUs (referred to simply as "VDUs") and/or through the use of dedicated and fixed position devices. Refer to 18.4.2, Standard Design Feature Descriptions, for descriptions of the HSI design, control, display, and alarm presentation capabilities. In Reference 18H-1, the particular method of design implementation for each control, display and alarm function is indicated in brackets as part of each relevant table entry.

In Reference 18H-1, entries are identified by bold face type and capitalized letters when they are first identified in the analysis as being the primary method of executing a particular control, display or alarm function. Note that a divisional or non-divisional VDU may not necessarily be the primary method of executing a particular control, display or alarm function. An example is the indication of RPV water level as a critical parameter displayed on the fixed mimic panel in the main control room:

(A) RPV WATER LEVEL [FIXED POSITION].

Information given in the brackets indicates the type of implementing device. Since one of the purposes of the control room inventory analysis is to identify a minimum set of fixed control, display, and alarm devices, to minimize needless duplication in table entries, subsequent identification of the same design attribute is indicated in the tables with an underline and is not bold type or capitalized. An example of indication of RPV water level in subsequent steps is:

(a) RPV water level [Fixed Position].

Critical process parameters that are displayed on the fixed position display panel are provided by Class 1E instruments via a non-safety related display controller. For these parameters, they are also available in the divisional Video Display Units (VDUs) and the non-divisional VDUs. Therefore, when a monitoring function is specified (entry conditions and usually the conditional statements of each step of the EPGs) and the primary source of the monitored parameter is identified for the first time as a parameter displayed on the fixed position display panel, the corresponding divisional VDUs and non-divisional VDUs are also included. However, to minimize unnecessary duplication in the table entries, subsequent identification of the same primary monitoring source (fixed display) will not have its corresponding display on divisional VDUs and VDUs identified. As an example, if average drywell pressure display is identified for the first time:

(A) AVERAGE DRYWELL TEMPERATURE

[FIXED POSITION],

(b) Average drywell temperature [Div.VDUs],

(c) Average drywell temperature [VDU].

Subsequent identification of average drywell temperature as a fixed display will be as follows:

(a) Average drywell temperature

[Fixed position].

To further reduce duplicate efforts, table entries which are underlined will not have their instrumentation classification summarized in Reference 18H-1.

In Reference 18H-1, certain information, such as system controls or a system lineup display, is specified in divisional VDUs and non-divisional VDUs. In the case of controls, all remote control equipment of a particular system can be controlled from the VDU. Also certain controls are specified as Mode Switches. An example is the RHR(A) Suppression Pool Cooling Mode Switch. Actuation of a system mode switch will initiate a predefined sequence of system level control actions, such as aligning valves and starting pumps. A system lineup display typically represents a graphical mimic of the system similar to that presented in a system P&ID, where the position of valves, operating status of pumps, and status of other components of the system are indicated. Key system parameters and process parameters are also indicated.

Certain displays in Reference 18H-1 are indicated as being fixed displays. Examples of this type of fixed displays are switch position indication of a standby liquid control pump control switch and mode switch selection indication of RHR shutdown cooling mode. For these examples, process parameters such as standby liquid control pump discharge pressure and RHR flow, respectively, provide sufficient information feedback on actions initiated by the operator. In addition, certain fixed displays such as recirculation pump trip status indication, main turbine stop valve and control valve status indication are not considered to be absolutely required because fixed position alarms are provided which will present the same status information to the operators. These types of fixed position displays are not indicated by bold face type and capitalized letters and hence will not be included as part of the minimum inventory of displays.

In Reference 18H-1, numerical numbers represent typical values. These values should be confirmed by plant-specific calculations and methods and updated if deemed necessary for a particular application of the information presented. Other clarification of the information presented in Reference 18H-1 is indicated by notes. For example, controls located outside of the main control room are indicated by an asterisk and a note.

The inventories of minium controls fixed displays, and fixed alarms necessary based upon the operational analyses of each step of the ABWR EPGs and certain PRA important operator actions are provided in Reference 18H-1 and are summarized in Appendix 18F.

18H.3 Analysis of Changes to EPGs

Prior to the issuance of the design certification for the ABWR, several EPG steps were added by request of the NRC staff to address operator actions associated with ATWS stability. In addition, several EPG Steps were deleted to address NRC staff issues associated with ATWS stability, containment spray, and low pressure venting of the containment. Since the issuance of the design certification for the ABWR, several EPG steps were deleted as a result of the

amended 10 CFR 50.44. These changes and their effect on information and control needs are discussed in this Section.

For ATWS stability, the following EPG Steps were added:

(1) RC/Q-6, first bullet item, “When periodic neutron flux oscillations in excess of [25% (Large oscillation threshold)] peak-to-peak commence or continue, or”. The required information is reactor neutron flux and reactor thermal power which are already included in Reference 18H-1 as fixed position displays.

(2) C5-2: “If any MSL is not isolated, bypass low RPV water level interlocks to maintain the main condenser as a heat sink.” This action has been analyzed previously for Step RC/P-2 Override Statement.

(3) C5-4: “If RPV water level is above [164.9 cm (Maximum Power Control RPV Water Level)] and the reactor is not shutdown, lower RPV water level to below [164.9 cm (Maximum Power Control RPV Water Level)] by terminating and preventing all injection into the RPV except from boron injection systems and CRD.” The lowering of RPV water level and terminating and preventing of injection systems has been analyzed in Step C5-3. The information need of RPV water level has been previously included in analyses of RC/L steps.

To address the containment spray issue, EPG Step PC/P-1, which specifies wetwell spray, has been deleted. The deletion of two fixed position controls (Wetwell Spray Mode Initiation Switch) has been included. Wetwell spray and drywell spray are now combined in Step PC/P-2 and consequently, the fixed position controls formerly labeled as RHR(B) Drywell Spray Mode Initiation Switch and RHR(C) Drywell Spray Mode Initiation Switch are now labeled as RHR(B) Containment Spray Mode Initiation Switch and RHR(C) Containment Spray Mode Initiation Switch, respectively. Finally, EPG Step PC/H-1.3, “If drywell or suppression chamber oxygen concentration are not below 5%, purge the primary containment with air or nitrogen in accordance with [procedure for primary containment purging]”, was deleted since purging of the containment with air after an accident using ACS is not allowed. Deleting this step does not require any changes to the initial control room inventory since the previous step, PC/H-1.2, uses the same information and controls.

Based on the above observations, there are no required changes to the minimum inventory as a result of these changes in the EPGs.

To address 10 CFR 50.44, "Combustible gas control for nuclear power reactors," amended after the issuance of the design certification for the ABWR to eliminate the requirements for hydrogen control systems and the use of the containment hydrogen and oxygen monitoring instrumentation to mitigate a design basis LOCA hydrogen release, the Flammability Control System (FCS) included in the original design certification was eliminated, and the following EPG Steps were deleted:

(1) PC/H, override statement, deleted the phrase "secure and prevent operation of the FCS" from the second bullet.

(2) PC/H-2 and PC/H-3, deleted the phrase "and control" from the step.

(3) PC/H-2.1: "When drywell hydrogen concentration reaches [0.5% (minimum hydrogen concentration for recombiner operation or minimum detectable hydrogen concentration, whichever is higher)] but only if drywell hydrogen concentration is below [6% (maximum hydrogen concentration for recombiner operation or 6%, whichever is lower)] or drywell oxygen concentration is below [5% (maximum oxygen concentration for recombiner operation or 5%, whichever is lower)], and only if suppression pool level is below [11.70 m (elevation of bottom of suppression pool-to-lower drywell vent)], place FCS in service and enter [procedure developed from the RPV Control Guideline] at [Step RC-1] and execute it concurrently with this procedure."

(4) PC/H-2.2: "When drywell hydrogen concentration reaches [6% (maximum hydrogen concentration for recombiner operation or 6%, whichever is lower)] and drywell oxygen concentration reaches [5% (maximum oxygen concentration for recombiner operation or 5%, whichever is lower)], secure FCS operation."

(5) PC/H-3.1: "When suppression chamber hydrogen concentration reaches [0.5% (minimum hydrogen concentration for recombiner operation or minimum detectable hydrogen concentration, whichever is higher)], but only if suppression pool level is below [11.70 m (elevation of bottom of suppression pool-to-lower drywell vent)], and only if drywell hydrogen concentration is below [6% (maximum hydrogen concentration for recombiner operation or 6%, whichever is lower)] or drywell oxygen concentration is below [5% (maximum oxygen concentration for recombiner operation or 5%, whichever is lower)], place FCS in service and enter [procedure developed from the RPV Control Guideline] at [Step RC-1] and execute it concurrently with this procedure."

(6) Secondary Containment Control Guideline, steps SC/T, SC/R, and SC/L, deleted references to "FCS" and "FCS Area" from Table 1.

The ABWR design and other requirements for control of combustible gases satisfy 10 CFR 50.44 as amended. The Atmospheric Control System (ACS) establishes and maintains an inerted containment atmosphere within the primary containment in accordance with Technical Specification 3.6.3.2, "Primary Containment Oxygen Concentration." The drywell and the suppression chamber will be mixed uniformly after the design basis LOCA due to natural convection and molecular diffusion, as described in Tier 2 Subsection 6.2.5.1(6), and mixing will be further promoted by operation of the containment sprays. Equipment for monitoring the concentration of oxygen and hydrogen in the containment atmosphere is described in Tier 2 Subsection 7.5.2.1(k), "Post Accident Monitoring System," and Table 7.5-2, "ABWR PAM Variable List."

As a result of the elimination of hydrogen control systems, corresponding references were removed from the minimum inventory. FCS control switches and FCS room cooler fan controls were deleted from Table 18F-1. Displays for FCS operating status and FCS room cooler operating status were deleted from Table 18F-2.

To address the deletion of the automatic reactor scram and main steam isolation valve (MSIV) closure on high main steam line radiation monitor trip since the issuance of the design certification for the ABWR, the function is no longer included in the RPV Control Guideline entry conditions as a condition which requires reactor scram, and a reference was deleted from the minimum inventory in Table 18F-1, Other Control Functions (associated with MSIV isolation logic bypass). In Tables 18F-2 and 18F-3, the function was relocated from the fixed position displays and alarms to other displays and alarms.

For changes to the Condensate and Feedwater System (CFS) since the issuance of the design certification for the ABWR, the system lineups, status, controls and other devices associated with referenced CFS components include the addition of condensate booster pumps and a fourth feedwater pump. Corresponding changes to the minimum inventory are shown in Table 18F-1, Fixed Position Controls, Nos. 21 through 24, for condensate and reactor pump standby and startup mode initiation switches.

18H.4 References

18H-1 Toshiba Task Report for Supporting Analysis for Emergency Operation Information and Controls, UTLR-0010-P Revision 0.