19Q ABWR Shutdown Risk Assessment

The information in this appendix of the reference ABWR DCD, including all subsections, tables, and figures, is incorporated by reference with the following departures and supplements.

STD DEP T1 2.4-1

STP DEP 1.1-2

STD DEP 8.3-1

STD DEP T1 3.4-1

STP 5.0-1

STD DEP 5.4-1 (Table 19Q-2)

STD DEP 6C-1

19Q.3 Summary of Results

The following site-specific supplement addresses the following departures identified in other sections of the FSAR:

STD DEP T1 2.4-1

STP DEP 1.1-2

STD DEP 8.3-1

STD DEP T1 3.4-1

STP DEP T1 5.0-1

STD DEP 5.4-1

STD DEP 6C-1

As discussed in the following subsections, these departures are either 1) improvements in the design and therefore decrease the CDF relative to the reference ABWR design; or 2) do not affect the CDF. Therefore, the results of the risk evaluation for the reference ABWR design are bounding.

19Q.4.1 Decay Heat Removal

ABWR Features

Other potential heat sinks include the suppression pool (via the safety relief valves), or under certain conditions the Reactor Water Cleanup System, or the Fuel Pool Cooling and Cleanup System (if the reactor water level is raised to the refueling level). As a final method, if the RPV head was removed, bulk boiling of reactor coolant in the RPV with adequate makeup would prevent fuel damage.

STD DEP 5.4-1

The RWCU design includes two 100% pumps instead of the reference ABWR DCD design of two 50% pumps. The two 100% RWCU pumps represent an improvement in the reliability of the RWCU system, and a decrease in shutdown risk.

STD DEP 2.4-1

The RHR design has three RHR loops connected to the FPC instead of two for the ABWR DCD with normally closed inter-ties to permit additional supplemental cooling during refueling outages to reduce outage time.

Increasing the number of RHR loops connected to FPC from two to three results in a decrease in CDF, because it is an improvement of the outage management control for the fuel pool cooling system.

19Q.4.2 Inventory Control

STD DEP 2.4-1

Residual Heat Removal System

The ABWR residual heat removal (RHR) system is a closed system consisting of three independent pump loops (A, B, and C-where B and C are similar) which inject water into the vessel and/or remove heat from the reactor core or containment. Loop A differs from B and C in that its return line goes to the RPV through the feedwater line whereas loop B & C return lines go directly to the RPV. In addition, loop A does not have connections to the drywell or wetwell sprays ~~or a return to the fuel pool cooling system~~. However, for purposes of this analysis, the differences are minor and the three loops can be considered identical. The RHR System has many modes of operation, each mode making use of common RHR System components. Protective interlocks are provided to prevent the most likely interactions of mode combinations.

The RHR design has three RHR loops connected to the FPC instead of two for the ABWR DCD with normally closed inter-ties to permit additional supplemental cooling during refueling outages to reduce outage time.

Increasing the number of RHR loops connected to FPC from two to three results in a decrease in CDF, because it is an improvement of the outage management control for the fuel pool cooling system.

STD DEP 6C-1

The ECCS suction strainer departure meets NRC requirements and does not result in an increase in the shutdown risk profile.

19Q.4.4 Electrical Power

ABWR Features

In the event that one phase of the main transformer were to fail, an installed spare is available to return the preferred source of offsite power to service without the need to procure and deliver a new transformer.

STP DEP 1.1-2

The STP FSAR is for a dual unit site (STP 3 & 4) compared with the ABWR DCD which is for a single unit site. The shared systems between the STP 3 & 4 (e.g., Fire Protection is credited in the shutdown risk evaluation) do not result in any changes to the assessed risk associated with shutdown conditions because the expected frequency for units being in a shutdown condition and requiring backup cooling from the fire protection system is extremely small.

STD DEP 8.3-1

The STP design incorporates two Reserve Auxiliary Transformers (RATs) in place of the ABWR DCD design that has a single RAT. The two RATs afford greater reliability for offsite AC power and therefore, decrease the frequency of a LOOP event.

STD DEP T1 3.4-1

Increasing the number of divisions from three (Div I, II, and III) to four (Div I, II, III, and IV) improves reliability and reduces the probability of mitigation system failure.

19Q.6 Flooding and Fire Protection

Flooding

The following is a site-specific supplement.

Hurricane Risk

The Abnormal Procedure for STP Units 1 & 2, which covers hurricanes and external floods, requires a plant shutdown prior to the arrival on site of hurricane winds in excess of 73 miles per hour. Therefore, the risk of hurricane damage is addressed as part of the shutdown risk evaluation.

Per the STP 3 & 4 external flooding evaluation, the storm surge from a hurricane was determined to result in a water level below plant grade. Similarly, the probable maximum precipitation event would result in a water level onsite that is one-foot below plant grade for Units 3 & 4.

Due to the likely impact on switchyard equipment, the hurricane is modeled to result in an extended loss of offsite power event. Given that the hurricane would not result in a storm surge to threaten additional plant equipment, the hurricane risk is judged to have a small quantitative impact on shutdown risk. In addition, the tornado analysis provided in Section 19.4.2 of the reference ABWR DCD would bound the hurricane analysis with respect to high winds. High winds would also result in an extended loss of offsite power event. With three EDGs available for sources of safety-related AC power, Section 19.4.2 of the reference ABWR DCD identifies that the tornado-induced core damage frequency is small compared to the internal events core damage frequency. The tornado-induced risk is bounded by the internal events LOOP analysis provided in Appendix 19D.4. The onsite fuel oil supply supports seven days of continuous EDG operation to cope with extended LOOP events. In addition, long term fuel supply arrangements are in place to provide fuel oil from offsite sources within seven days. The hurricane-induced risk is insignificant compared to the tornado-induced risk. The ABWR DCD remains bounding for shutdown risk.

In order to reduce the risk in responding to an approaching hurricane, STP 3 & 4 commits to developing a procedure prior to fuel load to cope with impending hurricanes. (COM 19Q-1)

External Flooding Risk

STP DEP T1 5.0-1

Appendix 19R presents the analysis performed for external flooding at STP Units 3 & 4 for power operation. These results are also applicable to shutdown conditions. If external flood barriers are open or removed and cannot be restored prior to high water levels reaching the site, then core damage is assumed. The incremental increase in risk during shutdown due to external flooding is very small due to the fraction of time the plant is in a shutdown condition during a year. The small likelihood of occurrence of an external flood is significantly less than the risk calculated for the ABWR during shutdown conditions. The ABWR DCD remains bounding for shutdown risk.

19Q.7.6 Success Criteria

(1) Decay Heat Removal from RPV

Recovery of the failed RHR System, use of one of the other two RHR Systems (SDC) or the Reactor Water Cleanup (CUW) System (under certain plant conditions) is sufficient for success. The CUW System capacity is temperature dependent and require requires a single both pumps pump and both nonregenerative heat exchangers (the regenerative heat exchangers must be bypassed). In Mode 5, the Fuel Pool Cooling and Cleanup (FPC) System can be used after the reactor cavity is flooded. FPC alone after 10 days is sufficient to remove all the decay heat. Both FPC pumps and heat exchangers and the supporting systems are required. CUW can remove the entire decay heat 8 days after shutdown.

STD DEP 5.4-1

The RWCU design includes two 100% pumps instead of the reference ABWR DCD design of two 50% pumps. The two 100% RWCU pumps represent an improvement in the reliability of the RWCU system, and a decrease in shutdown risk.

STD DEP T1 2.4-1

The RHR design has three RHR loops connected to the FPC instead of two for the ABWR DCD with normally closed inter-ties to permit additional supplemental cooling during refueling outages to reduce outage time.

Increasing the number of RHR loops connected to FPC from two to three results in a decrease in CDF, because it is an improvement of the outage management control for the fuel pool cooling system.

19Q.7.7.1 Loss of RHR Due to Failure in the Operating RHR System

Loss of RHR in Mode 3 or 4

If the main condenser fails or is unavailable, the operator can use the CUW System to remove the decay heat (W2) if the RPV temperature is above 386 K (234°F).

STD DEP 5.4-1

The RWCU design includes two 100% pumps instead of the reference ABWR DCD design of two 50% pumps. The two 100% RWCU pumps represent an improvement in the reliability of the RWCU system, and a decrease in shutdown risk.

Loss of RHR in Mode 5

Figure 19Q-4 shows the event tree for loss of RHR in Mode 5 for 3 - 8 days after shutdown. Figure 19Q-5 shows the event tree for loss of RHR in Mode 5 for the period 8 - 10 days and Figure 19Q-6 shows the event tree for greater than 10 days. The differences in these event trees are that for the period 8 - 10 days CUW alone is success (W2) and beyond 10 days FPC alone (FPC) is success.

STD DEP 2.4-1

The RHR design has three RHR loops connected to the FPC instead of two for the ABWR DCD with normally closed inter-ties to permit additional supplemental cooling during refueling outages to reduce outage time.

Increasing the number of RHR loops connected to FPC from two to three results in a decrease in CDF, because it is an improvement of the outage management control for the fuel pool cooling system.

Table 19Q-1 Success Criteria for Prevention of Core Damage

System(s)	Comment
1 RHR (SDC) or	All times when available.
Main Condenser or	If available, open MSIVs and establish condensate return path to RPV.
CUW or	**If temp 386 K (234°F) or after 8 days (using 21 pumps and using 2 nonregenerative heat exchangers and with regenerative heat exchanger bypassed).**
FPC or	Mode 5 only after 10 days. Both pumps and heat exchangers in each system required.
1 Feedwater + 1 Condensate	High pressure injection.
or	
1 HPCF	High pressure injection.
or	
1 CRD	High pressure injection (After 1 day shutdown. Prior to one day two pumps required).
or	
1 Condensate	Low pressure injection (may need ADS).
or	
1 LPFL	Low pressure injection (may need ADS).
or	
1 AC-Independent Water Addition System	Low pressure injection (may need ADS).