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

STD DEP T1 3.4-1 (Table 19Q-1)

STP DEP 1.1-2

STD DEP 8.3-1

STD DEP T1 2.12-2

STP DEP T1 5.0-1

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

STD DEP 6C-1

STD DEP 10.4-5 (Table 19Q-1, 19Q-2)

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 2.12-2

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 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.4.2 Inventory Control

STD DEP T1 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 2.12-2

Increasing the number of divisions from three (Div I, II, and III) to four (Div I, II, III, and IV) for Class 1E AC Safety-Related Interruptible Instrument Power improves reliability of the safety-related Distributed Control and Information System (DCIS) Division IV, but has no affect on the STP 3&4 PRA.

19Q.6 Flooding and Fire Protection

STD DEP T1 3.4-1

Plant Layout

A major difference between the ABWR and current reactor designs is that due to the ~~multiplexing~~ data communication functions *of plant systems, there is no need for a cable spreading room. This removes a significant source of potential fires that could lead to core damage both during normal plant operation and shutdown conditions.*

Systems

All divisions are present in the control room and this cannot be avoided. The remote shutdown panel provides redundant control of the DHR and ECCS functions from outside of the control room. The controls on the remote shutdown panel are hard wired

to the field devices and power supplies. The signals between the remote shutdown panel and the control room are ~~multiplexed~~ communicated *over fiber optic cables so that there are no power supply interactions between the control room and the remote shutdown panel.*

Flooding

The following is a site-specific supplement.

Many of the features that are designed to mitigate fires also serve to protect the plant from damage due to flooding. Physical separation of safety divisions not only prevents propagation of fires but also restricts or prevents flooding of safety-related equipment. The fire barriers will also prevent water due to flooding from non-divisional sources from entering a divisional area and contain water in the fire area from divisional water sources.

Other aspects of the ABWR design that minimize the risk from flooding are the practice of not routing unlimited sources of water (e.g., service water) through ECCS room areas and ensuring that other large water sources (e.g., suppression pool) can be contained without damaging equipment in more than one safety division if a flood were to occur.

A review has been completed of all ABWR internal flood sources and the results show that during shutdown conditions at least one safety division would be unaffected by water damage for any postulated flood. Features, beside separation, that contribute to this low level of risk are: Adequately sized room floor drains, water level alarms and automatic isolation of flood sources for potentially affected roooms, mounting motors and other electrical equipment at least 20.32 cm above foor level, and using watertight doors. As ~~was~~ discussed under fire protection, administrative controls will be implemented to assure that at least one safety division with intact barriers is available at all times during plant shutdown. In the ECCS rooms, *~~The~~ the seals on the doors seat with water pressure from floods outside the room,* which act to minimize leakage past the seals. *With the watertight doors dogged closed, ~~but~~ only a small leakage past the seals is expected from flooding in the ~~ECCS~~ room. Therefore, during shutdown if maintenance tasks require breaching the barriers of two divisions, flooding in the intact division will not cause damage to equipment in all three divisions.* For Reactor Service Water (RSW) pump house floods, the watertight doors for the pump rooms and electrical equipment rooms are capable of withstanding floods from either direction. *Additional detail on the ABWR flood mitigation capability is contained in Appendix 19R*.

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. The events considered include: The cascading failure of upstream dams on the Colorado River; probable maximum precipitation (PMP) events; main cooling reservoir breach; tsunamis, etc. The breach of the main cooling reservoir is the design basis flood for STP Units 3 & 4. The cascading failure of upstream dams

on the Colorado River scenario and the PMP scenario result in water level slightly above grade, but less than the flood level due to the main cooling reservoir breach, and are much more slowly developing floods. 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. An operating procedure for severe external flooding will be developed and implemented prior to fuel loading. (COM 19.9-3).

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 and the small likelihood of occurrence of an external flood 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

STD DEP 10.4-5

If the failed RHR System cannot be recovered, the operatior could initiate one of the other two RHR Systems, if available, in the shutdown cooling mode (R). If all RHR Systems fail, the RPV would pressurize and the main condenser could be made

available (V2) by opening the MSIVs, drawing a vacuum in the condenser, and operating the feedwater, condensate booster *and condensate pumps for makeup.*

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 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.

Table 19Q-1 ABWR Features That Minimize Shutdown Risk

Category	Feature	Shutdown Risk Capability
Decay Heat Removal (DHR)	*Remote Shutdown Panel (Two Divisions)*	*Cold Shutdown can be achieved and maintained from outside the control room if the control room is uninhabitable due to fire, toxic gas, or other reasons. The remote shutdown panel is powered by Class 1E power to ensure availability following a Loss Of Preferred Power (LOPP). Controls are hard wired and thus not dependent on ~~multiplexing~~* data communication *systems. A minimum set of monitored parameters and controls are included to ensure the ability to achieve and maintain cold shutdown.*

Table 19Q-1 ABWR Features That Minimize Shutdown Risk (Continued)

Category	Feature	Shutdown Risk Capability
Reactor Inventory	*Feedwater, Condensate Booster, and Condensate Pumps*	~~Three~~ Four *electric driven pumps that can be used during shutdown for makeup.*
	High Pressure/Low Pressure Interlocks	*Controls position of RHR valves to ensure that the RHR is not exposed to pressures in excess of its design pressure.*
	Makeup Sources	*Multiple sources of RPV makeup are potentially available while the plant is shutdown (e.g., main condenser hotwell, condensate storage tank, suppression pool, control rod drive system, AC-independent Water Addition System.*
	No Recirculation Piping	*Elimination of Recirculation piping external to RPV reduces probability of LOCA during normal operations and while shutdown.*
	RPV Level Indication	*Permanently installed RPV water level indication for all modes of shutdown. Redundant sensors use two-out-of-four logic configuration to ensure high reliability.*
Containment Integrity	*Containment*	*Reinforced concrete structure surrounds RPV to withstand LOCA loads and contain radioactive products from potential accidents during hot shutdown. Secondary containment permits isolation and monitoring all potential radioactivel leakage from the primary containment.*
	Standby Gas Treatment System	*Removes and treats contaminated air from the secondary containment following potential accidents.*
	Reactor Building Isolation Control	*Automatically closes isolation dampers on detection of high radiation. These dampers are potential leakage paths for radioactive materials to the environs following breach of nuclear system barriers or a fuel handling accident.*

Table 19Q-1 ABWR Features That Minimize Shutdown Risk (Continued)

Category	Feature	Shutdown Risk Capability
Electrical Power	*3 Diesel Generators*	*One diesel for each safety division. Independent, both electrically and physically, of each other to minimize common mode failure. Allows for diesel maintenance while still maintaining redundancy.*
	Combustion Turbine Generator	*Redundant and diverse means of supplying power to safety and non-safety buses in event of loss of offsite power and diesel generator failures.*
	2 Sources of Offsite Power	*Reduces risk of LOPP due to equipment failure or operator error.*
	Electrical Cable Penetrations	*Will prevent propagation of fire damage and water from postulated flooding sources.*
	4 Divisions of DC Power	*Electrically and physically independent. Includes batteries and charges. Diverse means of electrical power for control circuits and emergency lighting.*

Table 19Q-1 ABWR Features That Minimize Shutdown Risk (Continued)

Category	Feature	Shutdown Risk Capability
Flooding Control	*Flood monitoring and Control*	*Reactor* building, control building, RSW pump house, *and turbine building flooding is monitored and alarmed in the control room. This alerts the operator to potential flooding during shutdown. Many flood sources (e.g., HVAC, EDG Fuel) are relatively small volume and are self limiting. Operation of the fire water system is alarmed in the control room to help the operator differentiate between a break in the fire water system and the need to extinguish a fire. Larger sources are mitigated by means of, equipment mounted at least 20.32 cm off the floor, floor drains, watertight doors, pump trips, valves closing, ~~anti-siphon capability,~~ or operator actions except at the steam tunnel interface.*
	Room Separation	*The three divisions of ECCS are physically separated and self contained within flooding resisitant walls, floors, and doors. ECCS wall penetrations located below the highest potential flood level in the reactor building first floor corridor will be sealed to prevent water entering the ECCS room from the corridor. No external potential flooding sources are routed through the ECCS rooms and potential flooding sources in other rooms will not overflow into the ECCS rooms and cause damage to ECCS electrical equipment. If ECCS flood barriers must be breached during shutdown, administrative controls ensure that at least one ECCS division is operable and all barriers in that division are maintained intact.* RSW pump house divisions are separated into separate flood protected divisions. If RSW flood barriers must be breached during shutdown, administrative controls ensure that at least one RSW division is operable and all barriers in that division are maintained intact.
Fire Protection	~~*Multiplexed systems*~~ Data Communication Functions	*Eliminates the need for a cable spreading room which is a major fire concern in most plants.*

Table 19Q-2 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~~ 1 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 Booster + 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).