Response to

Request for Additional Information No. 66(1142), Revision 0

9/09/2008

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 19.01 - Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed
Application Section: 19.1.5.3
SPLA Branch

Question 19.01-18:

Generally, in performing fire analysis, the internal events (IEs) PRA human error probabilities (HEPs) included in the fire scenario quantification must reflect equipment/indication losses, fire induced stress, communications difficulties, availability of lighting, potential impacts from smoke and heat, etc. Please describe the method used to re-examine and modify the IEs PRA HEPs to account for the potential impacts of fire events.

Response to Question 19.01-18:

Probabilistic risk assessment (PRA) HEPs included in the fire scenario quantification were modeled as described below:

- HEPs are doubled for the fire scenario modeling the main control room (MCR) fire to account, as stated in the question, for the stress associated with the MCR fire and the MCR evacuation, potential impacts from smoke and heat, limited equipment/indication availability, and possible communications difficulties. Double HEPs are based on a simple doubling of the stress-related performance shaping factors (PSF).
- HEPs for the fire scenario outside the MCR are not changed. The impact of the fires outside of the MCR on the operator performance was not evaluated as being significant enough to change HEP values, based on the following considerations: (i) all operator actions credited in these fire scenarios are performed from the MCR; no local actions are credited, (ii) equipment/indication losses are not significant for these scenarios, (iii) fire induced stress and communications difficulties for the fires outside of the MCR are considered to be limited, (iv) the impact of the fires outside of the MCR on the smoke and heat in the MCR or the availability of lighting is not considered likely.

Similar to the internal events, HEP sensitivity studies, shown in the U.S. EPR FSAR Tier 2, Table 19.1-15, the fire-related code damage frequency (CDF) sensitivity case is summarized below:

Fire CDF (base case) = 1.8E-7/yr

Fire CDF (sensitivity case: all HEPs set to 95%) = 4.7E-7/yr

Delta increase = 168%.

Compared to similar results for the internal events, presented in the U.S. EPR FSAR Tier 2, Table 19.1-15, where the corresponding delta increase is 257%, the fire scenarios are less sensitive to the HEP values.

FSAR Impact:

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

Question 19.01-19:

FSAR, Page 19.1-135, last paragraph indicates that fire scenarios are quantified using the same event tree logic used in the Level 1 internal events evaluation, however it doesn't specifically identify the event tree. For each analyzed scenario, please identify the conditional fire event tree used to quantify the fire CDF and provide the basis for selection.

Response to Question 19.01-19:

Fire scenarios are quantified using the event trees from the Level 1 internal events PRA. The choice of an event tree to represent a specific fire scenario is based on the similarity in the expected plant response. For example, fire scenarios that result in a partial or complete loss of a division (e.g., Fire-SB14-AC, Fire-SB23-DC) are modeled via the 31BDA (loss of divisional AC) event tree. Fire-specific induced system unavailabilities associated with each initiating event/scenario are modeled explicitly in the fault trees by applying the modeling approach described in the response to RAI 53, Question 19-209 (for LOCCW initiators).

In summary, fire scenarios that are modeled to induce a specific plant response (general transient, LBOP, LOCCW, LOCA, spurious opening of an MSSV) are quantified using the appropriate event tree, with additional mitigating unavailabilities if necessary. Table 19.01-19-1 shows the corresponding fire scenarios and event trees (ET), as well as the fire-induced system unavailabilities for each scenario.

Table 19.01-19-1—Event Trees Used to Quantify Fire Scenarios (2 Sheets)

Fire Scenario	Description	Event Tree	Effects on mitigating systems
Fire-SB14-AC	Fire in Switchgear Room of Safeguard Building 4 (or 1)	31BDA (Loss of divisional AC)	All class 1E and non class 1E AC Buses in SB4 unavailable.
Fire-SB23-AC	Fire in Switchgear Room of Safeguard Building 2 (or 3)	31BDA	All class 1E and non class 1E AC Buses in SB2 unavailable.
Fire-SB14-DC	Fire in the DC Cabinets Room of Safeguard Building 4 (or 1) - I&C rooms included	31BDA	All class 1E and non class 1E DC and I&C Buses in SB4 unavailable.
Fire-SB23-DC	Fire in the DC Cabinets Room of Safeguard Building 2 (or 3) - I&C rooms included	31BDA	All class 1E and non class 1E DC and I&C Buses in SB2 unavailable.
Fire-SB-MECH	Fire in the Pump Room of Any Safeguard Building	31BDA	EFW4, CCWS4, CCW CH2, MHSI4, LHSI4, SAHR unavailable

Table 19.01-19-1—Event Trees Used to Quantify Fire Scenarios (2 Sheets)

Fire Scenario	Description	Event Tree	Effects on mitigating systems
Fire-MS-VR	Fire on the top of SB 4 (or 1), in the MFW/MS valve room	MSSV (Spurious opening of a main steam safety valve)	Spurious opening of MSRT on SG4, an increase in the probability of MS isolation failure on SG4 and SG3
Fire-FB	Fire in the Fuel Building	GT (General Transient)	CVCS trains 1 and 2 and EBS trains 1 and 2 unavailable
Fire-TB	Fire in the Turbine Building	LBOP (Loss of Balance of Plant)	MFW and SSS unavailable
Fire-SWGR	Fire in the Switchgear Building	LBOP	SBO DGs, 12 hr battery and non-class 1E 2 hr battery, and all non class 1E buses unavailable.
Fire-BATT	Fire in one of the 4 Battery Rooms	31BDA	2-hr Battery Div 4 unavailable
Fire-ESW	Fire in the Essential Service Water Building	LOCCW (Loss of Component Cooling Water)	UHS4 unavailable.
Fire-xFYard	Fire in the transformer yard	GT	Loss of one class 1E transformer.
Fire-CSR	Fire in the Cable Floor (Room under the MCR)	31BDA	All Div 4 control power unavailable
Fire-MCR	Fire in the Main Control Room	A dedicated single event tree transferring to LBOP	Failure to transfer to RSS results in core damage; success transfers to the LBOP event tree with all HEPs doubled
Fire-PZR	Fire in the pressurizer compartment	SLOCA	Primary bleed unavailable

FSAR Impact:

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

Question 19.01-20:

As discussed in the U.S. EPR fire assessment, a fire in a PRA fire area (PFA) is assumed to disable all components located within that area. Please clarify whether damage to each cable routed through that area would have an impact on components located outside the PFA.

Response to Question 19.01-20:

Based on the basic concepts of cable routing, the fire scenarios are defined such that damages to cables routed through a specific PFA would either have no impact on components located outside of the PFA, or their impact is implicitly modeled in the fire scenario, as illustrated by the following examples:

- Within a single Safeguard Building, cables are routed from the switchgear and I&C rooms via cable floors and ducts (part of PFA-SB14-AC) to the mechanical components. Therefore, a fire in PFA-SB14-AC could damage cables that power components located in the mechanical area (PFA-SB-MECH). This effect is taken into account because the switchgear that powers the cables will be failed by the fire.

- Cables originating in one division safeguard building and powering equipment in a different division safeguard building, or in the Fuel Building, are routed through the annulus and do not travel through any other PFAs. Cables routed to or from the buildings other than the Safeguard Buildings (i.e., Switchgear Building, Emergency Diesel Generator (EDG) Building) will travel from their PFA of origin to their PFA of destination in separate underground conduits. Traveling through a third PFA will not occur.

The PRA assumptions will be reevaluated, if necessary, when detailed cable routing information is available. If necessary, updates to the PRA are performed in accordance with the PRA maintenance and upgrade process described in U.S. EPR FSAR Tier 2, Section 19.1.2.4. COL item 19.1-9 listed in U.S. EPR FSAR Tier 2, Table 1.8-2—U.S. EPR Combined License Information Items is provided to confirm that assumptions used in the PRA remain valid for the as-to-be-operated plant.

FSAR Impact:

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

Question 19.01-21:

For consistency purposes, please correct all valve room identifiers (i.e., MS/MFW, MFW/MS, MS/MF, MS/FS, and MFWS/MSS) to one name (e.g., FSAR Pages 19.1.135, 19.1.137, etc.).

Response to Question 19.01-21:

For consistency, the U.S. EPR FSAR will be revised so that all valve room identifiers are written as “MFW/MS”.

FSAR Impact:

U.S. EPR FSAR Tier 2 Sections 19.1.5.2.1.2, 19.1.5.3.1.2, 19.1.5.3.2.2, 19.1.5.3.2.3, and Tables 19.1-62, 19.1-63, 19.1-64, 19.1-66, 19.1-74, 19.1-76, 19.1-104 will be revised as described in the response and indicated in the enclosed markup.

Question 19.01-22:

For the MS/MF valve room fire scenario, please provide the basis for the probabilities of 0.1 and 0.5 of main steam isolation failures on steam generators 3 and 4, respectively.

Response to Question 19.01-22:

In the MFW/MS valve room fire scenario, all valves in the room (including the main steam isolation valves (MSIV)) are assumed to be affected. The probabilities of 0.1 and 0.5 are estimates of the probability of a specific failure mode: fail open.

The fire scenario assumes the spurious opening of a main steam relief isolation valve (MSRIV). The consequences of a spurious opening of an MSRIV are higher if additional steam generators (SG) are not isolated, which would occur if the associated MSIVs fail to close. Given a fire that causes a spurious opening of an MSRIV in Division 4, the conditional probabilities that the Division 4 and Division 3 MSIVs (located on top of the same safeguard building) will fail open are estimated to be:

- 0.5 for the nearest Division 4 MSIV.
- 0.1 for Division 3 MSIV, which is separated by a wall.

These PRA assumptions will be reevaluated, if necessary, when combustible loads and actual spatial arrangements are known. If necessary, updates to the PRA are performed in accordance with the PRA maintenance and upgrade process described in U.S. EPR FSAR Tier 2, Section 19.1.2.4. COL item 19.1-9 listed in U.S. EPR FSAR Tier 2, Table 1.8-2—U.S. EPR Combined License Information Items is provided to confirm that assumptions used in the PRA remain valid for the as-to-be-operated plant. The assumed probabilities are conservative based on the following:

- The MSIVs are designed to fail closed on loss of power; therefore, the most likely failure mode for the valve should be to fail closed.
- Due to the distance between the MSRIV and the nearest MSIV, a small MSRIV motor fire (low combustible) is not likely to propagate to the associated MSIV. Additionally, Division 4 MSRIV and Division 3 MSIV are separated by a wall and a larger distance, making this propagation even less likely.

In addition, a design change not included in the U.S. EPR FSAR PRA added a fire barrier between Divisions 4 and 3 (similar to Divisions 1 and 2) valve rooms. With this change, the two valve rooms can be evaluated as two separate fire areas, and the probability of a fire affecting the MSIV in the next division can be set to zero.

Two sensitivity cases are provided in U.S. EPR FSAR Tier 2, Table 19.1-74 (cases 12a and 12b) to study the impact of the values chosen for these two factors.

FSAR Impact:

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

Question 19.01-23:

Please provide the basis for the assumption on FSAR, Page 19.1.135 (first paragraph) that for the transformer yard and MS/MFW valve room, the transient contributions would be very limited.

Response to Question 19.01-23:

In the U.S. EPR FSAR Fire Risk Evaluation, for the three fire areas where component-specific fire frequencies are used, which includes the transformer yard and MFW/MS valve room, it was assumed that the transient contributions would be very limited and therefore could be excluded from the total fire frequency. This assumption is based on an engineering judgment that it is unlikely that transient combustibles would be present or stored in these two areas because maintenance activities at power are not expected there and these areas are not on the access paths to the other areas.

These PRA assumptions will be reevaluated, if necessary, when maintenance procedures and plant-specific experience are available. If necessary, updates to the PRA are performed in accordance with the PRA maintenance and upgrade process described in U.S. EPR FSAR Tier 2, Section 19.1.2.4. COL item 19.1-9 listed in U.S. EPR FSAR Tier 2, Table 1.8-2—U.S. EPR Combined License Information Items is provided to confirm that assumptions used in the PRA remain valid for the as-to-be-operated plant.

FSAR Impact:

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

Question 19.01-24:

Given limited information available on cable routing during the design phase, please discuss how the electrical hot shorts were analyzed.

Response to Question 19.01-24:

For each fire in the selected fire area, it was assumed that all equipment located in the area, and all the cable routed through the area, are failed. An analysis of hot shorts would not affect the conservatism of this analysis, if these hot shorts would not have an additional negative impact on the plant mitigating ability. The hot shorts that could have a significant impact on the plant response, and areas where these hot shorts could occur, are identified in the analysis and their frequency estimated. Conditional probabilities of hot shorts in the event of a fire are used; representative values for a motor-operated valve and for a solenoid-operated valve are obtained from NUREG/CR-6850, Appendix J, as shown in the response to Question 19.01-29.

Hot shorts are analyzed for two areas: a spurious opening of a main steam relief train (MSRT) by a fire in the MFW/MS valve room and a spurious opening of a pressurizer safety valve (PSV) or primary depressurization system (PDS) train by a fire in the pressurizer area. Multiple hot shorts are needed for both these openings. Spurious system actuation is not analyzed for the fires in the MCR because the fiber optic cables in this area are not considered susceptible to hot shorts.

FSAR Impact:

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

Question 19.01-25:

The discussion on FSAR, Pages 19.1-135 and 19.1-136 reads as follows:

"A different value was used for consequential LOOP for fire events leading to a controlled shutdown. The value is estimated based on the value for the consequential LOOP leading to auto scram, reduced by a factor of five. The reduction is based on an estimate that 20 percent of fire initiators leading to a controlled shutdown may result in an automatic plant trip."

Should the LOOP for fire events lead to a controlled shutdown or an automatic plant trip? Also, should the 2nd sentence reference the consequential LOOP leading to auto scram or a controlled shutdown?

Response to Question 19.01-25:

Any loss of offsite power (LOOP) event leads to an automatic plant trip. The U.S. EPR FSAR citation in this Question refers to a LOOP after a trip (a consequential LOOP) that occurs as a result of a fire event requiring a controlled shutdown. A consequential LOOP is not likely to occur when a controlled shutdown proceeds as planned; it is assumed to occur only if a controlled shutdown results in an auto scram. The U.S. EPR FSAR citation in this Question states that for fire events leading to a controlled shutdown, the consequential LOOP probability is different than for the non-fire internal events leading to a controlled shutdown. Probability of this consequential LOOP is estimated based on the percentages of the fire-related controlled shutdowns that result in auto scram, as discussed in the response to Question 19.01-46.

This discussion can be illustrated in the following example: In the event of a fire in a Safeguard Building (SB) DC Switchgear Room, operators may decide to shut the plant down. While they are in the process of shutting down, an unplanned auto scram may occur, leading to a LOOP event. As discussed in the response to Question 19.01-44, these consequential LOOP events are not fire related; they happen as a result of an unexpected auto scram during a controlled shutdown.

For the fire events that lead to an automatic plant trip, the value used for the consequential LOOP probability is the same as for the other internal events that lead to an automatic plant trip.

FSAR Impact:

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

Question 19.01-26:

FSAR, Section 19.1.5.3.2.1, what is the basis for comparing to 1E-6/yr?

Response to Question 19.01-26:

The value of 1E-6/yr was not intended as a comparison value, and there are no associated regulatory or U.S. EPR related goal bases for comparison of the fire core damage frequency (CDF) (1.8E-7/yr to 1E-6/yr). Similar to the other probabilistic risk assessment (PRA) metrics sections, the 1E-6/yr value is identified as a general upper CDF bracket (1E-7, 1E-6).

FSAR Impact:

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

Question 19.01-27:

Please provide justification for the use of RES/OERAB/S02-01 fire ignition method to derive U.S EPR fire frequencies instead of NUREG/CR-6850.

Response to Question 19.01-27:

The use of NUREG/CR-6850 fire ignition frequencies require a detailed knowledge of all the components located in a fire area, as well as the total number of components in the plant. Such information is not fully available at this stage of the design. Therefore, the RES/OERAB/S02-01 method was selected, which is based on the type of locations instead of using fire frequencies for all the components at the specific location.

For locations that did not match any location included in the RES/OERAB/S02-01 method, the component-based method from NUREG/CR-6850 was used with appropriate assumptions, as addressed in the responses to Questions 19.01-29 and 19.01-37.

Therefore, the U.S. EPR fire initiating event frequencies are judged to be reasonable and, if necessary, can be re-evaluated when updates to the PRA are performed in accordance with the PRA maintenance and upgrade process described in U.S. EPR FSAR Tier 2, Section 19.1.2.4. COL item 19.1-9 listed in U.S. EPR FSAR Tier 2, Table 1.8-2—U.S. EPR Combined License Information Items is provided to confirm that assumptions used in the PRA remain valid for the as-to-be-operated plant.

FSAR Impact:

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

Question 19.01-29:

Please describe how fire area PFA-CNTMT frequency of 1.9E-5/yr was estimated (e.g., selecting fixed ignition sources, applying correction/weighting factors, etc.) and justify the exclusion of transient ignition frequency.

Response to Question 19.01-29:

The containment PFA is treated differently from other PFAs. Due to the large size and small combustible loading of the PFA, a fire that would affect all components is not postulated. Instead, a specific analysis of vulnerable locations is performed. Reactor coolant pump fires due to oil leakage have been the source of most fires in-containment in operating history. Due to the specific oil collecting system described in U.S. EPR FSAR Tier 2, Section 5.4.1.2.2, it was concluded that this event could not occur in the U.S. EPR. Reactor coolant pump fires are therefore not analyzed as a credible fire scenario. A scenario involving a spurious opening of a pressurizer valve was chosen to represent fires in the containment.

The frequency of 1.9E-05/yr applies to the fire scenario “fire in the pressurizer compartment,” which assumes the spurious opening of one of three pressurizer safety valves or both MOVs on one of the two primary depressurization system (PDS) trains. It is obtained by multiplying the area ignition frequency of 4.9E-05/yr by the conditional probability of a hot short induced spurious operation of the above pressurizer valves/train.

The pressurizer compartment does not match any of the locations for which RES/OERAB/S02-01 provides ignition frequencies. Therefore, the ignition frequency of 4.9E-05/yr is estimated using the NUREG/CR-6850 method, based on the number of components in the area that present potential ignition sources. (The response to Question 19.01-27 provides the justification for the use of the RES/OERAB/S02-01 fire ignition method.)

The main sources of ignition identified in the pressurizer compartment are electric motors that operate the multiple valves located in the compartment (e.g., safety valves, nitrogen sweep isolation valves, degasification line isolation valves). The generic frequency of fires caused by electric motors is multiplied by the ratio of electrical motors in the area and the estimated total number of electrical motors in the plant. Table 19.01-29-1 shows the details of the calculation.

The conditional probability of a spurious actuation in the event of a fire is calculated for the considered pressurizer valves (3 pressurizer safety relief valves (PSRVs), and 2 pressurizer depressurization system (PDS) motor operated valves (MOVs). Each PSRV is powered through two different divisions that are routed to two pilot solenoid operated valves (SOVs). Spurious opening of the valve could occur only if two simultaneous hot shorts occur in two trains. Similarly, in order to open a primary depressurization train, two simultaneous hot shorts have to occur for two MOVs in series that are supplied from two different divisions. From NUREG/CR-6850, Appendix J, the probability of one hot short is assumed to be 0.33 for SOVs and 0.17 for MOVs. For two simultaneous hot shorts, these probabilities become 0.33 * 0.33 = 0.11 and 0.17 * 0.17 = 0.029.

The frequency of a fire with a valve opening is 1.9E-05/yr; it is calculated as the sum of the contributions from PSRVs (SOVs) and the PDS MOVs, as shown in Table 19.01-29-2.

Table 19.01-29-1—Fire Ignition Frequency for the Pressurizer Compartment

Location	Ignition Source	Generic Frequency (per year)	Factor of the components on the location vs. the total components in the plant.	Plant-Specific Frequency (per year)
Pressurizer Compartment	Electric Motors – plant-wide	4.6E-03	0.011	4.9E-05

Table 19.01-29-2—Frequency of a Fire Scenario in the Pressurizer Compartment with One Train Spurious Opening

Trains Considered	Compartment Fire Ignition Frequency (per year)	Hot Short Probability for the Corresponding Valve	Number of hot shorts needed to open the train	Number of Trains	Spurious opening frequency (per year)
PZR PSRV (SOVs)	4.88E-05	0.33	2	3	1.6E-05
PZR PDS Train (2 MOVs in series)	4.88E-05	0.17	2	2	2.8E-06
		Total Spurious Opening Scenario Frequency			**1.9E-05**

FSAR Impact:

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

Question 19.01-30:

Please provide more details on the correction factors (e.g., ratios and bases) used to adjust PFA fire frequencies as shown in FSAR, Table 19.1-63.

Response to Question 19.01-30:

Correction factors shown in U.S. EPR FSAR Tier 2, Table 19.1-63 include correction factors applied to generic frequencies derived from RES/OERAB/S02-01 as well as the ratios applied to component-specific ignition frequencies following the NUREG/CR-6850 method. The latter are explained in more detail in the responses to Questions 19.01-29 (Pressurizer Compartment) and 19.01-37 (MFW/MS valve room) and are not addressed here.

Three different types of correction factors that are applied to generic frequencies derived from RES/OERAB/S02-01 are defined below:

- Correction Factor 1 (CF1) is a ratio of the number of analyzed PRA fire areas (PFAs) (usually one), over the total number of the PFAs in the same location bin, in the U.S. EPR.
- Correction Factor 2 (CF2) accounts for the specificity of the U.S. EPR with respect to the existing plants that are used as a data base for the generic frequencies in the RES/OERAB/S02-01.
- Correction Factor 3 (CF3) is used to further divide the electrical busses fire ignition frequencies between AC and DC switchgear rooms.

Table 19.01-30-1 shows the details of the calculation of the fire ignition frequencies for the PFAs shown in U.S. EPR FSAR Tier 2, Table 19.1-63, including the values assigned for all correction factors (CF1, CF2 and CF3) and the basis for these values.

Table 19.01-30-1—Correction Factors Used in the U.S. EPR FSAR Table 19.1-63 (4 Sheets)

PRA Fire Area	PFA Description	Corresponding Room in RES/OERAB	Generic Room Fire Ignition Frequency	CF1 (locations)		CF2 (EPR specificity)		CF3 (AC/DC buses)		PFA Fire Ignition Frequency
				CF1	Basis for CF1	CF2	Basis for CF2	CF3	Basis for CF3	
PFA-SB4-MECH	Pump Room of Safeguard Building 4	Aux. Building	2.70E-02	0.17	1 out of 6 locations (4SBs, Nuclear Auxiliary Building, Fuel Building)	1.1	Estimated 10% more pumps than typical operating plant	N/A		5.0E-03
PFA-SB4-AC	AC Switchgear Room of Safeguard Building 4	Switchgear Room	5.10E-03	0.17	1 out of 6 switchgear rooms (4 electrical divisions + 2 non-safety electrical trains)	1.5	Estimated 50% more electrical buses than typical operating plant	0.8	Estimated 80% of electrical buses are AC buses	1.0E-03
PFA-SB4-DC	DC Switchgear Room of Safeguard Building 4	Switchgear Room	5.10E-03	0.17	1 out of 6 switchgear rooms (4 electrical divisions + 2 non-safety electrical trains	1.5	Estimated 50% more electrical buses than typical operating plant	0.2	Estimated 20% of electrical buses are DC buses	2.6E-04
PFA-SB2-AC	AC Switchgear Room of Safeguard Building 2	Switchgear Room	5.10E-03	0.17	1 out of 6 switchgear rooms (4 electrical divisions + 2 non-safety electrical trains	1.5	Estimated 50% more electrical buses than typical operating plant	0.8	Estimated 80% of electrical buses are AC buses	1.0E-03

Table 19.01-30-1—Correction Factors Used in the U.S. EPR FSAR Table 19.1-63 (4 Sheets)

PRA Fire Area	PFA Description	Corresponding Room in RES/OERAB	Generic Room Fire Ignition Frequency	CF1 (locations)		CF2 (EPR specificity)		CF3 (AC/DC buses)		PFA Fire Ignition Frequency
				CF1	Basis for CF1	CF2	Basis for CF2	CF3	Basis for CF3	
PFA-SB2-DC	DC Switchgear Room of Safeguard Building 2	Switchgear Room	5.10E-03	0.17	1 out of 6 switchgear rooms (4 electrical divisions + 2 non-safety electrical trains	1.5	Estimated 50% more electrical buses than typical operating plant	0.2	Estimated 20% of electrical buses are DC buses	2.6E-04
PFA-FB	Fuel Building	Aux. Building	2.70E-02	0.17	1 out of 6 locations (4SBs, Nuclear Auxiliary Building, Fuel Building)	1.1	Estimated 10% more pumps than typical operating plant	N/A		5.0E-03
PFA-CSR	Cable Floor [Cable Spreading Room]	Cable Spreading Room	8.40E-04	N/A		0.5	Estimated 50% reduction factor due to fiber optic cables	N/A		4.2E-04
PFA-MCR	Main Control Room	Main Control Room	7.20E-03	N/A		0.5	Estimated 50% reduction factor due to fiber optic cables	N/A		3.6E-03
PFA-ESW4	ESW Cooling Tower Structure, Division 4	SWS Pumphouse	7.20E-03	0.25	1 out of 4 locations (4 ESW trains)	2	Estimated twice as many ESW trains	N/A		3.6E-03

Table 19.01-30-1—Correction Factors Used in the U.S. EPR FSAR Table 19.1-63 (4 Sheets)

PRA Fire Area	PFA Description	Corresponding Room in RES/OERAB	Generic Room Fire Ignition Frequency	CF1 (locations)		CF2 (EPR specificity)		CF3 (AC/DC buses)		PFA Fire Ignition Frequency
				CF1	Basis for CF1	CF2	Basis for CF2	CF3	Basis for CF3	
PFA-BATT4	Safety Battery Room	Battery Room	8.40E-04	0.17	1 out of 6 battery rooms (4 electrical divisions + 2 non-safety electrical trains)	2	Estimated twice as many battery rooms	N/A		2.8E-04
PFA-SWGR	Switchgear Building	Switchgear Room	5.10E-03	0.33	2 out of 6 switchgear rooms (4 electrical divisions + 2 non-safety electrical trains) in the switchgear building	1.5	Estimated 50% more electrical buses than typical operating plant	N/A		2.5E-03 + 5.6E-04 = **3.1E-03**
		Battery Room	8.40E-04	0.33	2 out of 6 battery rooms are in the switchgear building (non-safety trains)	2	Estimated twice as much battery rooms	N/A		
PFA-TB	Turbine Building	Turbine Building	4.10E-02	N/A		N/A		N/A		4.1E-02
PFA-xF YARD	Transformer Yard	NUREG/CR-6850 method used		N/A		N/A		N/A		7.2E-03
PFA-VLVR4	MFW/MSW Valve Room, Train 4	NUREG/CR-6850 method used		N/A		N/A		N/A		2.6E-05

Table 19.01-30-1—Correction Factors Used in the U.S. EPR FSAR Table 19.1-63 (4 Sheets)

PRA Fire Area	PFA Description	Corresponding Room in RES/OERAB	Generic Room Fire Ignition Frequency	CF1 (locations)		CF2 (EPR specificity)		CF3 (AC/DC buses)		PFA Fire Ignition Frequency
				CF1	Basis for CF1	CF2	Basis for CF2	CF3	Basis for CF3	
PFA-CNTMT	Containment, pressurizer area	NUREG/CR-6850 method used		N/A		N/A		N/A		1.9E-05

FSAR Impact:

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

Question 19.01-31:

FSAR, Page 19.1-133 indicates that the fire areas (FAs) defined in the Fire Hazard Analysis (FHA) were grouped into a limited number of PRA fire Areas (PFAs) that contain SSCs modeled in the PRA analysis. Please explain why Emergency Power Generating Buildings are excluded from the PFAs list.

Response to Question 19.01-31:

Emergency Power Generating Buildings are excluded from the fire risk evaluation based on the impact of the plant response:

- No initiating event.
- The plant impact is limited to the loss of one emergency diesel generator (EDG) train (fire frequency would be a negligible impact on the total train unavailability as addressed below).

With fire frequency from RES/OERAB/S02-01 for Emergency Power Generating Building equal to 7E-3/yr, the probability of losing an EDG due to a fire during the 24 hours mission time would be equal to 2E-5. That value is negligible compare to EDG non-fire-related unavailability: EDG failure to start equal to 4.4E-3 and EDG failure to run for 24 hours equal to 2.8E-2.

The U.S. EPR FSAR will be updated to include a description of the basis for excluding fires from the fire evaluation for the Emergency Power Generating Buildings and Nuclear Auxiliary Building.

FSAR Impact:

U.S. EPR FSAR, Tier 2 Section 19.1.5.3.1.2 will be revised as described in the response.

Question 19.01-33:

Please identify the conservative assumptions that were made for the fires in MSS/MFWS valve room as mentioned on FSAR, Page 19.1-137.

Response to Question 19.01-33:

Modeling of the MFW/MS valve room scenario is discussed in the response to Question 19.01-22. The conservatism in assumptions mentioned in U.S. EPR FSAR Tier 2, Page 19.1-137 is based on the modeling of the two main steam isolation valve (MSIV) failures to close. The estimated probabilities of the fire-related failures to close two MSIVs located in the valve room are judged to be conservative based on the following:

- The MSIVs are designed to fail closed on loss of power, therefore the most likely failure mode for the valve should be to fail closed.
- Due to the distance between the Division 4 main steam relief isolation valve (MSRIV) (i.e., fire ignition source) and the nearest MSIV, a small MSRIV motor fire (low combustible) is not likely to propagate to the associated MSIV. Additionally, Division 4 MSRIV and Division 3 MSIV are separated by a wall and a larger distance, making this propagation even less likely.

As stated in the response to Question 19.01-22, a design change not included in the U.S. EPR FSAR probabilistic risk assessment (PRA), added a fire barrier between Divisions 4 and 3 (similar to Divisions 1 and 2) valve rooms. With this change the two valve rooms can be evaluated as two separate fire areas, and the probability of a fire affecting the MSIV in the next division can be set to zero.

Two sensitivity cases are provided in U.S. EPR FSAR Tier 2 Table 19.1-74 (cases 12a and 12b) to study impacts of the assumptions made on the two MSIV failures to close.

Therefore, the overall treatment of this scenario is confirmed as conservative and, if necessary, can be reevaluated when updates to the PRA are performed in accordance with the PRA maintenance and upgrade process described in U.S. EPR FSAR Tier 2, Section 19.1.2.4. COL item 19.1-9 listed in U.S. EPR FSAR Tier 2, Table 1.8-2—U.S. EPR Combined License Information Items is provided to confirm that assumptions used in the PRA remain valid for the as-to-be-operated plant.

FSAR Impact:

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

Question 19.01-34:

For the control room fire analysis, please provide additional information for the following:

a) The basis for control room evacuation of 90 minutes given a fire.

b) Operator actions/procedures required for transferring control of the plant to the remote shutdown station (RSS) (e.g., timing, location of transfer switch, etc.).

c) Systems/functions that could be controlled from the RSS.

d) Random failure probability of RSS given a successful transfer.

e) The basis for operator failure probability of 7E-5.

Response to Question 19.01-34:

a) The SPAR-H methodology, which was used to calculate the human error probability (HEP) for transfer of control to the RSS, relies on estimates of the time available and the time needed for the operator action. The time available parameter, 90 minutes, is a representative time based on the estimated time from the start of the main control room (MCR) fire until the undesired consequence (core damage) is irreversible.

   A fire in the MCR is assumed to cause an event similar to a loss of balance of plant (LBOP), which is modeled in the PRA as a turbine trip with unavailability of the main condenser, main feed water (MFW), startup and shutdown system (SSS), closed cycle cooling water, and conventional service water.

   The time available for this operator action is based on the representative time window available for operator action during a loss of all feedwater transient. For an event involving total loss of secondary side cooling, representative Modular Accident Analysis Program (MAAP) runs indicate that core damage can be prevented if operator action to restore cooling is taken within 90 minutes. This is conservative because the MCR fire will not impact performance of the protection system or automatic actuation of the emergency feedwater system (EFWS).

b) At this time, the design features for the transfer of control of the plant to the RSS have not been finalized; therefore specific actions/procedures required for transferring control of the plant to the RSS have not been developed. However, requirements for the transfer have been defined such that:

   - The transfer must be in a different fire area than the MCR and within close walking distance from the MCR.
   - The transfer must disable the MCR control and provide a seamless transfer to the RSS controls.

   Any impact to the PRA based on the detailed design will be evaluated in accordance with the human factors engineering (HFE)/HRA integration plan described in U.S. EPR FSAR Tier 2, Section 18.6 and the PRA maintenance and upgrade process described in U.S. EPR FSAR Tier 2, Section 19.1.2.4. COL item 19.1-9 listed in FSAR Table 1.8-2 is provided to confirm that assumptions used in the PRA remain valid for the as-to-be-operated plant.

c) The RSS is able to control all the systems and functions necessary to bring the plant to and maintain it in a safe shutdown state through a combination of the process information and control system (PICS) and the safety information and control system (SICS).

   The RSS includes two fully functional PICS workstations. The PICS in the RSS will have a different number of workstations and monitors than in the MCR; however their functionality will be the same as the MCR workstations. This enables all plant systems and functions to be controlled from the RSS.

   In addition, as described in U.S. EPR FSAR Tier 2, Section 7.1.1.3.1, the RSS will have a SICS workstation that provides a manual reactor trip and a minimum inventory of controls, displays, and alarms for manual control of systems to achieve and maintain safe shutdown.

d) The random failure probability of the RSS given a successful transfer has not been assessed. However, the RSS contains two PICS workstations and a SICS workstation for backup. The designs of the RSS and of the RSS transfer require divisional independence to be maintained, such that an electrical failure in one safety division can not impact another safety division. Physical independence and electrical isolation is also required in the RSS between safety-related systems and non-safety-related systems. Therefore, a complete random failure of the RSS is unlikely, and is not included in the PRA.

e) The HEP associated with control room evacuation includes the decision to evacuate the MCR, and the action of switching controls to the RSS. The egress route from the MCR to the RSS is a short walk that is protected with fire barriers, emergency lighting, a smoke confinement system, and positive differential air pressure. The HRA assumes 15 minutes to perform the evacuation and transfer control to the RSS. In the case of successful transfer, the PRA transfers to the LBOP event tree. If additional operator actions are needed after the transfer (e.g., to restore cooling), then the HEPs for the subsequent operator actions (performed from the RSS) are doubled.

   The operator failure probability for RSS transfer has been assessed using the SPAR-H human reliability methodology (NUREG/CR-6883). The performance shaping factors (PSF) used to derive the HEP are assigned as nominal (or insufficient information) except for:

   - The PSF for timing is determined based on the SPAR-H. The time parameters used in the formula are as follows:
     - 90 minutes for the total time window, as shown in the response to Question 19.01-34 a).
     - 10 minutes median time needed for diagnosis (to make the decision to evacuate the MCR).
     - 15 minutes median time needed for action (evacuation and RSS transfer).
     - Delay time for the cues is zero because the fire is in the MCR and it is always occupied.
   - The PSF for diagnosis stress is high (2x) because of the immediate nature of the threat (uncontrolled fire in the MCR).
   - The PSF for diagnosis complexity is obvious (0.1x).

- The PSF for training for the action is high (0.5x) because it is a scenario for which the operators are expected to be well trained.

This results in a failure probability of 2.0E-05 for the cognitive portion and a failure probability of 5.0E-05 for the execution portion. Therefore, the total HEP is 7.0E-05.

FSAR Impact:

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

Question 19.01-35:

The fire frequency location-based method provided in RES/OERAB/S02-01 gathers fire events occurring in the existing power plants that are smaller compared against the U.S. EPR plant size. Thus, to account for a larger number of components (e.g., pumps, batteries, AC/DC buses, EDGs, etc.) and a potential of more transient ignition sources (e.g., welding, cutting, hot pipe, etc.) in the EPR plant, the EPR fire frequencies shown in FSAR, Table 19.1-63 may be higher than the frequencies provided in RES/OERAB/S02-01 report. Please justify why EPR PFA fire frequencies are estimated to be lower.

Response to Question 19.01-35:

The fire frequencies shown in U.S. EPR FSAR Tier 2, Table 19.1-63 only apply to single PRA fire areas (PFAs). When a frequency defined in RES/OERAB/S02-01 applies to more than one PFA, the generic frequency is divided between all PFAs in the group corresponding to the generic location category. Therefore, if the fire ignition frequencies of all the PFAs included in the generic location category are summed, the result should be equal to the generic frequency, multiplied by the appropriate correction factors to account for the specificity of the U.S. EPR (see response to Question 19.01-30).

Table 19.01-35-1 shows the results of this comparison. In most cases, the U.S. EPR frequencies are higher due to the application of the correction factors as stated in the response to Question 19.01-30. For the Auxiliary Building, the frequency is lower because one of the buildings that are assumed to correspond to the Auxiliary Building location category, the Nuclear Auxiliary Building, is not included in the analysis.

As stated in this question, the U.S. EPR plant size (i.e., larger number of components) may result in slightly higher fire frequencies. However, given industry advances in the fire protection regulations, materials and procedures, and high spatial separations in the U.S. EPR, it is expected that the new generation of nuclear plants (including the U.S. EPR) will show significant reduction in the fire frequencies.

Table 19.01-35-1—Comparison of RES/OERAB/S02-01 Generic Location Frequencies with the Corresponding U.S. EPR Frequencies

Generic Location Category	RES/OERAB/S02-01 Frequency (per year)	Corresponding the U.S. EPR PFA Fire Frequencies (per year)
Auxiliary Building	2.7E-02	2.5E-02
Switchgear Room	5.1E-03	7.6E-03
SWS Pumphouse	7.2E-03	1.4E-02
Battery Room	8.4E-04	1.7E-03
Control Room	7.2E-03	3.6E-03

FSAR Impact:

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

Question 19.01-36:

For the transformer yard, please clarify why the transformer is the only fire source used in fire frequency estimate. What is the ratio of transformers in the transformer yard to the total transformers in the plant? What is the transient fire frequency?

Response to Question 19.01-36:

Detailed design information regarding the transformer yard was not available at the time of the analysis. Transformers are assumed to be the dominant source of fire ignition in the transformer yard; therefore, it is the only source considered. The ratio of transformers in the transformer yard to the total number of transformers is set to one because the NUREG/6850 component-specific ignition frequency used for transformers applies specifically to “transformer yard transformers” category.

Each transformer is separated from the others by fire barriers. The fire scenario models a fire affecting a transformer feeding the safety divisions. Therefore a factor of 2/5 is applied to the fire ignition frequency because 2 out of 5 transformers feed the safety divisions.

Transient fires are not included in this analysis, as stated in the response to Question 19.01-23

FSAR Impact:

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

Question 19.01-37:

For the MS/MFW valve room, are there any other potential ignition sources besides the identified electric motors, pumps, and fans? What are the percentages of these components in this PFA? What is the transient fire frequency assigned to this PFA?

Response to Question 19.01-37:

The fire ignition frequency of 6E-04/yr for a single main feedwater/main steam (MFW/MS) PRA fire area (PFA) (encompassing two divisions) is estimated using the NUREG/CR-6850 method, based on the number of components in the area. The only components identified in the area susceptible to ignite a fire are electric motors, pumps, and fans. A correction factor of 1.1 is also applied to account for the larger number of pumps, as stated in the response to Question 19.01-30. The details of the calculation are shown in Table 19.01-37-1. Transient fires are not included in this analysis, as stated in the response to Question 19.01-23.

The methodology used to derive the frequency of the fire scenario is similar to the one used for the pressurizer compartment (see the response to Question 19.01-29). The total fire ignition frequency for one PFA is multiplied by the number of PFAs (two) and the conditional probability of a spurious actuation. The details of the calculation of the scenario frequency are shown in Table 19.01-37-2.

Table 19.01-37-1—Fire Ignition Frequency for One MFW/MS Valve Room

Ignition Source	Generic Ignition Frequency (per year)	Factors of the components on the location vs. the total components in the plant.	Correction Factor	PFA-Specific Ignition Frequency (per year)
Electric Motors	4.60E-03	0.040		1.8E-04
Pumps	2.10E-02	0.012	1.100	2.9E-04
Ventilation Subsystems	7.40E-03	0.018		1.3E-04
			Total	6.0E-4

Table 19.01-37-2—Fire Scenario Frequency (Fire with at least One Spurious Opening)

Trains Considered	Total PFA Fire Ignition Frequency/ Two PFAs (per year)	Single Hot Short Probability for SOV	Number of Hot Shorts Needed to Open the Train	Number of Trains	Spurious Opening Frequency (per year)
MSRIV Train	1.2E-03	0.33	2	4	**5.2E-04**

FSAR Impact:

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

Question 19.01-38:

For the containment/pressurizer area, why are the electric motors considered as the only potential ignition sources? What is the ratio of electric motors in this PFA? What is the transient fire frequency?

Response to Question 19.01-38:

As stated in the response to Question 19.01-29, the containment PFA is treated differently from other PFAs. Due to the large size and small combustible loading of the PFA, a fire that would affect all components is not postulated. Instead, a specific analysis of vulnerable locations is carried out.

Reactor coolant pump fires due to oil leakage have been the source of most fires in-containment in operating history. Due to the specific oil collecting system described in U.S. EPR FSAR Tier 2, Section 5.4.1.2.2 it was estimated that this event could not occur in the U.S. EPR. Therefore, reactor coolant pump fires are not analyzed as a credible fire scenario.

A scenario involving a spurious opening of a pressurizer valve was chosen to represent fires in the containment. Electric motors are the only components identified in the pressurizer compartment PFA susceptible to ignite a fire. The details of the calculation are presented in the response to Question 19.01-29. The total number of the electrical motors in this area is 17, which operate safety valves, nitrogen sweep isolation valves, and degasification line isolation valves. The total number of the motors in the plant is estimated to be about 1,600; therefore, the ratio of the electrical motors in this room is estimated at 0.11.

Transient fire frequency is not considered because, similar to the areas stated in the response to Question 19.01-23, it is unlikely that transient combustibles would be present or stored in these two areas, given that maintenance activities at-power are not expected there and these areas are not on the access paths to the other areas. Therefore, this assumption is confirmed as reasonable and, if necessary, can be reevaluated when updates to the PRA are performed in accordance with the PRA maintenance and upgrade process described in U.S. EPR FSAR Tier 2, Section 19.1.2.4. COL item 19.1-9 listed in U.S. EPR FSAR Tier 2, Table 1.8-2—U.S. EPR Combined License Information Items is provided to confirm that assumptions used in the PRA remain valid for the as-to-be-operated plant.

FSAR Impact:

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

Question 19.01-39:

Due to divisional measures in the cable spreading room (CSR), a fire in the CSR is assumed to disable only one electrical safety division (Division 4). Because only one division is assumed to be failed, please further describe the conservative assumption mentioned in FSAR, Section 19.1.5.3.2.5, last bullet. Additionally, provide a detailed discussion on CSR separation measures.

Response to Question 19.01-39:

A response to this question will be provided by November 7, 2008.

Question 19.01-40:

(typos) In FSAR, Section 19.1.5.3.2.7, all references to Section 19.1.4.1.2.6 should be changed to Section 19.1.4.1.2.7.

Response to Question 19.01-40:

References to Section 19.1.4.1.2.7 were revised in the U.S. EPR FSAR as part of the response to RAI 2, Question 19-05.

FSAR Impact:

See U.S. EPR FSAR revisions associated with the response to RAI 2, Question 19-05.

Question 19.01-41:

Please provide (and include in FSAR, Section 19.1.5.3.2.7) a discussion of the constrained non-informative distribution that was used in the fire uncertainty analysis as mentioned in FSAR, Section 19.1.4.1.2.7, first bullet.

Response to Question 19.01-41:

As addressed in U.S. EPR FSAR Tier 2, Section 19.1.5.3.1.2—Internal Fire Frequencies, the internal fire initiating event frequencies are based on limited information and constrained non-informative (CNI) distributions (in the form of a Beta distribution) are used to model uncertainties in the estimated values. The CNI distribution applies because there is large uncertainty in the value of the parameter, and the shape of the distribution is unknown. The CNI distributions are shown associated with the fire scenario frequencies in U.S. EPR FSAR Tier 2, Table 19.1-64—Fire Scenarios Description and Frequency Calculation.

U.S. EPR FSAR Tier 2, Section 19.1.5.3.2.7 will be revised to include information on CNI distribution.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Section 19.1.5.3.2.7 will be revised as described in the response and indicated on the enclosed markup.

Question 19.01-42:

The following statement should be added to FSAR, Section 19.1.5.3.2.5, “A COL applicant that references the U.S. EPR design certification will confirm that the design-specific U.S. EPR fire IE frequencies, including fixed and transient fire ignition sources, are bounding for their specific site.”

Response to Question 19.01-42:

U.S. EPR FSAR Tier 2, Section 19.1.2.2 contains COL item 19.1-9, which calls for a review of as-designed and as-built information to confirm that the assumptions used in the PRA remain valid. This includes key assumptions associated with the quantification of internal fire PRA initiating event frequencies. Confirming the validity of the key assumptions associated with the PRA allows the plant specific PRA to be updated to account for site-specific design information and design changes or departures from the certified design in accordance with 10 CFR 52.79(d)(2). See U.S. EPR FSAR Tier 2, Section 19.0 COL item 19.0-1 and U.S. EPR Tier 2 Section 19.1.2.4 for more information on the U.S. EPR PRA maintenance and update program.

An additional COL item to specifically address changes or departures from the assumptions used to support fire initiating event frequencies is not necessary.

FSAR Impact:

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

Question 19.01-43:

Please describe why the fire CDF is very sensitive to the HVAC recovery as indicated in the sensitivity study (Case 4b) on FSAR, Page 19.1-354.

Response to Question 19.01-43:

The fire core damage frequency (CDF) is very sensitive to the HVAC recovery due to inter-division ventilation dependencies. A large number of the modeled fire scenarios result in the unavailability of one safety division. As stated in the U.S. EPR FSAR Tier 2, Section 19.1.4.1.2.8 (PRA Insights) "A total loss of an electrical division which supplies the running CCW pump, could without operator intervention, disable the second division through a loss of HVAC." The ventilation dependencies are addressed in more detail in the U.S. EPR FSAR Tier 2, Section 19.1.4.1.1.3; subsection "Modeling of System Dependencies."

The role played by this inter-division HVAC dependency in the fire PRA results is illustrated using Cutset Groups 3, 6 and 12 in the U.S. EPR FSAR Tier 2, Table 19.1-66.

FSAR Impact:

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

Question 19.01-44:

Was any credit given for fire-induced LOOP recovery? If yes, please describe.

Response to Question 19.01-44:

In the U.S. EPR fire risk evaluation, no fires are identified that could lead to a loss of offsite power (LOOP). Transformer yard fires, based on the fire barriers, are not likely to include multiple transformers, and LOOP events due to switchyard fires (outside of the plant) are assumed to be enveloped in the general LOOP frequency and recovery. For the fire-induced consequential LOOP, recovery within one hour was credited. It was assumed that consequential LOOPs after fire events are recoverable similar to the other consequential LOOPs because, although they occur due to a fire-related trip or controlled shutdown, they are not directly caused by equipment that has been damaged by fire.

FSAR Impact:

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

Question 19.01-46:

Please provide detailed discussion (e.g., probability value, basis, procedures, etc.) and state why fire recovery is considered for the following events: LOOP24+REC, "LOOP during mission time and failure of recovery within 1-hour," LOOPCON+REC, "Consequential LOOP and failure of recovery within 1-hour for IEs leading to auto scram," and LOOPFCSD+REC, "Consequential LOOP and failure of recovery within 1-hour for fire IEs Leading to a controlled shutdown."

Response to Question 19.01-46:

The basic events listed in the question, all related to losses of offsite power after different initiators, are shown in the Table 19.01-46-1 with associated nominal values. An additional basic event, LOOPCSD+REC, consequential loss of offsite power (LOOP) and failure of recovery within 1-hour for IEs leading to a controlled shutdown, is also included in Table 19.01-46-1 to complete the response.

Table 19.01-46-1—LOOP

ID	Description	Nom. Val.
1. LOOP24+REC	Loss Of Offsite Power During Mission Time and Failure of Recovery Within 1-Hour	4.80E-05
2. LOOPCON+REC	Consequential LOOP and Failure of Recovery Within 1-Hour for IEs Leading to Auto Scram	1.80E-03
3. LOOPCSD+REC	Consequential LOOP and Failure of Recovery Within 1-Hour for IEs Leading to a Controlled Shutdown	1.80E-04
4. LOOPFCSD+REC	Consequential LOOP and Failure of Recovery Within 1-Hour for Fire IEs Leading to a Controlled Shutdown	3.60E-04

The basis for these LOOP events nominal values are as follows:

1. **LOOP24+REC**: Loss of Offsite Power During Mission Time and Failure of Recovery Within 1-Hour, is estimated based on the LOOP probability from NUREG/CR-6890 Volume 1, "Reevaluation of Station Blackout Risk at Nuclear Power Plants, Analysis of Loss of Offsite Power Events: 1986 – 2004" (page xii) equal to 3.59E-2/year, adjusted to remove the contribution of consequential LOOP, which is included separately as addressed in the following items 2, 3 and 4. The consequential LOOP contribution is removed by repeating the calculation on page xii of NUREG/CR-6890, with the number of switchyard-centered events reduced by three. The result of 3.17E-2/year is divided by 365 to represent a 24-hour mission time and multiplied by a composite 1-hour non-recovery probability of 0.55 (as used in the U.S. EPR PRA non-recovery functional event).

2. **LOOPCON+REC:** Consequential LOOP and Failure of Recovery Within 1-Hour for IEs Leading to Auto Scram, 1.8E-3/demand, is estimated based on the consequential LOOP probability from NUREG/CR-6890 Volume 1, "Reevaluation of Station Blackout Risk at Nuclear

Power Plants, Analysis of Loss of Offsite Power Events: 1986 – 2004" (page 51) equal to 5.3E-3/demand, multiplied by 1-hour LOOP non-recovery of 3/9. A 1-hour offsite power non-recovery was conservatively applied to consider the possibility that offsite power is recovered prior to core damage. Based on NUREG/CR-6890, 6 of 9 consequential LOOPs were recovered within an hour.

(Note: the LOOP event tree applies an offsite power non-recovery at 2-hours or 1-hour, dependent on whether or not an RCP seal LOCA has occurred. However, for the sake of simplicity and conservatism, the consequential LOOP events only consider recovery of power within 1-hour).

3. LOOPCSD+REC: Consequential LOOP and Failure of Recovery Within 1-Hour for IEs Leading to a Controlled Shutdown, 1.8E-4/demand, is estimated based on the value presented in item #2 for LOOPCON+REC, then reducing it by a factor of 10. That factor is based on an estimate that 10 percent of IEs leading to a controlled shutdown may result in an automatic plant trip (engineering judgment).

4. LOOPFCSD+REC: Consequential LOOP and Failure of Recovery Within 1 Hour for Fire IEs Leading to a Controlled Shutdown, 3.6E-4/demand, is estimated based on the value presented in item #2 for LOOPCON+REC, than reducing it by a factor of 5. That factor is based on an estimate that 20 percent of fire IEs leading to a controlled shutdown may result in an automatic plant trip. Based on NUREG-5750, "Rates of Initiating Events at U.S. Commercial Nuclear Power Plants, 1987 through 1995," February 1999 (page 52) it was estimated that the reactor trip frequency from fires outside of the Turbine Building or switchyard would be approximately 7E-3 reactor trips per critical year. Based on U.S. EPR fire frequencies in these areas, it was estimated that less than 20 percent of fires at these locations would result in reactor trip. This is also addressed in the response to Question 19.01-25.

For LOCA events, a different consequential LOOP probability was used from NUREG\CR-6890, and no recovery was credited.

The fire-events related consequential LOOP recovery was considered because, as stated in the response to Question 19.01-44, even when the LOOP event occurred indirectly due to a fire related trip or controlled shutdown, the LOOP itself is not fire related.

FSAR Impact:

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

Question 19.01-47:

In accordance with guidance provided in SRP Section 19.1.3.4, please explicitly describe the uses of the EPR internal fire PRA and insights/assumptions in the design process to reduce the weaknesses/vulnerabilities, to develop design requirements, and to improve the EPR design safety profile.

Response to Question 19.01-47:

For new plants, the design requirements for fire protection are deterministic. Per the response to Questions 09.05.01-34 and 09.05.01-45, the results of the fire probabilistic risk assessment (PRA) were not used explicitly in the fire protection analysis. No fire protection features required by Regulatory Guide 1.189 were eliminated as a result of the fire PRA, and no fire protection features were added as a result of the fire PRA. However, the fire PRA results were examined by the fire protection design team to identify potential weaknesses and vulnerabilities that might be considered for additional fire protection features. No weaknesses or vulnerabilities were identified.

As indicated in U.S. EPR FSAR Tier 2, Section 19.1.5.3.2.8, the insights from the fire PRA indicate that the safety significance of SSC to the internal fires risk is evenly distributed across systems and plant functions. The absence of outliers shows that there are no specific dominant vulnerabilities in the U.S. EPR design with respect to the mitigation of the credible fire scenarios.

One of the reasons that there are no fire vulnerabilities identified in the PRA is that these risks were considered in the U.S. EPR design from the beginning. The U.S. EPR was designed with high levels of redundancy and separation of safety divisions to provide inherent protection against internal and external hazards. This includes four-train redundancy, location of safety trains in separate buildings, and separation and fire barriers between divisions of control and power cables. U.S. EPR FSAR Tier 2, Section 19.1.3 addresses these as well as other design features that are incorporated in the U.S. EPR to reduce known weaknesses and vulnerabilities in current-generation PWRs. U.S. FSAR Tier 2, Table 19.1-2 summarizes the U.S. EPR design features that are important to risk, including those most pertinent to internal fire risks.

FSAR Impact:

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

U.S. EPR Final Safety Analysis Report Markups

selected. A significant flooding event is defined for a given building as an event that results in a flood level of more than one foot in any room of that building. Main feedwater (MFW) and main steam (MS) pipes in the ~~MS/~~MFW/MS valve rooms on the top of SB 1 and SB 4 are not considered as flood sources in these buildings, because these floods do not have a potential to affect any other location inside the building. These pipe breaks are also evaluated as a part of the high energy line break (HELB) analysis.

19.01-21

The TB also houses ~~SSCs~~SSC that are credited in the PRA analysis. No P&IDs are available yet for the systems located in the TB; therefore, a generic flooding event frequency is used. It is taken from NUREG/CR-2300, PRA Procedures Guides, (Reference 41).

The U.S. EPR locations selected for the flooding analysis and corresponding flooding frequencies are defined in Table 19.1-38—U.S. EPR Locations Selected for the Flooding Analysis and Corresponding Flooding Frequencies. Because these frequencies are based on limited information, constrained non-informative distributions (CNI) are used to model uncertainties in the estimated values. The CNI distribution applies because there is a large uncertainty in the value of the parameter, and the shape of the distribution is basically unknown.

These distributions are shown associated with the flooding scenario frequencies, which will be discussed in the next section (see Table 19.1-39—Flooding Scenarios Description and Frequency Calculation).

19.1.5.2.1.3 Flooding Scenarios

For each location/building selected for the flooding analysis, the worst flooding scenario is defined, assuming that all mitigating equipment at the location is lost. Other effects of pipe breaks, like jet impingement, spray, pipe whip, or humidity, were not specifically evaluated because all equipment at a location is considered failed. The frequency of the selected flooding scenario is estimated based on the building flooding frequencies as defined in Table 19.1-38

The scenarios defined for each area are described in Table 19.1-39. Table 19.1-39 gives the flooding scenario identifiers and descriptions, summarizes the effects the flood has on mitigating systems and gives the scenario frequencies with the basis for their calculation.

One of the more complex scenarios for which frequency was calculated using a simple event tree is the flood in the RB annulus. In this scenario, an operator action is credited to isolate a pipe break before a significant flood level occurs. In addition, two propagation possibilities were considered. The first propagation pathway accounts for the possibility that the doors between the RB annulus and SB 2 would fail open at a certain flood level. The second propagation pathway reflects the potential for the door all ~~SSCs~~SSC in the FA is modeled, and that the total area fire ignition frequency is applied to that scenario. Based on this approach, for each building containing ~~SSCs~~SSC credited in the PRA, the following steps are performed for the internal fire evaluation.

- Estimate fire frequency based on the available industry experience. Use conservative fire frequency estimates for locations where no available industry data applies.
- Assume that each fire will grow to be a fully developed fire (i.e., do not consider the possibility that the fire will self-extinguish).
- Analyze possible fire scenarios for the location and, based on the PRA model, select the worst-case scenario.
- Credit automatic fire suppression, if the specific fire does not affect it. Manual fire suppression is only credited in the MCR.
- Credit human recovery actions only for control room fires. These actions are implemented from the RSS that is physically separated from, and electrically independent of, the control room.
- Apply the total building/FA frequency to the worst scenario, and calculate the corresponding CDF and LRF.

Since the analyzed fire locations are all separated by three-hour fire barriers, as defined in the Fire Hazard Analysis (FHA), the propagation between areas is not considered. Fire-damage models and associated computer codes are not used, since all equipment inside an FA is assumed to fail.

19.1.5.3.1.2 Internal Fire Frequencies

Fire Areas Selected for Internal Fire Risk Evaluation

The fire PRA utilizes the partition of the plant into FAs as defined in the FHA. In order to streamline quantification, the numerous FAs in the plant are grouped into a limited number of PRA fire areas (PFAs) that contain ~~SSCs~~SSC modeled in the PRA analysis, and where a loss of equipment due to a fire would have a similar impact on the plant response. For example, the SB 1 is divided into five PFAs:

- PFA-SB 1-MECH, which includes the pump room of SB 1.
- PFA-SB 1-AC, which includes the AC switchgear room and cable floor of SB 1.
- PFA-SB 1-DC, which includes the DC switchgear room and the I&C room of SB 1.
- PFA-BATT1, which includes the battery room of SB 1.
- PFA-VLVR1, which represents the ~~MSS/MFWS~~MFW/MS valve room located on top of SB 1.

19.01-21

19.01-31

U.S. EPR FAs and corresponding FAs modeled in the PRA are defined in Table 19.1-62—U.S. EPR Fire Areas and Corresponding Fire Areas Modeled in the PRA (PFAs), and, for SB 4 and SB 2, illustrated in Figure 19.1-16—Cross-section of Safeguard Building 4 Illustrating the PRA Fire Areas and Figure 19.1-17—Cross-section of Safeguard Building 2 Illustrating the PRA Fire Areas, respectively.

The fire areas where fire would not lead to a fire induced initiator, or does not lead to a plant trip with a significant impact on the mitigating systems, are excluded from the fire evaluation. Based on this limited impact assessment, the four Emergency Power Generating Buildings and the Nuclear Auxiliary Building are excluded from further analysis.

The PFAs defined in Table 19.1-62 are further grouped as fire scenarios are defined (see Section 19.1.5.3.1.3), by selecting one PFA as representative of symmetrical PFAs. The fire scenario is defined and modeled as occurring in the chosen PFA; its frequency is defined as the sum of fire ignition frequencies for all the PFAs represented by the scenario.

Fire Frequencies for the Selected Fire Areas

The method used to evaluate fire ignition frequencies is based on the U.S. operating experience documented in RES/OERAB/S02-01, "Fire Events – Update of U.S. Operating Experience 1986-1999" (Reference 42). Each evaluated PFA is matched with a corresponding generic location in that reference. Correction factors are also applied to account for the specificity of the U.S. EPR compared to standard U.S. plants (e.g., a larger number of components and locations).

For areas that do not directly correspond to generic locations defined in Reference 42, the method described in Reference 6 is used. This method defines plant-wide fire ignition frequencies for each type of component. An ignition frequency for a specific U.S. EPR PFA is derived by estimating the percentage of components in that area, for each component type. As defined above, the correction factors are also used to account for the specificity of the U.S. EPR. This method is only used for three PFAs: transformer yard, ~~MS/~~MFW/MS valve room, and containment pressurizer area. Sources of information for identifying the fire sources within each fire area of the plant included the following:

19.01-21

- The Plant-Specific Spatial Database.
- General Arrangement Drawings.
- Fire Hazard Analysis.

The transient fires are not specifically considered in the analysis. It is assumed that they are enveloped in the used generic fire frequencies. For the areas where component specific frequencies are used (transformer yard, ~~MS/~~MFW/MS valve room and containment), it was assumed that a transient contribution would be very limited.

19.01-21

The PRA fire area frequencies and their basis are defined in Table 19.1-63—Basis for PFA Fire Frequencies. Because these frequencies are based on limited information, CNI are used to model uncertainties in the estimated values. The CNI distribution applies because there is a large uncertainty in the value of the parameter, and the shape of the distribution is basically unknown. These distributions are shown associated with the fire scenario frequencies, which will be discussed in the next section (see Table 19.1-64—Fire Scenarios Description and Frequency Calculation).

19.1.5.3.1.3 Fire Scenarios

As explained above in Section 19.1.5.3.1.2, the worst fire scenarios, one for each selected area, are defined in order to provide a conservative estimate of the internal fire risk. In all but one case, a fire in a PRA FA is assumed to disable all components located within that area.

As discussed in the previous section, close to 30 PFAs, which are defined in Table 19.1-62 , are further grouped by selecting one PRA FA as representative of multiple symmetrical PRA FAs. For example, the fire scenario Fire-SAB14-AC represents a fire occurring in the AC switchgear room of SB 1 or SB 4. The scenario is modeled as failing all of Division 4. The frequency of the scenario is calculated as the sum of the fire ignition frequencies in the switchgear rooms of SB 1 and SB 4. Division 4 is chosen as representative and more conservative, since the single train of SAHRS is supplied from Division 4.

Spurious actuation of systems caused by simultaneous electrical hot shorts is considered when applicable. The applied probability of a hot short, given a fire, is 0.17 for an MOV and 0.33 for an SOV (refer to Reference 6).

Automatic fire suppression is credited when available and not affected by the fire. Two 100 percent capacity diesel engine-driven fire pumps ensure that suppression can be credited even if a consequential LOOP occurs. Manual suppression is credited only in the MCR because it is constantly manned.

Fire scenarios are quantified using the same fault tree and event tree logic used in the Level 1 internal events evaluation. Mitigating systems that are assumed to be unavailable in a fire scenario are not credited. A different value was used for consequential LOOP for fire events leading to a controlled shutdown. The value is estimated based on the value for the consequential LOOP leading to auto scram, reduced by a factor of five. The reduction is based on an estimate that 20 percent of fire initiators leading to a controlled shutdown may result in an automatic plant trip. The fifteen fire scenarios selected in the internal fires PRA are defined in Table 19.1-64. This table gives the fire scenario identifier and description, summarizes the effects the scenario has on mitigating systems, defines the suppression credited, and gives the scenario frequency and basis for that frequency.

19.1.5.3.2 Results from the Internal Fire Risk Evaluation

19.1.5.3.2.1 Risk Metrics

The total CDF from internal fire events is 1.8E-07/yr, less than 1E-06/yr. This is well below the NRC goal of 1E-04/yr (SECY-90-016, Reference 30) and the U.S. EPR probabilistic design goal of 1E-05/yr. Mean value and associated uncertainty distribution can be found in Section 19.1.5.3.2.7.

19.1.5.3.2.2 Significant Initiating Events

All fire scenarios/initiating events modeled and their contribution to the internal fire CDF are given in Table 19.1-65—U.S. EPR Initiating Event Contributions – Level 1 Internal Fires. Fire initiating events and their contributions are illustrated in Figure 19.1-15. As can be seen from Table 19.1-65 and Figure 19.1-15, 10 out of 15 fire initiating events contribute less than one percent of the internal fire CDF. The fire in the AC switchgear room of SB 1 or SB 4 is the single largest contributor. This could be explained by the importance of electrical Divisions 1 and 4 for the supply of front-line and support systems, as explained in the discussion of system dependencies in Section 19.1.4.1.1.3.

19.01-21

The next two biggest contributors to fire risk are the fire in the ~~MSS/MFWS~~MFW/MS valve room and the fire in the MCR. The valve room contribution results largely from a specific fire-induced sequence that combines spurious operation of an MSRT and the inability to close two MSIVs (see Section 19.1.5.3.2.3). The MCR contribution includes the failure of the operator action to transfer to the RSS following a fire in the MCR. Although this failure probability is low, it is assumed to directly result in core damage.

The fourth biggest contributor to the internal fire risk is the fire in the switchgear building. The fire in the switchgear building has effects comparable to an LBOP initiating event with a loss of non-safety electrical power and SBO DGs. Its relatively high risk can be explained by the loss of some non-safety systems and subsystems that are credited in the PRA model.

The fifth fire scenario that contributes more than one percent to the internal fire risk is a fire in the mechanical division (pump room) of an SB. This scenario is modeled as affecting the running train of CCW. The system dependencies detailed in Section 19.1.4.1.1.3 explain this relatively important contribution.

19.1.5.3.2.3 Significant Cutsets and Sequences

In order to simplify discussion of the sequences related to the fire scenarios, two fire-specific failure patterns are explained below:

1. A fire in SB 1 could result in a failure of the CCW CH 1, in the following sequence of the events: the fire disables the Division 1 running CCW train and the corresponding switchover valves, thereby disabling a switchover to the CCW standby train. A loss of CH1 results in the failure of cooling to Division 2 SCWS chillers, and to two out of four OCWS chillers. As explained in Section 19.1.4.1.1.3, this would lead to a complete loss of ventilation in SB 2, and, if not recovered, a total loss of Division 2. Therefore, a fire in SB 1 could result in a loss of two divisions. The same is true for SB 4, which hosts another running CCW train.

2. A fire in the switchgear room of SB 1 or SB 4 directly results in the failure of the primary bleed function. In order to succeed, the bleed function requires either three out of three PSRVs to open, which requires the four electrical divisions, or one out of two SADVs to open, which requires Division 1 and Division 4. A fire in the switchgear room of SB 4, therefore, prevents both combinations.

19.01-21

The top 100 cutsets from the RS output for quantification of the fire CDF are evaluated in detail. Two cutsets dominate the fire risk, with individual contributions of about 15 percent to the fire CDF. Due to the lack of detailed design and procedures, conservative assumptions were made for the fires in the ~~MSS/MFWS~~MFW/MS valve room and the MCR, and the importance of those cutsets could be attributed to these assumptions. Other than these two outliers, cutset contribution to the internal fire CDF is evenly distributed: fewer than 10 cutsets contribute more than one percent to the fire CDF. The number of cutsets that contribute to 95 percent of the fire CDF is larger than 2300.

The significant cutsets for the internal fires are shown in Table 19.1-66—U.S. EPR Important Cutset Groups – Level 1 Fire Events. In this table the first 100 cutsets are grouped based on the associated initiating event and on their similar impact on mitigating systems. The corresponding sequence in the event tree is identified for each group. The table indicates for each group its number, the number of cutsets in the group, the total CDF of the group, its percentage contribution to the total fire CDF (i.e., contribution of the group itself and cumulative contribution), a representative cutset and the description of the sequence of events. As shown in Table 19.1-66, the top 100 cutsets are organized into 12 groups, representing over 76 percent of the fire CDF. These groups are discussed below:

19.01-21

Groups 1 and 9 in Table 19.1-66 represent sequences that result from a fire in the ~~MSS/MFWS~~MFW/MS valve room. The fire results in a spurious opening of an MSRIV, then two MSIVs fail to close due to the fire. In Group 1, failure to align the RHR or failure of the RHR results in core damage. In Group 9, independent failure of a third MSIV to

19.1.5.3.2.4 Significant, SSC, Operator Actions and Common Cause Events

Table 19.1-67 through Table 19.1-73 show the important contributors to the internal CDF. Importance is based on the FV importance measure (FV ≥0.005), or the RAW importance measure (RAW ≥2).

Table 19.1-67—U.S. EPR Risk-Significant Equipment based on FV Importance – Level 1 Fire Events shows the top risk-significant ~~SSCs~~SSC based on the FV importance measure. The EDG trains, the cooling tower fan trains, and the air-cooled SCWS chiller trains have the highest FV. The presence of EDG trains highlights the importance of consequential LOOP events following a fire. The cooling tower fan trains are needed for long term cooling in seal LOCA sequences, which represent a large part of the fire risk. The air-cooled SCWS chillers importance reflects the importance of ventilation dependencies.

Table 19.1-68—U.S. EPR Risk-Significant Equipment based on RAW Importance – Level 1 Fire Events shows the top risk-significant ~~SSCs~~SSC based on the RAW importance measure. The most important components are 6.9kV divisional switchgears, 480V load centers, 24V DC I&C Power Rack, and 480V MCCs. This dominance of electrical and I&C components is partly due to the fact that the scenario which dominates the fire risk (i.e., fire in the switchgear room of SB 1 or SB 4) directly results in the failure of all buses for one division. Failure of buses in another division could have a significant impact on the mitigating systems like the MSRTs that require a specific combination of two divisions to perform their function.

19.01-21

Table 19.1-69—U.S. EPR Risk-Significant Human Actions based on FV Importance – Level 1 Fire Events shows the risk-significant human actions based on the FV importance measure. The most important operator actions are operator failure to recover room cooling locally, failure to initiate RHR cooling in four hours and failure to transfer to the RSS following an MCR fire. The first action reflects the importance of ventilation dependencies in the plant risk in general. The second and third actions are required in order to mitigate the two most important fire sequences (i.e., a fire in the ~~MSS/MFWS~~MFW/MS valve room with MSIVs failure to isolate and a fire in the MCR).

Table 19.1-70—U.S. EPR Risk-Significant Human Actions based on RAW Importance – Level 1 Fire Events shows the risk-significant human actions based on the RAW importance measure. Only four operator actions are considered important based on their RAW value: transfer to the RSS following an MCR fire, operator failure to initiate RHR cooling in four hours, operator failure to recover room cooling locally, and operator failure to initiate a feed and bleed for transient events. The very high RAW of the failure to transfer to the RSS can be explained by the fact that this event is assumed to lead directly to core damage.

The impact on the CDF of the assumptions specific for the fire events modeling is also analyzed. The fire CDF is found to be sensitive to an assumption of a fire affecting both an MSRT and an MSIV. The modeling assumption on a complete separation of the safety and non-safety divisions in the CSR is also found to have a high impact on the fire CDF.

19.1.5.3.2.7 Uncertainty Analysis

The results of the uncertainty evaluation for the Level 1 Fire Events CDF are presented in Figure 19.1-18—U.S. EPR Level 1 Internal Fire Events Uncertainty Analysis Results – Cumulative Distribution for Fire Events CDF.

The uncertainty results are summarized below:

- CDF Internal Fire Events Mean Value: 2.1E-07/yr.
- CDF Internal Fire Events 5% Value: 9.5E-09/yr.
- CDF Internal Fire Events 95% Value: 7.0E-07/yr.

This ninety-fifth percentile CDF value is more than two orders of magnitude below the NRC goal of 1E-04/yr.

19.01-41

Uncertainty on the Level 1 Fire PRA results is quantified using a process similar to that described for internal events in Section 19.1.4.1.2.6 Section 19.1.4.1.2.7. Parametric uncertainty was represented by selecting an uncertainty distribution for each parameter type including fire initiating events, as described in Section 19.1.4.1.2.6 Section 19.1.4.1.2.7. Because the internal fire intiating event frequencies are based on limited information, CNI are used to model uncertainties in the estimated values. The CNI distribution applies because there is large uncertainty in the value of the parameter, and the shape of the distrubiton is basically unknown. These distrubtions are shown associated with the fire scenario frequencies in Table 19.1-64—Fire Scenarios Description and Frequency Calculation. The modeling uncertainty was represented with limited scope by adding uncertainty to the success criteria of EFW pumps and primary relief valves, and by adding uncertainty to the times to overheat for electrical equipment on a loss of HVAC, and to the effectiveness of creative alternate cooling means. These modeling uncertainties are described in detail in Section 19.1.4.1.2.6.

The results of the uncertainty analysis for fire events are shown in Figure 19.1-18—U.S. EPR Level 1 Internal Fire Events Uncertainty Analysis Results—Cumulative Distribution for Fire Events CDF. Two distributions are presented: one that only incorporates parametric uncertainty and one that incorporates the three cases of modeling uncertainty in addition to the parametric uncertainty. The inclusion of

Table 19.1-62—U.S. EPR Fire Areas and Corresponding Fire Areas Modeled in the PRA (PFAs) Sheet 2 of 4

Building	Elevation	Fire Area	Summarized Description of the Rooms Corresponding to the Fire Area	PRA Fire Area (PFA)	Simplified PFA Description
Safeguard Building 1		FA-1UJH-03	Pump Room, Division 1	PFA-SB 1-MECH	Pump room of Safeguard Building 1
		FA-1UJH-04 (cable floor sub area)	Cable Shaft and Cable Floor, Division 1	PFA-SB 1-AC	AC switchgear room, Division 1
		FA-1UJH-06	Switchgear Room, Division 1		
		FA-1UJH-04	DC Equipment Room, I&C Cabinets Room, Division 1	PFA-SB 1-DC	DC and I&C rooms, Division 1
		FA-1UJH-05	Battery Room, Division 1	PFA-BATT1	Battery room, Division 1
Safeguard Building 1 (Valve room)		FA-1UJH-03 (valve room sub area)	MFW/~~ and ~~MS Valve Room, Division 1	PFA-VLVR1	MFW~~S~~/MS~~S~~ valve room, Divisions 1 and 2
		FA-2UJH-10	MFW/~~ and ~~MS Valve Room, Division 2		

19.01-21

Table 19.1-62—U.S. EPR Fire Areas and Corresponding Fire Areas Modeled in the PRA (PFAs)
Sheet 4 of 4

Building	Elevation	Fire Area	Summarized Description of the Rooms Corresponding to the Fire Area	PRA Fire Area (PFA)	Simplified PFA Description
Safeguard Building 4		FA-4UJH-03	Pump Room, Division 4	PFA-SB 4-MECH	Pump room of Safeguard Building 4
		FA-4UJH-04	Cable Shaft and Cable Floor, Division 4	PFA-SB 4-AC	AC switchgear room, Division 4
		FA-4UJH-06	Switchgear Room, Division 4		
		FA-4UJH-04	DC Equipment Room, I&C Cabinets Room	PFA-SB 4-DC	DC and I&C rooms, Division 4
		FA-4UJH-05	Battery Room, Division 4	PFA-BATT4	Battery room, Division 4
Safeguard Building 4 (Valve rRoom)		FA-4UJH-03 (valve room sub area)	MFW/ and MS Valve Room, Division 4	PFA-VLVR4	MFWSS/MSS valve room, Divisions 3 and 4
		FA-3UJH-10	MFW/ and MS Valve Room, Division 3		
Switchgear Building	-13'	FA-UBA-01	SBO DG Cable Floors and Diesel Tank Rooms	PFA-SWGR	Switchgear Building
	0'	FA-UBA-02	Engine and SBO Control Rooms, Switchgear Room		
	13'	FA-UBA-03	Switchgear and Cable Rooms		
	24'	FA-UBA-04	Battery Room		
Transformer Yard	N/A	FA-UBE-01	Transformer 30BDT01	PFA-xF YARD	Transformer yard
	N/A	FA-UBE-05	Transformer 30BDT02		
Turbine Building	-23' to 65'	FA-UMA-01	Turbine Building	PFA-TB	Turbine Building

19.01-21

Table 19.1-63—Basis for PFA Fire Frequencies
Sheet 2 of 2

PRA Fire Area (PFA)	PFA Description	The Basis for Fire Frequency Estimates Generic Location from RES/OERAB/ S02-01 Component Frequencies from NUREG/ CR-6850	Applied Correction Factor (CF)	PFA Fire Frequency (1/yr)
PFA-xF YARD	Transformer Yard	Transformer	Percentage of components in the PFA	7.2E-03
PFA-VLVR4	~~MS/~~MFW/MS Valve Room, Train 4	Electric Motors, Pumps, Fans	Percentage of components in the PFA CF to account for a larger number of pumps in the U.S. EPR	2.6E-05
PFA-CNTMT	Containment, pressurizer area	Electric Motors	Percentage of components in the PFA	1.9E-05

19.01-21

Table 19.1-64—Fire Scenarios Description and Frequency Calculation
Sheet 1 of 3

Fire Scenario	Description	Effects on Mitigating Systems	Suppression Credited	Frequency (1/yr)	Distirbution Type (parameter)	Basis for Frequency
Fire-SAB 14-AC	Fire in Switchgear Room of SB 4 (or 1)	All class 1E and non class 1E AC Buses in SB 4 unavailable.	No	2.0E-03	Beta (0.5, 250)	PRA FA frequency (2 buildings)
Fire-SAB 23-AC	Fire in Switchgear Room of SB2 (or 3)	All class 1E and non class 1E AC Buses in SB2 unavailable.	No	2.0E-03	Beta (0.5, 250)	PRA FA frequency (2 buildings)
Fire-SAB 14-DC	Fire in the DC Cabinets Room of SB 4 (or 1) - I&C rooms included	All class 1E and non class 1E DC and I&C Buses in SB 4 unavailable.	No	5.1E-04	Beta (0.5, 980)	PRA FA frequency (2 buildings)
Fire-SAB 23-DC	Fire in the DC Cabinets Room of SB2 (or 3) - I&C rooms included	All class 1E and non class 1E DC and I&C Buses in SB2 unavailable.	No	5.1E-04	Beta (0.5, 980)	PRA FA frequency (2 buildings)
Fire-SAB-MECH	Fire in the Pump Room of Any SB	EFWS4, CCWS4, CCW CH2, LHSI4, SAHR unavailable	No	2.0E-02	Beta (0.5, 25)	PRA FA frequency (4 buildings)
Fire-MS-VR	Fire on the top of SB 4 (or 1), in the ~~MS/MF~~MFW/MS valve room 19.01-21	Spurious opening of MSRT on SG4, increase in probability of MS isolation failure on SG3 (set to 0.1) & SG4 (set to 0.5)	No	5.2E-04	Beta (0.5, 960)	PRA FA frequency (2 buildings) * spurious actuation probability

Table 19.1-66—U.S. EPR Important Cutset Groups – Level 1 Fire Events
Sheet 1 of 11

Group No	Cutset Numbers	Group Frequencies	Contribution to CDF (%) Group	Contribution to CDF (%) Cumulative	Sequence Type and a Representative Cutset: Event Identifier	Sequence Type and a Representative Cutset: Event Description	Sequence Description
1	1, 38, 41, 84-89	2.9E-08	16.5	16.5	**Sequence MSSV-16 /MSS-24: Fire MS-VR, MSIV ISO(3), OP RHR / RHR**		
					IE FIRE-MS-VR	Fire in One of Two MFW/MS Valve Rooms With Spurious Opening of 1 MSRIV	A fire in the MFW/MS valve room causes spurious opening of an MSRIV. MSIV 3 and 4 fail open due to the fire, leading to two steam generators blowing down simultaneously. Then failure to align RHR leads to core damage. A variant of this cutset has RHR (or its support systems) failing randomly.
					MSIV TR3 ISO-FIRE	MSIV 3 Fails to Isolate Due to Fire in ~~MS/FW~~MFW/MS Valve Room	
					MSIV TR4 ISO-FIRE	MSIV 4 Fails to Isolate Due to Fire in ~~MS/FW~~MFW/MS Valve Room	
					OPE-RHR-4H	Operator Fails to Initiate RHR Within 4 Hours.	

19.01-21

Table 19.1-66—U.S. EPR Important Cutset Groups – Level 1 Fire Events
Sheet 8 of 11

Group No	Cutset Numbers	Group Frequencies	Contribution to CDF (%) Group	Cumulative	Sequence Type and a Representative Cutset: Event Identifier	Event Description	Sequence Description
9	34, 35	1.3E-09	0.7	70.7	**Sequence MSSV-32: FIRE-MS-VR, MSIV ISO(4), EBS**		
					IE FIRE-MS-VR	Fire in One of Two MFW/MS Valve Rooms With Spurious Opening of 1 MSRIV	A fire in the MFW/MS valve room causes spurious opening of an MSRIV. MSIV 3 and 4 fail open due to the fire, and a third MSIV fails to close. Three steam generators blowing down simultaneously cause an overcooling event, and the operators fail to control reactivity by actuating the EBS.
					MSIV TR3 ISO-FIRE	MSIV 3 Fails to Isolate Due to Fire in ~~MS/FW~~MFW/MS Valve Room	
					MSIV TR4 ISO-FIRE	MSIV 4 Fails to Isolate Due to Fire in ~~MS/FW~~MFW/MS Valve Room	
					LBA10AA002PFC	MSS, Train 1 Main Steam Isolation Valve LBA10AA 002, Fails to Close on Demand	
					OPF-EBS-30M	Operator Fails to Manually Actuate EBS (SLB& ATWS)	

19.01-21

Table 19.1-74—U.S. EPR Level 1 Fire Events Sensitivity Studies
Sheet 3 of 3

Sensitivity Case Group	Case #	Sensitivity Case Description	SC CDF (1/yr)	Delta CDF
11		**Simultaneous Hot Shorts not Considered**		
	11	Simultaneous hot shorts not considered, therefore no inadvertent valve openings for PZR cubicle or MFW/MS valve room fire	1.4E-07	-20%
12		**Assumptions on MS isolation, given a Fire in MFW/MS Valve Room**		
	12a	MSIV3 & MSIV4 isolation not credited for a fire in MFW/MS valve room	7.8E-07	340%
	12b	MSIV3 and MSIV4 assumed to be separated by a fire barrier, for a fire in MFW/MS4 Valve Room	1.5E-07	-17%

19.01-21

Table 19.1-76—Level 2 Fire Events Significant Cutsets and Sequences
Sheet 7 of 16

Release Category	Freq /yr	LRF Fraction	Event Identifier	Event Description	Sequence of Events that Lead to CD and to Containment Failure
Fire RC301	1.26E-13	0.0035%	IE FIRE-MS-VR	Fire in One of Two MFW/MS Valve Rooms With Spurious Opening of 1 MSRIV	**Level 1:** • A fire in the MFW/MS valve room causes spurious opening of an MSRIV. • MSIV 3 and 4 fail open due to the fire, leading to two steam generators blowing down simultaneously. • Failure to align RHR leads to core damage.
			MSIV TR3 ISO-FIRE	MSIV 3 Fails to Isolate Due to Fire in ~~MS/FW~~MFW/MS Valve Room	
			MSIV TR4 ISO-FIRE	MSIV 4 Fails to Isolate Due to Fire in ~~MS/FW~~MFW/MS Valve Room	
			OPE-RHR-4H	Operator Fails to Initiate RHR Within 4 Hours.	19.01-21
			L2FLCDES-TRD	Level 2 FLAG: TR1 CDES	**Level 2:** • Sequence enters CET1 High Pressure • Operators depressurize primary • Sequence enters CET Low Pressure • Containment fails before vessel rupture due to hydrogen flame acceleration • In vessel recovery of core fails, core is released from vessel • Significant CCI occurs with no system failures
			L2FLCET1 HI PRESSURE	Level 2 FLAG: CET1 HI PRESSURE	
			L2FLOP DEPRESS	Level 2 FLAG: Depressurization of high CDES by operator	
			L2FLCET LO PRESSURE	Level 2 FLAG: CET LO PRESSURE	
			L2PH VECF-FA(H)	Very early containment failure due to H2 Flame Acceleration (Hi pressure sequences)	
			L2PH INVREC(T-DEP)=N	In-vessel recovery, phenomenological failure given sufficient injection	
			L2PH CCI	Level 2 phenomena: significant MCCI, no system failures	

Table 19.1-76—Level 2 Fire Events Significant Cutsets and Sequences
Sheet 9 of 16

Release Category	Freq /yr	LRF Fraction	Event Identifier	Event Description	Sequence of Events that Lead to CD and to Containment Failure
Fire RC303	4.20E-10	11.6666%	IE FIRE-MS-VR	Fire in One of Two MFW/MS Valve Rooms With Spurious Opening of 1 MSRIV	**Level 1:** ● A fire in the MFW/MS valve room causes spurious opening of an MSRIV. ● MSIV 3 and 4 fail open due to the fire, leading to two steam generators blowing down simultaneously. ● Failure to align RHR leads to core damage. 19.01-21
			MSIV TR3 ISO-FIRE	MSIV 3 Fails to Isolate Due to Fire in ~~MS/FW~~MFW/MS Valve Room	
			MSIV TR4 ISO-FIRE	MSIV 4 Fails to Isolate Due to Fire in ~~MS/FW~~MFW/MS Valve Room	
			OPE-RHR-4H	Operator Fails to Initiate RHR Within 4 Hours.	
			L2FLCDES-TRD	Level 2 FLAG: TRD CDES	**Level 2:** ● Sequence enters CET1 High Pressure ● Operators depressurize primary ● Sequence enters CET Low Pressure ● Containment fails before vessel rupture due to hydrogen flame acceleration
			L2FLCET1 HI PRESSURE	L2FLCET1 HI PRESSURE	
			L2FLOP DEPRESS	Level 2 FLAG: Depressurization of high CDES by operator	
			L2FLCET LO PRESSURE	Level 2 FLAG: CET LO PRESSURE	
			L2PH VECF-FA(H)	Very early containment failure due to H2 Flame Acceleration (Hi pressure sequences)	

Table 19.1-104—U.S. EPR Level 1 Total Events Sensitivity Studies
Sheet 3 of 3

Sensitivity Case Group	Case #	Sensitivity Case Description	SC CDF (1/yr)	Delta CDF (%)
11		**Physical Separation of Non-safety Cables**		
	11	Fire in CSR kills Safety Train 4 and all Non-Safety Divisions	8.3E-07	58%
12		**Simultaneous Hot Shorts not Considered**		
	12	Simultaneous hot shorts not considered, therefore no inadvertent valve openings for PZR cubicle or MFW/MS valve room fire	4.9E-07	-7%
13		**Assumptions on MS isolation, given a Fire in MFW/MS Valve Room**		
	13a	MSIV3 & MSIV4 isolation not credited for a fire in MFW/MS valve room	1.1E-06	114%
	13b	MSIV3 and MSIV4 assumed not to be separated by a fire barrier, for a fire in MFW/MS4 Valve Room	5.0E-07	-6%
14		**Combination of Different Cases**		
	14	Combination of Cases 1b, 2b, 2e, 3a, 3b, 5b, 6a	7.5E-06	1318%

19.01-21