**Response to**

**Request for Additional Information No. 120 (1536), Revision 0**

**10/31/2008**

**U. S. EPR Standard Design Certification**
**AREVA NP Inc.**
**Docket No. 52-020**
**SRP Section: 19 - Probabilistic Risk Assessment and Severe Accident Evaluation**
**Application Section: FSAR 19.1.2**

**QUESTIONS for PRA Licensing, Operations Support and Maintenance Branch 1 (AP1000/EPR Projects) (SPLA)**

**Question 19-228:**

Follow-up on Question 19.01-15. Table 19.01-15-1 of AREVA's response to RAI No. 54.

a) Page 22, No. 2, according to this peer review finding, the component boundaries need to be reviewed and verified against the generic data sources. Since the review action is necessitated, this finding should not be classified as documentation issue. Furthermore, without conducting a data review, the potential impact on PRA results is assumed to be unknown. Please provide the basis to conclude that the finding would have no impact on the PRA results.

b) Page 27, No. 7, sixth column "AREVA Issue Summary/Classification" does not clearly indicate whether multiple failures from a common cause were included in the initiating event frequency development or not. If not, what is the basis for concluding that this finding would have no impact on the PRA results?

c) Page 29, No. 13, last column "Impact on the PRA Results" states that "Human-induced flooding events will be reconsidered after maintenance procedures are available." Please identify the applicant (AREVA or COL) responsible for performing this task. If AREVA will be developing the maintenance procedures, when will they be completed? If the COL applicant will be developing these procedures, please identify a COL action item to perform this task. Since maintenance procedures are currently unavailble, perform a sensitivity study to estimate the increment in flooding CDF by including human-induced flooding in the assessment. Additionally, this peer review finding indicates that failures of components such as gaskets, expansion fittings, seals, etc. are also excluded from the flooding analysis. Thus, justify their exclusion and describe the impacts on PRA results.

d) Pages 32, No. 17, please provide the justification for screening the flooding scenarios that could impact multiple divisions as a result of ESWS/DWS pipe break.

e) Page 34, No. 19 and No. 20, these two peer review findings indicate that the potential impacts of barrier failure have not been adequately assessed and door failure should not be credited in the flooding model, respectively. Since, annulus flooding is the largest contributor to the flooding CDF, please provide the impact of these findings on the PRA results. It should be noted that, bounding in modeling may not resolve the identified inappropriate practice issue.

f) Page 40, No. 29, please clarify the assessment (i.e., probabilistic, deterministic, or blended) used to evaluate the potential impacts due to excessive heat loads, electrical loads, humidity, HVAC dependency, etc. Also, provide the basis to conclude that these conditions would have no impact on the PRA results.

g) Page 41, No. 31, it is not clear whether all spatial and environmental hazards have been evaluated or not, please clarify. If not, provide the basis to conclude that the unanalyzed hazards would have no impact on the PRA results.

**Response to Question 19-228:**

**(a)** A review of the components boundaries from the generic data sources is summarized in Table 19-228-1. The corresponding finding was classified as a documentation issue, because this generic data review was not fully documented. This generic data review was performed to determine the level of detail required for each component in the fault tree analysis. For example, based on the review of generic data, it was determined that the solenoid operated valves for pneumatic valves need to be modeled separately from the valve itself, but that the pump breakers do not need to be modeled separately from the pumps.

Since this review was performed prior to the PRA model development, it provides the basis to conclude that this finding would have no impact on the PRA results, and that the PRA components are modeled with an adequate level of detail.

**Table 19.228-1—Definition of the Component Boundaries for the Major PRA Components**

| Component | Component Boundary |
|---|---|
| Various sized motor driven pumps | Pump body, seal water cooler, seal water supply, motor air cooler, oil pump, oil cooler, pump breaker |
| Heat exchangers | Heat exchanger |
| Motor operated valves | Valve body, valve operator, and limit or torque switches on valve |
| Pneumatic valves | Valve body, valve operator, and limit or torque switches on valve |
| Solenoid operated valves | Valve body, valve operator, and limit or torque switches on valve |
| Fans and Compressors | Body, breaker |
| Electrical bus | Busbar |
| Diesel generators | Generator, diesel engine, preheater, prelubrication, cooler. Auxiliary systems: fuel & lube oil supply (day tanks), starter system (compressed air system/batteries), exhaust gas system (silencer), air intake system (filter air intake dampers), instrumentation & control equipment (control panel/monitoring/open-loop controls) |
| Inverters/Rectifiers | Static converter, closed-loop controls, monitoring equipment |
| Batteries | Battery |
| Circuit breakers | Breaker |

**(b)** Multiple failures due to common cause events are explicitly included in the initiating event frequency development. These common cause failures include:

- Common cause failures of the running pumps leading to losses of the operating systems such as closed cooling water system (CLCWS), component cooling water/essential service water (CCW/ESW), are included in the loss of balance of plant (LBOP) and loss of component cooling water (LOCCW) initiators.

- Common cause failures of the running cooling tower fans leading to losses of the operating systems (CCW/ESW), are included in the LOCCW initiators.
- Common cause failures of the valves (to open) leading to losses of the operating systems such as auxiliary cooling water system (ACWS), CCW/ESW, are included in the LBOP and LOCCW initiators.
- Common cause failures of multiple isolation valves (to close) are included in the intersystem loss of coolant accident (ISLOCA) events.

These common cause events are not specifically identified in the Initiating Events (IE) notebook even though they are shown in the corresponding IE cutsets. This is the reason this was classified as a documentation related finding, and it was concluded that it would have no impact on the PRA results.

**(c)** To estimate effects on the flooding core damage frequency (CDF) from the human-induced flooding events, a summary evaluation was performed, as follows. The significant operational flooding events were reviewed to identify occurrences and types of the human-induced floods.

The following types of events could lead to human-induced floods:

- Maintenance on a system that is not isolated.
- Spurious valve operation or valves rupture while system is open for maintenance.
- System vent valve or other valve left open during system restoration.
- Inadvertent tank overflow during tank fill.
- Inadvertent actuation of a fire water system.

Some of these events (due to ‘systems open for maintenance’, for example) are more likely to occur during shutdown operation. Over 80 percent of the historical maintenance-induced floods have occurred in shutdown. In the U.S. EPR PRA, floods induced due to maintenance in shutdown are not likely to have significant risk impact, because it is assumed that an entire train is out for maintenance and such floods are not likely to propagate to a different Safeguard Building.

Maintenance activities are less likely to occur during power operation. Industry data shows that the historical frequency of significant (greater than 2000 gallons released) human-induced flooding at-power is low. There have been four events of this type, three of which were in the Turbine Building. The operational experience covered by this data includes over 9000 reactor-years, giving human-induced flooding at-power a point estimate frequency of:

A. 3.3E-04/yr in the Turbine Building.
B. 1.1E-04/yr in the Safeguard Buildings (total for all Safeguard Buildings).
C. 4.4E-04/yr the total flooding frequency for all areas.

The U.S EPR PRA used the following flooding point estimate frequencies:

A. 3.3E-02/yr in the Turbine Building.
B. 9.9E-03/yr in the Safeguard Buildings (total for all Safeguard Buildings).
C. 4.3E-2/yr the total flooding frequency for all areas.

Based on the comparison presented above, a contribution from the human-induced floods is not likely to change the flooding frequencies significantly (less than 1.5 percent), and is not expected to have a significant impact on the PRA insights.

As indicated in the peer-review finding, failures of gaskets, expansion joints, fittings, seals, etc., are not included in the flooding frequencies. The reasons for the exclusion are:

- Limited information on location of these components is available at this phase of design.
- Limited failure data is available on these components.
- Walkdowns can not be conducted to estimate other spatial effects of these failures.

Comparing the initiating event frequencies estimated for the U.S. EPR with industry flooding data, explicit modeling of these components is not expected to have a significant impact on the U.S. EPR PRA insights.

As described in U.S. EPR FSAR Tier 2, Section 13.5, the COL applicant is responsible for the development of plant procedures, including maintenance procedures. Assumption number 10 in U.S.EPR FSAR Tier 2, Table 19.1-109—U.S. EPR PRA General Assumptions (refer to RAI 26, Supplement 2, Response to Question 19-166), states that human errors during maintenance are not considered as possible initiators. This PRA assumption will be re-evaluated as part of the PRA maintenance and update process.

**(d)** Item No. 17, peer review finding IF-D7-01, refers to the exclusion from the flooding analysis of the scenarios that could impact multiple divisions, which is based on a qualitative argument. Two systems, the essential service water system (ESWS) and the demineralized water system (DWS), are identified in the internal flooding PRA as having a high flooding potential.

A flood induced by a DWS break could flood one Fuel Building division above ground level. In that case, propagation could impact either the neighboring division of the Fuel Building (FB) or the adjacent Safeguard Building (SB) – both these buildings are already assumed to be flooded in the FB flooding scenario, therefore an impact from the DWS large flood is already modeled in the flooding PRA.

A flood induced by an ESWS break could release enough water to flood one Safeguard Building above Elevation +0.0 feet. If water were to reach that elevation, the presence of doors and other openings could potentially lead to a flood scenario affecting multiple divisions. Such a scenario is screened out of the flooding analysis, as discussed in the U.S. EPR FSAR Tier 2, Section 19.1.5.2.2.5, based on the following rationale:

- A high sump level in any SB would automatically isolate the corresponding ESWS train by means of closing an motor operated valve (MOV) and would also automatically trip the pump. Once the pump is tripped, the maximum level that the flood can reach is below Elevation +0.0 feet, since the ESWS draws its inventory from the ultimate heat sink (UHS) basin, which is located below ground level.

- If automatic isolation were to fail, a flooding event of this magnitude would be detected by the operators who could manually terminate the flood (by isolating the system or shutting off the pump) before it reaches Elevation +0.0 feet.

The combination of these features makes such a flooding event very unlikely and that is the rationale for qualitatively screening it out.

A quantitative approach can also be used to screen such a scenario by assessing failure probabilities for the two mitigating functions credited above. If these mitigating functions were to fail, the worst failure scenario is postulated, affecting two connected SBs and the FB. The total CDF of this scenario is estimated below:

- The frequency of an ESWS-induced flooding in a Safeguard Building is calculated by summing the contributions of the ESWS piping to the flooding frequencies of SB1/4 and SB2/3: 7.0E-04/yr

- The probability of the automatic isolation failure is dominated by the failure of the process automation system (PAS), which fails both mitigating functions. The PAS failure probability is estimated to be: 1.0E-03.

- A basic failure probability is assigned for the operator action, assuming that a local action is required to shut down the pump and that the time available is 50 minutes before the flood reaches ground level: 2.0E-02

- The conditional core damage probability (CCDP) for flooding of two SBs (4 and 3) and the FB is calculated to be 4.0E-05.

Therefore the CDF for a scenario involving a large flood event would approximately be:

7.0E-04/yr x 1.0E-03 x 2.0E-02 x 4.0E-05 = 6.0E-13/yr.

Based on this evaluation, it is concluded that this scenario can be screened on a quantitative basis.

**(e)** As explained in U.S. EPR FSAR Tier 2, Section 19.1.5.2.1.3 and in the response to RAI Question 19-52, the annulus flooding scenario is modeled as follows:

- Operator action isolation is credited with a grace period of 30 minutes. This grace period was chosen based on the following: in the worst case fire water distribution system (FWDS) break, if the flood is terminated within 30 minutes, water would remain below Elevation +0.0 feet and there is no structural concern associated with this water column.

- If isolation fails, the water column is assumed to challenge the doors that separate the annulus from Safeguard Building 2 and 3. A failure probability was estimated for each of the doors, leading to two flooding scenarios where one or two SBs were flooded (FLD-ANN-SAB2 and FLD-ANN-SAB23).

- If no door fails, water eventually reaches the lowest electrical penetration located at Elevation +16 feet on the shield wall side of the annulus (scenario FLD-ANN-ALL). This was assumed to have a 50 percent chance of failing all penetrations and resulting in core damage.

If failure of the doors between the annulus and the SBs is not to be modeled, which would also imply that barrier structural failure is not to be considered, the approach to modeling this scenario would change as discussed below.

Without the concern for door opening, the operators will have more time to isolate, because the new height of concern becomes the elevation of the lowest electrical penetration (Elevation +16 feet) and not the elevation of the doors (Elevation +0.0 feet). The operator action is re-evaluated based on the time that it would take for the water column to reach Elevation +16 feet (calculated to be 73 minutes). The human error probability (HEP) is re-calculated based on that timing and with a nominal stress for diagnosis and action. The resulting HEP is 2.0E-04.

The CDF resulting from this event would become:

CDF = Initiating Event Frequency x HEP x Probability that the penetrations would fail

CDF = 3.2E-04/yr x 2.0E-04 x 0.5 = 3.2E-08/yr

Should the entire fire water inventory (approx. 600,000 gallons (80,000 $ft^3$)) be released into the annulus, the resulting water column would reach Elevation +17 feet, slightly above the lowest electrical penetrations.

The current CDF for all annulus floods is equal to the sum of three scenarios (FLD-ANN-ALL, FLD-ANN-SAB2 and FLD-ANN-SAB23), which is equal to 3.2E-08/yr (dominated by FLD-ANN-ALL CDF).

The two approaches yield similar results. Not crediting door failures does not change the results and insights from the U.S. EPR PRA internal flooding analysis. Based on the fact that the doors are not designed to withstand a water column from the annulus side, it is judged that the current approach is more realistic than the approach discussed above.

**(f)** Item No. 29 corresponds to ASME PRA Standard supporting requirement SY-A19, which requires identification of system conditions that could cause a loss of desired system function, including excessive heat loads, electrical loads, and humidity.

Potential impacts on the PRA structures, systems and components (SSC), due to excessive heat loads and humidity, are explicitly modeled in the PRA and discussed as follows:

- Excessive heat load impacts due to the heating, ventilation and air conditing (HVAC) failure (including the HVAC dependencies) are explicitly included in the U.S. EPR PRA model by modeling the HVAC system as a major supporting system and including the HVAC failures in the fault trees for the majority of the PRA components (all electrical buses, pumps). The scope of this analysis is discussed in the response to Question 19-62.

- Excessive heat loads impacts due to the fire events are modeled explicitly, by failing all the PRA components in the corresponding fire area.
- Humidity impacts due to the flood events are modeled explicitly, by failing all the PRA components in the corresponding flood area. ISLOCAs or EFW tank leak events are included in this evaluation.

Equipment located inside containment is assumed to be qualified for loss of coolant accident (LOCA) and steam line break events. Similarly, the main steam/main feedwater (MS/MFW) equipment outside containment is assumed to be qualified for High Energy Line Breaks (HELB).

Environmental effects of a LOCA outside containment (ISLOCA) are also explicitly taken into account in fault trees by not crediting mitigating equipment located in the affected SB.

Potential impacts from electrical loads are not explicitly modeled. The failure of a 6.9 KV switchgear is assumed to fail any connected buses and associated trains. It could be considered to implicitly include potential electrical overload failures.

The PRA model adequately takes into account the impact of environmental loads. Item 29 (peer-review F&O SY-A19-01) finds that the discussion of these loads and their impact on system models, as provided in the system notebooks, is insufficient. This is the reason why Item 29 was classified as a documentation-related finding, and it was concluded that it would have no impact on the PRA results.

**(g)** Item No. 31 corresponds to ASME PRA Standard supporting requirement SY-B8, which requires identification of spatial and environmental hazards that may impact multiple systems or redundant components, and their inclusion in the system fault trees or accident sequences. SY-B8 gives in the example use of the plant walkdown as a source of information regarding these hazards and their impacts.

As stated in the finding, in the design certification phase, plant walkdowns cannot be conducted. Therefore, no information is available to support identification of the some of the spatial hazards, like water spray impacts or pipe whips. Given that in the flooding analysis pipe breaks are assumed to disable all equipment in the flooding area, exclusions of these spatial impacts is considered to have no significant risk impact. All other spatial and environmental hazards are assumed to be covered in the analysis discussed in the response to Question 19-228(f), which includes the PRA modeling of the HVAC failures and fire and flood events.

As discussed in the response to Question 19-228 (f), equipment in the containment is assumed to be qualified for LOCA events and steam line breaks, and the MS/MFW equipment outside containment is assumed to be qualified for the HELBs.

This finding could also be classified as a “limited information” finding, given that plant walkdowns cannot be conducted. Based on the PRA modeling of the internal hazards and HVAC failures, it was concluded that the finding would have no impact on the PRA results in the design certification phase.

**FSAR Impact:**

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