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MFN 08-639

Docket No. 52-010

August 22, 2008

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555-0001

Subject: **Response to NRC Request for Additional Information Letter No. 206 Related to NEDO-33411, "Risk Significance of Structures, Systems, and Components for the Design Phase of the ESBWR," Revision 0 – RAI Numbers 17.4-18 through 17.4-47**

Enclosure 1 contains the GE Hitachi Nuclear Energy (GEH) responses to the subject NRC RAIs originally transmitted via Reference 1.

Enclosure 2 contains mark-ups to NEDO-33411, "Risk Significance of Structures, Systems, and Components for the Design Phase of the ESBWR", Revision 0 in response to RAI 17.4-18, 17.4-20, 17.4-24, and 17.4-25.

Responses to RAIs 17.4-27, 17.4-29, 17.4-32, 17.4-33, 17.4-34, 17.4-36, 17.4-38, 17.4-39, and 17.4-45 may involve changes to NEDO-33411 however mark-ups are not provided at this time because the specific changes depend on re-quantification results associated with Revision 4 of NEDO-33201, "ESBWR Probabilistic Risk Assessment".

If you have any questions or require additional information, please contact me.

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

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NRO

Reference:

1. MFN 08-500, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, GEH, *Request For Additional Information Letter No. 206 Related to NEDO-33411, "Risk Significance of Structures, Systems, and Components for the Design Phase of the ESBWR," Revision 0*, dated May 28, 2008.

Enclosures:

1. Response to NRC Request for Additional Information Letter No. 206 Related to NEDO-33411, "Risk Significance of Structures, Systems, and Components for the Design Phase of the ESBWR," Revision 0 - RAI Numbers 17.4-18 through 17.4-47.

2. Mark-ups to NEDO-33411, "Risk Significance of Structures, Systems, and Components for the Design Phase of the ESBWR" in Response to NRC Request for Additional Information Letter No. 206.

cc:	AE Cubbage	USNRC (with enclosure)
	RE Brown	GEH/Wilmington (with enclosure)
	DH Hinds	GEH/Wilmington (with enclosure)
	eDRF	0000-0088-0576

Enclosure 1

MFN 08-639

Response to NRC Request for Additional Information Letter No. 206 Related to NEDO-33411, "Risk Significance of Structures, Systems, and Components for the Design Phase of the ESBWR," Revision 0

RAI Numbers 17.4-18 through 17.4-47

NRC RAI 17.4-18

Section 2.1 of NEDO-33411, Revision 0, states "The common industry practice is to apply recommended thresholds for plants with CDFs in the 1E-4/yr to 1 E-6/yr range (F-V greater than or equal to 0.05, Risk Achievement Worth (RAW) greater than or equal to 2.0)." The staff requests that GEH clarify in NEDO-33411 the Fussell-Vesely (F-V) value used in this statement since the F-V values typically used in common industry practice are 0.005 at the component level and 0.05 at the system level.

GEH Response

In Revision 1 of NEDO-33411, this statement in Section 2.1 will be clarified to define ranges of values for components and systems that are typically used in the industry.

That is it will read "The common industry practice is to apply recommended thresholds for plants with CDFs in the 1 E-4/yr to 1 E-6/yr range (F-V greater than or equal to 0.005 at the component level, 0.05 at the system level, and RAW greater than or equal to 2.0)."

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

NEDO-33411 is being updated as shown in the attached mark-up.

NRC RAI 17.4-19

Section 2.1 of NEDO-33411, Revision 0, provides the common cause threshold criteria (i.e., common cause basic events having a RAW greater than or equal to 50 is considered potentially risk-significant). The RAW for a common cause event generally reflects the relative increase in Core Damage Frequency/Large Release Frequency (CDF/LRF) that would exist if a set of components or an entire system was made unavailable. GEH did not provide the basis for the common cause threshold criteria (i.e., a basis was not found in NEDO-33411 or any of its references). The following suggest that a common cause threshold of 50 may be too high and inappropriate:

- *A RAW of 50 equates to a risk increase of about 6E-7/yr (based on ESBWR internal events CDF of 1.22E-8/yr), which is above GEH's CDF risk increase threshold of 1E-7/yr that is discussed in Section 17.1.2.2 of NEDO-33201, Revision 2 (i.e., "An increase in CDF risk of greater than or equal to 1E-7/yr is considered risk-significant for the design certification ESBWR PRA").*
- *Common cause failure probabilities generally have higher uncertainties; therefore, the RAWs associated with common cause basic events have higher uncertainties.*
- *Technical guidance report NEI 00-04, Revision 0, 10 CFR 50.69 SSC "Categorization Guideline" (NEI 00-04 is endorsed by, with appropriate clarifications and exceptions, Regulatory Guide (RG) 1.201, "Guidelines for Categorizing Structures, Systems, and Components in Nuclear Power Plants According to Their Safety Significance") uses a common cause RAW greater than or equal to 20 (which equates to a risk increase of about 2.0E-7/yr for the ESBWR).*

The staff requests that GEH provide the basis for the common cause threshold criteria (i.e., common cause basic events having a RAW greater than or equal to 50 is considered potentially risk-significant).

GEH Response

The 1E-7/yr criterion for a risk-significant change in CDF is primarily oriented toward design changes or the importance measures of a single component. As shown in NEDO-33201 Section 17.1.2.2, this translates to a RAW value of approximately 9.2; the single-component threshold is then conservatively set to a RAW value of 5. To categorize components as risk significant based on common cause failures, the RAW value of 50 was chosen based on multiple factors:

1) The significant redundancy in ESBWR design necessitates that "CCF of all" events are the primary CCF contributors to plant risk. For example, there are 8 depressurization valves (DPVs) in the automatic depressurization system (ADS), but only 4 are required for system success. Only combinations of 2, 3, or all DPVs failing due to common cause are modeled. As such, only the "CCF of all DPVs" event contributes to CDF/LRF. Since the risk-significant CCF events

typically involve many components, a RAW value of 50 was deemed appropriate to emphasize component, rather than basic event, significance.

2) The guidance presented in NEI 00-04 uses a RAW significance threshold for CCF events (20) that is a factor of 10 greater than the threshold for single failure events (2). For consistency, the CCF threshold for ESBWR (50) is also a factor of 10 greater than the ESBWR single failure threshold (5).

3) The CCF modeling in the ESBWR PRA is conservative in that only combinations of 2, 3, and all components are considered. That is, if there are eight components in a CCF group, it is assumed that if more than three fail, all fail. In addition, no recovery of equipment is modeled, which exaggerates the importance of CCF events that contribute to long-term failures. These conservative modeling techniques do not contribute significantly to CDF (Fussell-Vesely values are low) but do have high RAW values because of their potentially (and sometimes, for long-term failures, artificially) significant impact.

4) The current guidance in NEI 00-04 suggests that risk significant CCF events have a RAW value of greater than or equal to 20. This value is used for current operating plants, which have CDF values of approximately 1E-6/yr and higher. For a CDF of 1E-5/yr, a RAW of 20 corresponds to a CDF of 2E-4/yr if the CCF event is true, which corresponds to a CDF increase of 1.9E-4/yr. A risk-significant increase in CDF is typically accepted as 1E-6/yr for operating plants, so it is assumed to be acceptable to have a RAW criterion for CCF events that leads to CDF changes that exceed the threshold for risk significance. A RAW value of 50 for ESBWR correlates to a CDF increase of approximately 6E-7, much less than the increase for an operating plant with a RAW of 20 and much closer to the defined risk-significant CDF increase (6E-7/yr vs the defined "significant" 1E-7/yr increase) than an operating plant (1.9E-4/yr vs 1E-6/yr).

5) Uncertainties in the CCF data are dealt with primarily by a combination of two factors:

   a. The Multiple Greek Letter (MGL) factors used are either generic data or bounding estimates based on the EPRI ALWR URD. The most uncertain components, such as DPVs and vacuum breakers, use the bounding MGL approximations to account for data uncertainty.

   b. As discussed in paragraph 3, the RAW criterion of 50 leads to a much smaller change in CDF than the criterion of 20 for currently operating plants. This significant amount of extra "margin" also helps to bound potential uncertainties in the CCF data for the ESBWR PRA.

The use of 50 as a RAW criterion for CCF event risk significance is justified because of the ESBWR design certification PRA modeling practices and PRA results. The criterion is similar, relative to the single failure threshold, to the established thresholds as described in paragraph 2. As discussed in paragraphs 1 and 3, the modeling practices lead to more events that are potentially damaging (high RAW) while providing little contribution to results (low F-V). Paragraph 4 discusses the impact of the low CDF on risk-significance thresholds. Uncertainties in CCF data are discussed in paragraph 5.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33411 changes will be made in response to this RAI.

NRC RAI 17.4-20

Section 2.1 of NEDO-33411, Revision 0, states "Basic events that do not meet the threshold values are considered not risk-significant." The staff requests that GEH clarify in NEDO-33411 the "not risk-significant" used in this statement since basic events or SSCs not meeting the risk threshold values may be risk-significant under other methods (e.g., regulatory treatment of nonsafety systems (RTNSS), seismic margins analysis (SMA), expert panel).

GEH Response

The purpose of NEDO-33411 is to support Phase 1 of the design reliability assurance program (D-RAP), as described in Section 3.1 of NEDO-33289 (ESBWR Reliability Assurance Program Plan). Revision 1 of NEDO-33411 will more clearly emphasize this scope.

Phase 1 of the D-RAP provides assurance that risk-significant component reliability assumptions made in the design certification PRA are retained during the detailed design process and are used in ongoing operational reliability assurance activities, such as the Maintenance Rule. Accordingly, the D-RAP only considers components that are modeled in the PRA. Components that are not modeled in the PRA are outside the scope of D-RAP because there is no PRA-modeled reliability that can be "maintained".

In addition, some components modeled in the PRA are not risk significant based on PRA results, but are risk significant based on other methods, e.g., seismic margins assessment (SMA). These components are not within the scope of D-RAP Phase 1 because their assumed PRA reliability is not what causes them to be risk significant.

For example, the Standby Liquid Control System squib valves are modeled in the PRA. They are not risk significant based on RAW and F-V, but are risk significant under the SMA. These components are considered risk significant, but not because of the assumed "fail to open" reliability data. In this case, ensuring that their reliability for opening on demand through D-RAP would not address the risk significance of the components; rather, seismic programs would be used to ensure adequate seismic capacity.

The statement in Section 2.1 will be revised in Revision 1 of NEDO-33411. The basic events that are modeled in the PRA but do not meet the risk thresholds for F-V and RAW will still be considered for risk significance by the expert panel.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

NEDO-33411 is being updated as shown in the attached mark-up.

NRC RAI 17.4-21

Section 2.1 of NEDO-33411, Revision 0, presents GEH's methodology for determining risk significance of SSCs using RAWs and F-Vs. Under this methodology, each risk hazard/contributor (i.e., internal/fire/flood/high winds at power and shutdown) is evaluated separately. This helps avoid reliance on a combined result that may mask the results of individual risk contributors. However, it is desirable in a risk-informed process to also understand risk significance from an overall perspective (e.g., an integrated importance assessment that combines the risk hazards). For example, if non-common cause basic event "a" has an internal events RAW of 4 and F-V of 0.001 (with internal events CDF = 1.22E-8/yr) and a high wind RAW of 45 and F-V of 0.001 (with high wind CDF = 1.3E-9/yr), then basic event "a" would be considered not risk-significant based on GEH's risk significance importance criteria. However, from an integrated importance assessment the RAW would be about 8 (i.e., a weighted-average importance based on the importance measures and the risk contributed by each hazard using the equations in Section 5.6 of technical guidance report NEI 00-04, Revision 0), which would suggest that basic event "a" may be risk-significant from an overall perspective. An integrated assessment allows the expert panel to determine whether risk significance of the SSC should be based on significance for individual hazards or from the overall integrated results.

The staff requests that GEH discuss how risk significance evaluations under NEDO-33411, Revision 0, considered integrated importance assessments (i.e., risk significance based on an overall assessment that combines the risk hazards). If integrated importance assessments were not considered in the risk significance evaluations under NEDO-33411, then provide the basis for not considering these integrated importance assessments or incorporate them in the risk significance evaluations under NEDO-33411.

GEH Response

According to NEDO-33411, the significance threshold for RAW is considered to be 5. However, the RAW required to achieve a "significant change" in CDF, which is defined as 1E-7/yr, is actually 9.2 for the internal events Level 1 model. As such, there is already significant margin built into the RAW significance threshold to account for uncertainties.

The risk significance evaluation in NEDO-33411 is considered an integrated importance assessment based on the wide spectrum of PRA analyses considered:

- Level 1 / Level 2 At-Power Internal Events
- Level 1 / Level 2 At-Power Fire
- Level 1 / Level 2 At-Power Flood
- Level 1 / Level 2 At-Power High Winds
- Shutdown Internal Events
- Shutdown Fire
- Shutdown Flood

- Shutdown High Winds

Following the F-V and RAW thresholds based on top event values discussed in Section 2.1, it is reasonable to assume that all risk-significant basic events will exceed one of the threshold criteria in at least one of the twelve PRA analyses.

All of the PRA models are developed in a bounding manner with conservative assumptions to account for equipment reliability, design, and operating uncertainties. This is especially true of the Fire and Flood models, which are documented in detail in NEDO-33201 Sections 12 and 13, respectively. Because of the bounding assumptions made in the external events models, it could significantly distort component and system importances to numerically combine the results of multiple analyses.

The methodology for PRA risk-significance determination in NEDO-33411 considers the results of the twelve PRA models listed above. This comprehensive list of at-power, Level 1 and Level 2, and external events PRA models is considered sufficient to capture all risk significant components modeled in the PRA. Mathematically combining the results of multiple models is not considered necessary; it is assumed that any truly risk significant components would appear in at least one of the twelve model results. Additionally, the expert panel may include modeled components that do not qualify as risk-significant based on PRA results.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33411 changes will be made in response to this RAI.

NRC RAI 17.4-22

From Section 2.1 of NEDO-33411, Revision 0, the risk significance criteria for the ESBWR is not based on common industry practice but is a function of the ESBWR base CDF/LRF. This is acceptable under NRC RG 1.174. However, as indicated in RG 1.174, uncertainties associated with CDF, LRF, RAW, and F-V could mask the importance of SSCs (e.g., importance measures computed by the PRA may indicate that a component does not meet the RAW or F-V criteria, but sensitivity studies may show that other conditions might lead to the component being risk significant). Uncertainties in human error rates, common cause failures, and component data contribute to the uncertainties in CDF, LRF, RAWs, and F-Vs.

The staff requests that GEH discuss how these uncertainties were addressed in the risk significance evaluations under NEDO-33411, Revision 0 (i.e., how the sensitivities of importance measures caused by uncertainties in the parameter values were addressed in the risk significance evaluations).

GEH Response

The uncertainties in human error rates, common cause failures, and component data have been implicitly addressed through a multi-faceted approach:

1) The human reliability numbers in the PRA are all screening values based on the methodology outlined in Section 6 of NEDO-33201. These values are conservatively generated to bound uncertainty in plant design and plant procedures.

2) Component reliability data is either based on historical generic data from the EPRI ALWR URD or estimated based on conservative engineering judgment. As discussed in paragraph 1, various sensitivity studies have been done to show that the PRA results are not significantly dependent on data for individual component types.

3) ESBWR plant design provides significant diversity and redundancy such that no particular type of component, plant system, or type of accident is an overwhelming contributor to risk. As shown in many sensitivity studies in Revision 3 of NEDO-33201 Section 11.3, variations in human reliability (11.3.1.1), common cause failures (11.3.1.2), and component reliability (11.3.1.3, 11.3.1.6, and 11.3.1.14) do not have a significant effect on PRA results. Table 11.5-1 shows the UNCERT distribution of ESBWR CDF to be well focused near the mean CDF.

4) As discussed in the GEH response to RAI 17.4-19, the thresholds for risk significance in NEDO-33411 are significantly lower with respect to both CDF/LRF contribution (F-V) and the increase in CDF/LRF (RAW) as compared to the current operating plants. That is, risk significant events based on F-V contribute much less to absolute CDF/LRF in ESBWR than in current plants; risk significant

events based on RAW cause much smaller increases in absolute CDF/LRF in ESBWR than in current plants.

5) The external events models have been developed with significant bounding assumptions to account for uncertainty in equipment location, cable routing, and general spatial layout.

6) Twelve PRA model configurations are used to generate the risk-based, risk significant basic events:

    a. Level 1 / Level 2 At-Power Internal Events
    b. Level 1 / Level 2 At-Power Fire
    c. Level 1 / Level 2 At-Power Flood
    d. Level 1 / Level 2 At-Power High Winds
    e. Shutdown Internal Events
    f. Shutdown Fire
    g. Shutdown Flood
    h. Shutdown High Winds

The ESBWR design certification PRA has been modeled conservatively to bound uncertainties in plant design and operational practices. Operator actions are given limited credit, bounding data for component failures and common cause are used, and external events models make many conservative assumptions to bound potential plant configurations. In addition, the twelve sets of results from the PRA models are considered adequate to define all risk-significant basic events.

Given the conservative nature of the design certification PRA in terms of both the data itself and the modeling practices, the uncertainties in human error probabilities and component / common cause failure data are considered to be adequately treated by the methodology outlined in NEDO-33411.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33411 changes will be made in response to this RAI.

NRC RAI 17.4-23

In Section 2.3 of NEDO-33411, Revision 0, GEH stated that SSCs meeting RTNSS Criterion C or D are considered risk-significant and included in the reliability assurance program (RAP). GEH does not include SSCs that meet RTNSS Criterion A, B, or E, which are considered risk significant based on deterministic methods. (The staff notes that this is contrary to DCD Tier 2, Section 19A.8.2 which states that "All RTNSS systems shall be in the scope of the Design Reliability Assurance Program…") During the design phase of RAP risk-significant SSCs are identified for inclusion in the program by using probabilistic, deterministic, and other methods (e.g., industry experience, expert panel).

The staff requests that GEH include in RAP (i.e., Tables 3 and 6 of NEDO-33411, Revision 0) all SSCs identified as risk-significant under RTNSS (i.e., SSCs meeting Criterion A, B, C, D, or E of SECY-95-132, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems, RTNSS, in Passive Plant Designs). Otherwise, provide the basis for not including in Table 6 of NEDO-33411, Revision 0, the SSCs identified as risk-significant under RTNSS Criterion A, B, or E.

GEH Response

As discussed in the GEH response to RAI 17.4-20, NEDO-33411 is intended to support Phase 1 of the D-RAP; only components that are modeled in the PRA are candidates for Phase 1. Phase 1 of the D-RAP is intended to provide assurance that the risk significant assumptions about component reliability made in the design certification PRA remain valid throughout the detailed design process.

Components not modeled in the PRA do not have an assumed reliability that Phase 1 of the D-RAP can control, and are thus not included at this time.

The SSCs considered risk significant by other deterministic means are tracked in Phases 2 and/or 3 in programs such as the Maintenance Rule.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33411 changes will be made in response to this RAI.

NRC RAI 17.4-24

Based on Section 2.6 and Figure 1 of NEDO-33411, Revision 0, the expert panel did not review the categorization of SSCs determined to be not risk-significant (NRS) from quantified PRA results, seismic margins analysis, and RTNSS. The expert panel plays an important role in reviewing the information that lead to these NRS determinations (e.g., assure the basis used in the categorization is technically adequate, review defense-in-depth implications, review safety margin implications, for additional information see Sections 9.2.2 and 9.2.3 of technical guidance report NEI 00-04, Revision 0). This is particularly important for those safety-related SSCs determined to be NRS from these processes.

The staff requests that GEH incorporate into their risk significance methodology the use of an expert panel to review the categorization of SSCs that were determined to be not risk significant from quantified PRA results, seismic margins analysis, and RTNSS. NEDO-33411, Revision 0, should be revised, accordingly, to describe the role that the expert panel has in reviewing these NRS determinations (e.g., assure the basis used in the categorization is technically adequate, review defense-in-depth implications, review safety margin implications).

GEH Response

The GEH process for determining risk significance does include a review of NRS components by the expert panel. The methodology described in Section 2.6 states "the expert panel uses their collective experience to evaluate information from the inputs described in Sections 2.1 through 2.5." The input from Section 2.1 is the PRA-generated list of risk-significant and NRS components. Figure 1 of NEDO-33411 will be revised to clarify this process in Revision 1.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

NEDO-33411 is being updated as shown in the attached mark-up.

NRC RAI 17.4-25

Section 2.1.2 of NEDO-33411, Revision 0, states the following: "For example, a system that has an undeveloped basic event above the risk thresholds is evaluated in a sensitivity study by quantifying the effect of deleting that system entirely. If the revised CDF is less than 1E-6/yr and if the revised results do not introduce any new systems above the risk thresholds, then the system is considered not risk-significant. Undeveloped events representing functions that are safety-related or RTNSS are retained and evaluated with respect to other basic events representing those functions."

An undeveloped event represents a higher-level event that is not broken down into lower basic events because further resolution of that event is not necessary for proper evaluation, or the information necessary for developing this event is not currently available. For example, an undeveloped event may represent: multiple failure modes of a single component, a single train of components, multiple components in parallel, and so on. The staff's understanding of the criterion described in GEH's statement provided above is that undeveloped events not representing functions that are safety-related or RTNSS are subjected to the 1E-6/yr criteria, and undeveloped events representing functions that are safety-related or RTNSS are evaluated with respect to other basic events representing those functions. This 1E-6/yr criterion is equivalent to a RAW of about 80 (i.e., 1E-6/1.22E-8, where 1.22E-8/yr is the internal events base CDF) and this criterion exceeds GEH's CDF risk increase threshold of 1E-7/yr (which is discussed in Section 17.1.2.2 of NEDO-33201, Revision 2). Though this criterion may be appropriate for some undeveloped events (e.g., an undeveloped event representing failure of several systems), it is not appropriate in the general sense. For example, an RAW of five (which represents the individual basic event threshold) may be a more appropriate criterion for an undeveloped event representing a single train of components. An RAW of 50 (which represents the current common cause threshold) may be a more appropriate criterion for an undeveloped event representing a system.

The staff requests that GEH justify or revise the 1E-6/yr criterion used for evaluating risk significance of undeveloped events to a more appropriate criterion (for example, the following may be a more appropriate criteria: evaluate undeveloped events with respect to other basic events/systems representing those functions; evaluate undeveloped events representing individual components, single trains, single systems against the basic event/common cause risk threshold criteria presented in Section 2.1 of NEDO-33411, Revision 0).

GEH Response

The methodology in Section 2.1.2 will be updated to specify that undeveloped events (UE) are evaluated on a case-by-case basis. Initially, the UE will be treated as single component failures and subjected to the most limiting F-V and RAW significance thresholds described in NEDO-33411 Section 2.1; this process ensures that all potentially risk-significant UE are identified.

Once identified, the UE can be either included as risk-significant or dismissed as NRS with appropriate justification. One reason for dismissing a UE could be a RAW less than 50 for a system that requires multiple component failures to fail its function. Based on NEDO-33201 Revision 2 results, all UE meeting the screening criteria are shown below.

Potentially Significant Undeveloped Events Based on F-V				
Event Name	**Prob**	**F-V**	**Description**	**Risk Significance**
BOPCWS-SYS-FAILS	1E-3	2.7E-2	BALANCE OF PLANT CHILLED WATER SYSTEM FAILS	NRS – The BOP chilled water system will have two trains such that a single failure will not fail the system. Two single failures or one CCF event will have a probability lower than the given 1E-3, which will reduce the F-V of individual components below the 1E-2 threshold; the current value is already close to the lower limit for potential risk significance. In addition, the BOP CWS only supports condensate and feedwater pumps, which are not risk-significant system components.
L2-BI_FN-ESTIMATE	1E-2*	1.07 E-1	POINT ESTIMATE - CORE NOT COOLED BY DELUGE FLOW	Risk-significant – This event represents failure of the BiMAC system and is already included in the RAP because it is a RTNSS SSC.

*The BiMAC failure rate will be updated in Revision 4 of the PRA to more accurately estimate the failure modes based on scale testing documented in NEDE/NEDO-33392. The revised importance measures will be considered for risk significance in Revision 1 of NEDO-33411.

Potentially Significant Undeveloped Events Based on RAW				
Event Name	**Prob**	**RAW**	**Description**	**Risk Significance**
BOPCWS-SYS-FAILS	1E-3	27.89	BALANCE OF PLANT CHILLED WATER SYSTEM FAILS	NRS – The BOP CWS will require at least two failures to fail the system; either two independent failures or one CCF event must occur. In addition, the BOP CWS only supports condensate and feedwater pumps, which are not

Potentially Significant Undeveloped Events Based on RAW				
Event Name	**Prob**	**RAW**	**Description**	**Risk Significance**
				risk-significant system components.
R10-SYS-FF-500KV	1E-3	5.81	500KV SWITCHYARD FAILS DURING OPERATION	NRS – Typically, more than one failure is required to fail the 500kV switchyard's ability to supply the plant with offsite power. Additionally, the switchyard is outside the scope of the plant design and the RAP.
C63-UNDEVSPUR58	1E-3	5.09	Undeveloped spurious failure	NRS – Spurious actuations by Q-DCIS require at least two failures as part of the system design. As such, either two independent failures or one common cause failure must occur; the RAW value of 5.09 is much less than the required RAW value of 50 for CCF events.
C63-UNDEVSPUR59	1E-3	5.09		
C63-UNDEVSPUR62	1E-3	5.09		
C63-UNDEVSPUR63	1E-3	5.09		
C63-UNDEVSPUR66	1E-3	5.09		
C63-UNDEVSPUR67	1E-3	5.09		
C63-UNDEVSPUR70	1E-3	5.09		
C63-UNDEVSPUR71	1E-3	5.09		

Revision 1 of NEDO-33411 will incorporate this methodology and include a table similar to what is shown in this RAI response based on Revision 4 PRA results.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

NEDO-33411 is being updated as shown in the attached mark-up.

NRC RAI 17.4-26

In Table 4 of NEDO-33411, Revision 0, undeveloped event BOPCWS-SYS-FAILS represents failure of Balance of Plant Chilled Water System (BOPCWS) (see Section 4.9 of NEDO-33201, Revision 2). GEH did not include BOPCWS in RAP because its undeveloped event (BOPCWS-SYS-FAILS) is considered not risk-significant due to it being an "undeveloped event requiring multiple failures" (Table 4 of NEDO-33411, Revision 0). The basis for not including BOPCWS in RAP is insufficient, and the evidence presented below suggests that BOPCWS is risk-significant and should be included in RAP:

- *BOPCWS is considered risk-significant under Table 17.1-2 of NEDO-33201, Revision 2.*
- *The ESBWR PRA models BOPCWS as a support system to the Condensate and Feedwater System (C&FS). C&FS is considered a risk-significant system and is included in RAP (i.e., Table 6 of NEDO-33411, Revision 0) and has an internal events RAW of about 30 and F-V of about 0.02 (Table 11.3-14 of NEDO-33201, Revision 2).*

The staff requests that GEH include in Table 6 of NEDO-33411, Revision 0, the BOBCWS. Otherwise, provide the basis for considering the BOPCWS system not risk-significant. Please include, in your discussion, the RAWs and F-Vs of BOPCWS basic events/undeveloped events (with consideration of uncertainties in these importance values due to parameter uncertainties), consideration of deterministic methods (e.g., defense-in-depth), and the expert panel's deliberation for not including BOPCWS in RAP.

The staff requests that GEH provide the basis for considering the condensate and feedwater system pumps as not risk-significant. Please include, in your discussion, the individual and common cause RAWs and F-Vs for these pumps (with consideration of uncertainties in these importance values due to parameter uncertainties), and the expert panel's deliberation for not including these pumps in RAP.

GEH Response

Regarding the evidence for the risk-significance of the BOPCWS:

- Revision 2 of NEDO-33201 Section 17 did not take into account the fact that the BOPCWS basic event represented an entire system rather than a single component. Please see the response to RAI 17.4-25 for an updated treatment of the BOPCWS with the most recent methodology.
- Revision 3 of NEDO-33201 Section 11 has an updated system importance sensitivity. The BOPCWS is modeled to support the condensate and feedwater / feedwater booster pumps, which are shown to be non-risk significant (NRS) in the table below. As shown in Table 11.3-14, the injection function of the condensate and feedwater system (UF-TOP1) is not risk-significant based on either F-V or RAW.

The discussion in the response to RAI 17.4-25 and the importance of the C&FS pumps provide the basis for considering BOPCWS as NRS.

The condensate and feedwater pumps do not meet the F-V or RAW criteria for risk significance based on their common cause failure importance measures (single failures do not appear in the cutsets). The F-V and RAW for the associated basic events are shown below:

F-V and RAW for Condensate and Feedwater Pumps			
Basic Event	**Description**	**F-V**	**RAW**
N21-MP_-FR-COND_ALL	All Condensate pumps fail to run	3.62E-4	26.4
N21-MPF-FR_ALL	All Feedwater pumps fail to run	7.84E-4	10.2
N21-MPF-FR-BP_ALL	All Feedwater Booster pumps fail to run	7.84E-4	10.2

All common cause failures associated with the condensate and feedwater pumps have F-V values below 0.01 and RAW values below 50; as such they are considered NRS SSCs.

The response to RAI 17.4-22 discussed how the uncertainties in importance measures due to parameter uncertainties are accounted for in the risk-significance determination process.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33411 changes will be made in response to this RAI.

NRC RAI 17.4-27

GEH did not include in Table 6 of NEDO-33411, Revision 0, the components related to the following basic events of the Turbine Component Cooling Water System (TCCWS) and Plant Service Water System (PSWS) because they are considered not risk-significant due to it being an "undeveloped system requiring multiple failures" (Table 4 of NEDO-33411, Revision 0):

P22-HX_-PG-B001A	*P22-MOV-OC-F0005A*
P22-HX_-PG-B001B	*P22-MOV-OC-F0005B*
P22-ACV-OC-F0006	*P22-TNK-RP-A001*
P22-ACV-CO-F0008	
P41-ACV-OC-F001A	*P41-MOV-OC-F008A*
P41-ACV-OC-F001B	*P41-MOV-OC-F008B*

The basis for not including these components in RAP is insufficient, and the evidence presented below suggests that these components are risk-significant and should be included in RAP:

- *The basic events listed above are considered risk-significant under Table 17.1-2 of NEDO-33201, Revision 2.*
- *These events do not appear to be undeveloped events in that they refer to specific failure modes of individual components (e.g., P22-ACV-CO-F0008 refers to valve F0008 of the TCCWS system failing to remain closed). Therefore, the risk threshold criteria for individual/common cause events (i.e., individual event RAW threshold of 5, common cause RAW threshold of 50, F-V threshold of 0.01 from Section 2.1 of NEDO-33411, Revision 0) would appear to be more appropriate criteria for determining the risk significance of these basic events.*
- *The ESBWR PRA models these basic events for supporting the Condensate and Feedwater System (C&FS). C&FS is considered a risk-significant system and is included in RAP (Table 6 of NEDO-33411, Revision 0) and has an internal events RAW of about 30 and F-V of about 0.02 (Table 11.3-14 of NEDO-33201, Revision 2).*

The staff requests that GEH include in Table 6 of NEDO-33411, Revision 0, the TCCWS and PSWS components that are associated with the basic events listed above. Otherwise, provide the basis for considering the TCCWS and PSWS components not risk-significant. Please include, in your discussion, the RAWs and F-Vs of these events (with consideration of uncertainties in these importance values due to parameter uncertainties), consideration of deterministic methods (e.g., defense-in-depth), and the expert panel's deliberation for not including these components in RAP.

GEH Response

The basic events listed in the RAI are in fact representative of specific components and failure modes; they are not undeveloped basic events representing systems that require multiple failures. The F-V and RAW values for these individual failures (risk-significant thresholds of 0.01 for F-V and 5 for RAW) relative to at-power, internal events CDF are shown below.

Basic Event	F-V	RAW	Risk Significance
P22-HX_-PG-B001A	1.89E-4	8.85	F-V = No; RAW = Yes
P22-MOV-OC-F0005A	2.13E-5	7.30	F-V = No; RAW = Yes
P22-HX_-PG-B001B	1.89E-4	8.85	F-V = No; RAW = Yes
P22-MOV-OC-F0005B	2.13E-5	7.30	F-V = No; RAW = Yes
P22-ACV-OC-F0006	6.16E-4	26.6	F-V = No; RAW = Yes
P22-TNK-RP-A001	5.65E-5	24.4	F-V = No; RAW = Yes
P22-ACV-CO-F0008	1.56E-5	22.6	F-V = No; RAW = Yes
P41-ACV-OC-F001A	1.89E-4	8.85	F-V = No; RAW = Yes
P41-MOV-OC-F008A	2.13E-5	7.30	F-V = No; RAW = Yes
P41-ACV-OC-F001B	1.89E-4	8.85	F-V = No; RAW = Yes
P41-MOV-OC-F008B	2.13E-5	7.30	F-V = No; RAW = Yes

All of the basic events are initially categorized as risk significant based on the RAW values. The plant service water system (PSWS, P41) components are already included as risk-significant SSCs because PSWS is a RTNSS system as shown in DCD Table 19A-2. The turbine component cooling water system (TCCW, P22) components are categorized as risk significant by these RAW values. If these TCCW basic events remain risk significant as judged by Revision 4 PRA results, they will be included in Table 6 (Risk Significant SSCs) in Revision 1 of NEDO-33411.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

NEDO-33411 will be updated to incorporate results from NEDO-33201, "ESBWR Probabilistic Risk Assessment", Revision 4, as discussed above. This response is being tracked by GEH as a commitment.

NRC RAI 17.4-28

Undeveloped events P41-SYS-FC-HVACPSW-A (B) represent failure of Plant Service Water (PSWS) HVAC Trains A and B (Section 4.11 of NEDO-33201, Revision 2). GEH did not include PSWS HVAC Trains A (B) in RAP because their undeveloped events are considered not risk-significant due to it being an "undeveloped event requiring multiple failures" (Table 4 of NEDO-33411, Revision 0). The basis for not including PSWS HVAC Trains A (B) in RAP is insufficient, and the evidence presented below suggests that PSWS HVAC Trains A (B) are risk significant and should be included in RAP:

- *Undeveloped events P41-SYS-FC-HVACPSW-A (B) are considered risk-significant under Table 17.1-2 of NEDO-33201, Revision 2.*
- *These undeveloped events are defined at a train level. Therefore, the risk threshold criteria for individual/common cause events (i.e., individual event/train RAW threshold of 5, common cause RAW threshold of 50, F-V threshold of 0.01 from Section 2.1 of NEDO-33411, Revision 0) would appear to be more appropriate criteria for determining the risk significance of these undeveloped events.*
- *The ESBWR PRA models these undeveloped events as a support system to the PSWS. PSWS is considered a risk-significant system and is included in RAP (i.e., Table 6 of NEDO-33411, Revision 0) and has an internal events RAW of about 400 and F-V of about 0.05 (NEDO-33201, Revision 2, Table 11.3-14).*

The staff requests that GEH include in Table 6 of NEDO-33411, Revision 0, the PSWS HVAC Trains A and B. Otherwise, provide the basis for considering PSWS HVAC Trains A (B) not risk-significant. Please include, in your discussion, the RAWs and F-Vs of the associated basic events/undeveloped events (with consideration of uncertainties in these importance values due to parameter uncertainties), consideration of deterministic methods (e.g., defense-in-depth), and the expert panel's deliberation for not including PSWS HVAC Trains A (B) in RAP.

GEH Response

The basic events for PSWS HVAC (P41-SYS-FC-HVACPSW-A (B)) represent entire trains of PSWS HVAC. The HVAC system has not been designed in detail so these approximations are used to represent an entire train of equipment. The F-V and RAW values of the PSWS HVAC events relative to at-power internal events CDF are shown below.

Basic Event	F-V	RAW	Risk Significance
P41-SYS-FC-HVACPSW-A	7.45E-3	8.44	F-V = No; RAW = No
P41-SYS-FC-HVACPSW-B	7.45E-3	8.44	F-V = No; RAW = No

These basic events are evaluated against the CCF event risk significance thresholds (F-V > 1E-2, RAW > 50) because more than one active failure is typically required to cause an entire HVAC train to fail. In addition, the PSWS HVAC is modeled to conservatively bound all failure modes and may not actually be required for system success; uncertainty in the RAW values would tend to reduce the importance of PSWS.

The response to RAI 17.4-22 discusses how uncertainties in the importance measures due to component parameter uncertainties are treated in the risk significance determination process.

The PSWS is considered risk significant based on its RTNSS status, so the reliability and requirement for PSWS supports (including HVAC, if required for PSWS success) will be monitored throughout the system design process.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33411 changes will be made in response to this RAI.

NRC RAI 17.4-29

GEH did not include in Table 6 of NEDO-33411, Revision 0, the components related to the following basic events of the Instrument Air System (IAS) because they are considered not risk significant due to it being an "undeveloped system requiring multiple failures" (Table 4 of NEDO-33411, Revision 0):

P52-BV_-OC-F004
P52-BV_-OC-F005
P52-TNK-RP-RCV002
P52-UV_-OC-F006

The basis for not including these components in RAP is insufficient, and the evidence presented below suggests that these components are risk-significant and should be included in RAP:

- *The basic events listed above are considered risk-significant under Table 17.1-2 of NEDO-33201, Revision 2.*
- *These events do not appear to be undeveloped events in that they refer to specific failure modes of individual components (e.g., P52-BV_-OC-F004 refers to valve F004 of the IAS system failing to remain open). Therefore, the risk threshold criteria for individual/common cause events (i.e., individual event RAW threshold of 5, common cause RAW threshold of 50, F-V threshold of 0.01 from Section 2.1 of NEDO-33411, Revision 0) would appear to be more appropriate criteria for determining the risk significance of these basic events.*
- *The ESBWR PRA models these basic events in the IAS top event. The IAS top event has an internal events RAW of about 11 (Table 11.3-14 of NEDO-33201, Revision 2). The RAWs for the basic events listed above should be similar (i.e., about 11) since each basic event fails the IAS top event. Also, Section 4.12.11 of NEDO-33201, Revision 2, shows these basic events to have an RAW of about 28 (this value is not consistent with Table 11.3-14 of NEDO-33201 which shows a RAW of about 11).*

The staff requests that GEH include in Table 6 of NEDO-33411, Revision 0, the IAS components that are associated with the basic events listed above. Otherwise, provide the basis for considering these components not risk-significant. Please include, in your discussion, the RAWs and F-Vs of these events (with consideration of uncertainties in these important values due to parameter uncertainties), consideration of deterministic methods (e.g., defense in-depth), and the expert panel's deliberation for not including these components in RAP.

GEH Response

The basic events for the listed Instrument Air System (IAS) components do represent specific components and failure modes; they are not undeveloped events. The F-V and

RAW values of the IAS events relative to the Revision 2 at-power internal events CDF are shown below.

Basic Event	F-V	RAW	Risk Significance
P52-BV_-OC-F004	3.75E-06	6.12	F-V = No; RAW = Yes
P52-BV_-OC-F005	3.75E-06	6.12	F-V = No; RAW = Yes
P52-TNK-RP-RCV002	1.66E-05	7.76	F-V = No; RAW = Yes
P52-UV_-OC-F006	3.60E-05	8.38	F-V = No; RAW = Yes

As shown, the IAS events (from PRA Revision 2) discussed in the RAI do qualify as risk significant based on the RAW threshold for single component failures.

The response to RAI 17.4-22 discusses how uncertainties in the importance measures due to component parameter uncertainties are treated in the risk significance determination process.

A significant re-design of the Instrument Air and Service Air systems has occurred since Revision 2 of the PRA. The current IAS model no longer contains any of the basic events discussed in this RAI. Revision 1 of NEDO-33411 will contain any risk significant IAS basic events from the updated system model and Revision 4 PRA results.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

NEDO-33411 will be updated to incorporate results from NEDO-33201, "ESBWR Probabilistic Risk Assessment", Revision 4, as discussed above. This response is being tracked by GEH as a commitment.

NRC RAI 17.4-30

Standby Liquid Control System (SLC) squib valves F003 A, B, C, D are considered risk significant from the Seismic Margins Analysis (SMA) (Table 2 of NEDO-33411, Revision 0). Based on GEH's discussion in Section 2.2 of NEDO-33411, these SLC squib valves should be included in Table 6 of NEDO-33411. However, these squib valves do not appear in Table 6 of NEDO-33411.

The staff requests that GEH include the SLC squib valves F003 A, B, C, D in Table 6 of NEDO-33411, Revision 0. Otherwise, provide the basis for considering these valves not risk significant. Please include, in your discussion, consideration of deterministic methods (e.g., defense-in-depth), and the expert panel's deliberation for not including these valves in RAP.

GEH Response

The SLCS squib valves are considered risk significant based on the SMA, but are not risk significant based on PRA results as shown below.

Basic Event	F-V	RAW	Risk Significance
C41-SQV-CC_ALL	4.88E-03	33.5	F-V = No; RAW = No
C41-SQV-CC_1_3	1.81E-03	33.5	F-V = No; RAW = No
C41-SQV-CC_2_4	1.81E-03	33.5	F-V = No; RAW = No
C41-SQV-CC-F003A	3.03E-04	1.1	F-V = No; RAW = No
C41-SQV-CC-F003B	3.03E-04	1.1	F-V = No; RAW = No
C41-SQV-CC-F003C	3.03E-04	1.1	F-V = No; RAW = No
C41-SQV-CC-F003D	3.03E-04	1.1	F-V = No; RAW = No

Compared to the SLCS containment isolation check valves and the discharge isolation valves (included in Table 6 of NEDO-33411 Revision 0), the injection squib valves are not as risk significant. The two squib valves per train are in parallel and only one must open for system success; the other valves are all single failure points for their train of the system.

As discussed in the GEH response to RAI 17.4-20, the scope for Phase 1 of the D-RAP is limited to those components whose PRA-modeled reliability is judged to be risk significant. The SLCS squib valves do not meet the F-V (0.01) or RAW (5 for single failure, 50 for CCF events) thresholds for risk significance. The expert panel does not consider it necessary to include the squib valve reliability as risk significant because there are two in parallel per train, and the PRA makes the assumption that both trains are required for success for accident mitigation.

The SLCS squib valves are risk significant because their performance during a seismic event is important. Seismic programs, not Phase 1 of the D-RAP, will be used to ensure that adequate seismic capacity is maintained in the SLCS squib valve design.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33411 changes will be made in response to this RAI.

NRC RAI 17.4-31

Isolation Condenser System (ICS) motor-operated and nitrogen-operated valves are considered risk-significant from the SMA (Table 2 of NEDO-33411, Revision 0). Based on GEH's discussion in Section 2.2 of NEDO-33411, these ICS valves should be included in Table 6 of NEDO-33411. However, these ICS motor-operated and nitrogen-operated valves do not appear in Table 6 of NEDO-33411. Also, it is unclear as to what specific ICS valves are referred to by the SMA (e.g., are valves F001, F002, F003, F004, F005, F006, F011, F012, and F013 risk-significant under SMA?).

The staff requests that GEH include in Table 6 of NEDO-33411, Revision 0, the specific ICS motor-operated and nitrogen-operated valves (i.e., specific component IDs) determined to be risk-significant under the SMA. Otherwise, provide the basis for considering these valves not risk-significant. Please include, in your discussion, consideration of deterministic methods (e.g., defense-in-depth), and the expert panel's deliberation for not including these valves in RAP.

GEH Response

As discussed in the GEH response to RAI 17.4-20 and its associated mark-up, components that are only considered risk significant because of the SMA are not necessarily included in Phase 1 of the D-RAP. Phase 1 is intended to maintain risk significant component reliability assumptions made in the design certification PRA. If a component is only risk significant from a SMA perspective, then maintaining the PRA-assumed reliability through Phase 1 of the D-RAP does not address the truly risk significant performance requirement of the component.

Components that are risk significant because of the SMA are addressed in seismic programs.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33411 changes will be made in response to this RAI.

NRC RAI 17.4-32

For Uninterruptible AC Power Supply (UPS), it is unclear as to what specific UPS components are considered risk-significant in Table 6 of NEDO-33411, Revision 0. For example: Does "Load Group B Transformer" refer to the UPS Nonsafety-Related Reactor Building Load Group B Transformer? Does "Nonsafety-Related Bus A, B" refer to UPS Nonsafety-Related 480VAC Buses A1, B1? Does "Manual Transfer Switch A,B" refer to the manual transfer switches for UPS Nonsafety-Related Buses A1 and B1? Does "Static Transfer Switch A, B" refer to the static transfer switches for UPS Nonsafety-Related Buses A1 and B1? Does the "UPS Inverters" refer to both the safety-related and nonsafety-related inverters of UPS?

The staff requests the GEH more clearly identify the UPS risk-significant SSCs in Table 6 of NEDO-33411, Revision 0.

GEH Response

The requested clarifications for risk significant UPS components are shown below. No mark-up of NEDO-33411 Table 6 is given because Revision 1 will be based on Revision 4 PRA results and will likely have other modifications.

Original Description	Revised Description
Nonsafety-Related Bus A,B	Nonsafety-related 480V UPS Buses A1 & B1
Manual Transfer Switch A,B	Manual Transfer Switches for Nonsafety-related 480V UPS Buses A1 & B1
Load Group B Transformer	Nonsafety-related Transformer from 480V UPS Bus B1 to Reactor Building Load Group B
Static Transfer Switch A,B	Static Transfer Switches for Nonsafety-related 480V UPS Buses A1 & B1
UPS Inverters	Safety-related and Nonsafety-related UPS Inverters

The UPS components that qualify as risk-significant according to Revision 4 PRA results will be clearly identified in Table 6 in Revision 1 of NEDO-33411.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

NEDO-33411 will be updated to incorporate the information discussed above. This response is being tracked by GEH as a commitment.

NRC RAI 17.4-33

GEH did not include in Table 6 of NEDO-33411, Revision 0, the components related to the following basic events of UPS, which are considered risk-significant in Table 17.1-2 of NEDO-33201, Revision 2:

R13-BAC-LP-R13RBB (Nonsafety-Related UPS Reactor Building Load Group B Bus)
R13-LCB-CO-FR13RBB
R13-LCB-CO-R13RBB
R13-LCB-CO-TOR13A1
R13-LCB-CO-TOR13B1
R13-XFL-LP-R13RBA
R13-XFL-LP-R13RBC

The staff requests that GEH include in Table 6 of NEDO-33411, Revision 0, the UPS components that are associated with the basic events listed above. Otherwise, provide the basis for not including these components in Table 6 of NEDO-33411. Please include, in your discussion, the RAWs and F-Vs of these events (with consideration of uncertainties in these importance values due to parameter uncertainties), consideration of deterministic methods (e.g., defense-in-depth), and the expert panel's deliberation for not including these components in RAP.

GEH Response

The RAW and F-V importance measures of the events addressed in the RAI are shown below.

Basic Event	Description	RAW	PRA Model
R13-LCB-CO-TOR13B1	Circuit breaker to NSR bus R13-B1 opens spuriously	40.49	L1-AP-Fire (1)
R13-LCB-CO-FR13RBB	Circuit breaker to NSR RB loads spuriously opens	39.89	L1-AP-Fire
R13-LCB-CO-R13RBB	Circuit breaker to NSR RB loads spuriously opens	39.89	L1-AP-Fire
R13-BAC-LP-R13RBB	RB UPS bus R13-RBB fails	39.85	L1-AP-Fire
R13-LCB-CO-TOR13A1	Circuit breaker to NSR bus R13-A1 opens spuriously	39.50	L1-AP-Fire
R13-XFL-LP-R13RBA	Transformer to loads from NSR bus R13-RBA fails during operation	3.28	L1-AP-Fire
R13-XFL-LP-R13RBC	Transformer to loads from NSR bus R13-RBC fails during operation	*Does not appear in any model results*	
Basic Event	**Description**	**F-V**	**PRA Model**
R13-LCB-CO-TOR13B1	Circuit breaker to NSR bus R13-B1 opens spuriously	4.74E-4	L1-AP-Fire
R13-LCB-CO-	Circuit breaker to NSR RB loads	4.67E-4	L1-AP-Fire

Basic Event	Description	RAW	PRA Model
FR13RBB	spuriously opens		
R13-LCB-CO-R13RBB	Circuit breaker to NSR RB loads spuriously opens	4.67E-4	L1-AP-Fire
R13-BAC-LP-R13RBB	RB UPS bus R13-RBB fails	1.87E-4	L1-AP-Fire
R13-LCB-CO-TOR13A1	Circuit breaker to NSR bus R13-A1 opens spuriously	4.62E-4	L1-AP-Fire
R13-XFL-LP-R13RBA	Transformer to loads from NSR bus R13-RBA fails during operation	4.42E-5	L1-AP-Fire
R13-XFL-LP-R13RBC	Transformer to loads from NSR bus R13-RBC fails during operation	*Does not appear in any model results*	
Notes: 1) Level 1, at-power, fire PRA model			

The first five events qualify as risk-significant based on their RAW values from quantified PRA results. The event "R13-XFL-LP-R13RBA" does appear in the model results (the L1-AP-Fire model shows the highest importance measures) but does not exceed the risk-significance thresholds. The event "R13-XFL-LP-R13RBC" does not appear in any of the quantified PRA model results; this is likely because nonsafety-related load group "C" is only used as one of the triply redundant power supplies for the diverse protection system (DPS) in the design certification PRA. As such, it is always AND'ed with load groups A and B in its functional applications and does not contribute significantly to plant risk. The "C" nonsafety-related UPS group is designed to be a swing bus, so it's importance is masked in the PRA, which assumes certain configurations for quantification efficiency.

The "A" and "C" transformers were included in NEDO-33201 Table 17.1-2 because the "B" transformer was risk significant based on PRA results. Importance measures of different trains within a given system often vary because the design certification PRA assumed default equipment configurations to simplify the quantification. To bound risk significance, trains "A" and "C" should be included in Table 6 of NEDO-33411 if Revision 4 PRA results continue to show any of the trains as risk significant.

The response to RAI 17.4-22 discusses how uncertainties in the importance measures due to component parameter uncertainties are treated in the risk significance determination process.

The fire PRA generally shows the greatest risk for the electrical systems because of the defined initial conditions of the fire scenarios. For Revision 1 of NEDO-33411, all model iterations will again be considered and the appropriate UPS (R13) system SSCs will be included as risk significant.

No mark-up for Revision 1 of Table 6 in NEDO-33411 is provided because it will be based on Revision 4 PRA results and will likely have other modifications.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

NEDO-33411 will be updated to incorporate the information discussed above. This response is being tracked by GEH as a commitment.

NRC RAI 17.4-34

For UPS in Table 6 of NEDO-33411, Revision 0, there are numerous instances of similar SSCs of different UPS trains having dissimilar risk significances (e.g., based on Table 6 of NEDO-33411, Load Group B Transformer is considered risk-significant while Load Group A and C Transformers are considered not risk-significant). Often these dissimilar risk significances are real as they reflect actual differences in supporting functions. However, it is possible that these dissimilarities are not real and arise from assumptions made in the risk analyses.

The staff requests that GEH provide the basis for considering the following UPS SSCs as not risk-significant (also, explain what is driving the risk differences relative to their risk-significant counterparts):

1) *Nonsafety-Related UPS Bus C (note, Nonsafety-Related UPS Buses A, B are considered risk-significant in Table 6 of NEDO-33411).*
2) *Manual Transfer Switch on Nonsafety-Related UPS Bus C (note, Manual Transfer Switches A, B are considered risk-significant in Table 6 of NEDO-33411).*
3) *Static Transfer Switch on Nonsafety-Related UPS Bus C (note, Static Transfer Switches A, B are considered risk-significant in Table 6 of NEDO-33411).*
4) *Nonsafety-related UPS Reactor Building Load Group A and C Transformers and associated breakers (note, Load Group B Transformer is considered risk-significant in Table 6 of NEDO-33411).*
5) *Nonsafety-related UPS Reactor Building Load Group A and C buses (note, UPS Reactor Building Load Group B bus is considered risk-significant in Table 2 of NEDO-33201, Revision 2).*

GEH Response

1) The nonsafety-related (NSR) UPS train "C" is only modeled as one of the triply redundant power supplies for the diverse protection system (DPS). The "A" and "B" trains of NSR UPS are used as DPS power supplies and they provide the power for trains "A" and "B" of N-DCIS control for nonsafety-related equipment. Since the train "A" and "B" buses of NSR UPS control almost all of the nonsafety-related plant equipment in the assumed design certification PRA alignment, they appear more risk significant than train "C", which is only one of three power supplies for DPS.

   The "C" train of NSR UPS can be used as a swing bus to provide power to either train "A" or "B". However, the "C" train is only used as a DPS power supply in the assumed alignment for the PRA. Per the methodology in Section 2.1.1 of NEDO-33411, the "C" NSR UPS bus will be included as risk significant in Revision 1 of NEDO-33411 if Revision 4 PRA results continue to support that conclusion.

2) Train "C" of NSR UPS is only modeled as a DPS power supply in the design certification PRA and should be considered risk significant; see response to bullet 1.

3) Train "C" of NSR UPS is only modeled as a DPS power supply in the design certification PRA and should be considered risk significant; see response to bullet 1.

4) The discrepancy in importance of NSR UPS load groups C and B can be attributed to the use of load group "C" as discussed in bullet 1. The discrepancy between load groups "A" and "B" is more complicated and has to do with conservative modeling assumptions regarding the TCCW system.

   The TCCW has three pumps; train "A", train "B", and a swing pump. The swing pump is assumed to be controlled by N-DCIS train "A", although in reality it will mostly likely be switchable between "A" and "B" N-DCIS. Consistent with this assumption, a fire in fire area F5550 (NSR Upper Electrical Equipment "A") will fail both train "A" and "C" of TCCW, which causes failure of feedwater injection, the power conversion system, and the service air system. Compared to a fire in fire area F5560 (NSR Upper Electrical Equipment "B"), the F5550 fire damage state includes more failures, which increases the importance of the "B" NSR UPS components such as the load group "B" transformer highlighted in the RAI.

   The discrepancy between importances of train "A" and "B" NSR UPS components results from assumed equipment alignments in the design certification PRA. The load group transformers for both trains "A" and "B" (as well as "C") should be considered risk significant in this case, and Revision 1 of NEDO-33411 will include all three components if the Revision 4 PRA results continue to show that at least one of them is risk significant.

5) See discussion in item 4 for the explanation in importance measure discrepancy. The load group "B" bus has elevated importance for the same reason as the load group "B" transformer.

   The discrepancy between importances of train "A" and "B" NSR UPS components results from assumed equipment alignments. The load group transformers for both trains "A" and "B" should be considered risk significant in this case, and Revision 1 of NEDO-33411 will include both components if the Revision 4 PRA results continue to show that at least one of them is risk significant.

In some cases, modeling assumptions regarding alignments or power supplies have been made in the design certification PRA that significantly affect the importances of equipment. These effects are primarily seen in the spatial models such as fire and flood.

As discussed throughout this response and in Section 2.1.1 of NEDO-33411, if only one train appears risk significant as a result of modeling assumptions, components from all three trains will be included as risk significant. Revision 1 of NEDO-33411 will incorporate all trains if Revision 4 PRA results continue to support their inclusion as risk significant.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

NEDO-33411 will be updated to incorporate the information discussed above. This response is being tracked by GEH as a commitment.

NRC RAI 17.4-35

For UPS in Table 6 of NEDO-33411, Revision 0, manual transfer switches, static transfer switches, buses, transformers, and circuit breakers are considered risk-significant under the nonsafety-related portion of UPS, but not considered risk-significant under the safety-related portion of UPS.

The staff requests that GEH provide the basis for considering the safety-related UPS components as not risk-significant. Please include, in your discussion, the associated risk importance measures (e.g., RAWs and F-Vs), consideration of deterministic methods (e.g., defense-in-depth), and the expert panel's deliberation for not including these components in RAP.

GEH Response

The general N-2 design philosophy of the safety-related (SR) UPS system intentionally decreases the importance of individual system components. The N-2 design for safety-relate instrumentation and control (I&C) and power supply ensures that at least three divisions of I&C (which includes the SR UPS) are available to perform any given safety-related function. As such, one division may be out of service for maintenance and all safety-related functions are still able to function with the failure of an additional division.

This design allows two divisions of SR Q-DCIS to be unavailable and not impact a given safety-related function. For example, every depressurization valve (DPV) receives three divisions of Q-DCIS; any two divisions can be out of service (either due to divisional failures or testing/maintenance) and all DPVs will still function as designed.

This design significantly reduces the importance of individual safety-related components so that they do not appear as risk-significant in NEDO-33411. The nonsafety-related (NSR) UPS primarily uses a single train of equipment to support the nonsafety-related plant equipment. In these cases, a single failure of NSR UPS switch, bus, transformer, or circuit breaker can fail either that entire train of NSR UPS or that train's load center for an entire building. Swing NSR UPS train "C" is not credited for the scenarios in the design certification PRA.

The only SR UPS that qualifies as risk significant based on F-V or RAW values is the CCF of all safety-related inverters; this event qualifies the SR UPS inverters as risk significant (they are included with NSR UPS inverters within "UPS Inverters" in Table 6 of NEDO-33411, Revision 0). All other SR UPS common cause and individual failures fall below the risk significance thresholds outlined in Section 2.1 of NEDO-33411, Revision 0.

In summary, the N-2 design philosophy was intended to reduce the risk significance of safety-related power and I&C such that online maintenance would not affect plant reliability. The risk significance determination process for SSCs has confirmed the effectiveness of the N-2 design; with the exception of the inverters, no SR UPS components are considered to be risk-significant. The SR UPS components will be reconsidered for risk significance based on Revision 4 PRA results in Revision 1 of NEDO-33411.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33411 changes will be made in response to this RAI.

NRC RAI 17.4-36

In Table 6 of NEDO-33411, Revision 0, many risk-significant SSCs are identified through text descriptions, rather than specific component Identification numbers. As a result, it is unclear as to what specific components are in RAP.

The staff requests that GEH more clearly describe the risk-significant SSCs in Table 6 of NEDO-33411, Revision 0 through use of text descriptions and specific component identification numbers, when applicable. For example: from Table 6 of NEDO-33411 the description "FDW Line A Check Valves (B21-F102A, F103A)" is clearer than description "FDW Line A Check Valves"; and "FAPCS Suppression Pool Isolation Valve (G21-F308)" is clearer than description "FAPCS Suppression Pool Isolation Valve".

GEH Response

The risk significant SSCs listed in Table 6 of NEDO-33411 Revision 0 are clarified in the table below. Some components have not been assigned formal component identifiers at this point in the design so they are assumed for the PRA. As such, PRA-assumed component identifiers are subject to change during the detailed design process.

System / Function	**Risk Significant SSC**
B21 Nuclear Boiler	Depressurization Valves (B21-F004A/B/C/D/E/F/G/H) Safety/Relief Valves (B21-F006A/B/C/D/E/F/G/H/J/K) Safety Valves (B21-F003A/B/C/D/E/F/G/H) FDW Line A Check Valves (B21-F102A, B21-F103A) FDW Line B Check Valves (B21-F102B, B21-F103B)
B11 Reactor Pressure Vessel	Fuel assemblies Reactor Pressure Vessel Support RPV Pedestal Shroud supports
B32 Isolation Condenser	ICS Heat Exchangers (B32-B001A/B/C/D, B32-B002A/B/C/D) IC/PCC Pool Valves (B32-F104A/B/C/D)

System / Function	Risk Significant SSC
C12 Control Rod Drive	Control Rods CRD Guide tubes CRD Housings Hydraulic Control Units CRD Injection Manual Valves A,B (C12-F021A/B) CRD Injection MOVs A,B (C12-F020A/B) CRD to RWCU/SDCS Check Valve (G31-F023/F024) CRD Pumps A,B (C12-C001A/B) Scram Pilot Solenoid Valves Scram Valves to FMCRDs CRD suction inlet valves A,B (C12-F013A/B) CRD suction outlet valves A,B (C12-F015A/B) CST supply to CRD (P30-F065)
C41 Standby Liquid Control	SLC Discharge Isolation Valves (C41-F002A/B/C/D) SLC Outboard Check Valves (C41-F004A/B) SLC Inboard Check Valves (C41-F005A/B) Accumulator Tanks (C41-A001A/B)
C62 Nonsafety-Related Distributed Control and Information (DCIS)	NDCIS Software
C63 Safety-Related DCIS	QDCIS Software
C71 Reactor Protection	RPS Digital Trip Module RPS Load Drivers RPS Output Logic Component RPS Trip Logic Unit Manual Scram
C72 Diverse Protection (DPS)	ATWS/SLC Logic Units (DPS) FW Runback NTB-DIVA,B DPS Analog Trip Module DPS Load Drivers DPS Logic Units DPS Processors
E50 Gravity Driven Cooling	Injection Squib Valves (E50-F002A/B/C/D/E/F/G/H) Injection Check Valves (E50-F003A/B/C/D/E/F/H) Deluge Squib Valves (E50-F009A/B/C/D/E/F/G/H/J/K/L/M) GDCS Strainers (E50-D002A/B/C/D)

System / Function	Risk Significant SSC
G21 Fuel and Auxiliary Pools Cooling	FAPCS Suppression Pool Isolation Valve (G21-F320) FAPCS Vessel Injection Isolation Valve (G21-F334) FAPCS Train A,B
N21 Condensate	Condensate Bypass Inlet Valve (N21-F0016) Condensate Header Isolation Valve (N21-F0018) Condensate Bypass Outlet Valve (N21-F0057)
P21 Reactor Component Cooling Water	RCCW Inlet to CRD HX Valves A,B (P21-F049A/B) RCCW Outlet from CRD HX Valves A,B (P21-F050A/B) RCCW Train A,B
P25 Chilled Water	NICWS Train A,B
P41 Plant Service Water	Cooling Tower Fans (P41-0001A/B, P41-0002A/B) Service Water Pumps (P41-C001A/B, P41-C002A/B) Service Water Strainers (P41-D001A/B, P41-D002A/B) Service Water Train A/B
R10 Electrical Power Distribution	Reserve Auxiliary Transformer Unit Auxiliary Transformer Switchyard
R11 Medium Voltage Distr.	6.9 kV PIP Bus A,B
R13 Uninterruptible AC Power Supply	Nonsafety-Related Bus A,B (480V UPS Buses A1 & B1) Manual Transfer Switch A,B (for Nonsafety-related 480V UPS Buses A1 & B1) Load Group B Transformer (from 480V UPS Bus B1 to Reactor Building Load Group B) Static Transfer Switch A,B (for Nonsafety-related 480V UPS Buses A1 & B1) UPS Inverters (Safety-related and Nonsafety-related UPS Inverters)
R16 Direct Current Power Supply	DC Batteries DC Cable trays DC Motor control centers DC Bus A,B DC Circuit Breakers
R21 Diesel Generators	Diesel Generator A,B

System / Function	Risk Significant SSC
T10 Containment	Containment Containment Vacuum Breakers Containment VB Isolation Valves Drywell Hatches BiMAC Device and Temperature Sensors
T15 Primary Containment Cooling	PCCS Filters (T15-D001A/B/C/D/E/F) PCCS Heat Exchangers (T15-B001A/B/C/D/E/F)
U36 Electrical Building HVAC	EER Train A,B DGVS Train A,B
U39 Turbine Building HVAC	TBVS Train A,B
U 43 Fire Protection	FPS to FAPCS Manual Isolation Valve (U43-FU439) FPS to FAPCS Check Valve (U43-FU438) FPS to LPI Manual Isolation Valve (G21-F346) FPS to LPI Check Valve (G21-F347) Diesel Driven Fire Pump (P1A)
U71 Reactor Building	Reactor Building
U73 Control Building	Control Building Control Building to Reactor Building Doors
U98 Fuel Building HVAC	FBGAVS Train A,B

Table 6 in Revision 1 of NEDO-33411 will be updated based on Revision 4 PRA results and will include clearer component descriptions.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

NEDO-33411 will be updated as discussed above in response to this RAI. This response is being tracked by GEH as a commitment.

NRC RAI 17.4-37

GEH did not include in Table 6 of NEDO-33411, Revision 0, the "hardware" of QDCIS (C63) and NDCIS (C62) systems. The evidence presented below suggests that the hardware of these systems are risk-significant and should be included in RAP:

- *QDCIS and NDCIS are very risk-significant (RAWs of about 4200 and 400, respectively, and F-V of about 0.24 and 0.04, respectively, from Table 11.3-14 of NEDO-33201, Revision 2).*
- *Undeveloped basic events C63-UNDEVSPUR## represent unmodeled hardware that could lead to a spurious actuation of an undesirable signal and are considered risk-significant in the ESBWR PRA (Table 17.1-2 of NEDO-33201, Revision 2).*
- *Uncertainties inherent with the PRA modeling of digital hardware/software are large; therefore, it is inappropriate to specifically rely on PRA models alone to show that hardware of digital systems are not risk-significant. Other methods would need to be assessed (e.g., deterministic methods, defense-in-depth, expert panel).*

The staff requests that GEH include "hardware" of QDCIS and NDCIS in Table 6 of NEDO-33411, Revision 0. Otherwise, provide the basis for not including the QDCIS and NDCIS hardware in Table 6 of NEDO-33411. Please include, in your discussion, consideration of deterministic methods (e.g., defense-in-depth), and the expert panel's deliberation for not including QDCIS and NDCIS hardware in RAP.

GEH Response

In the current Q-DCIS and N-DCIS designs, specific hardware components have not yet been specified. The PRA model utilizes "simplified" Q-DCIS and N-DCIS models (discussed in detail in NEDO-33201 Section 4.5 Revision 3) that only model software failures and power dependencies.

A sensitivity study was done in NEDO-33201 22.4.5 Revision 3 to model the hardware of a postulated DCIS design. The sensitivity showed that the modeling of individual hardware components had negligible risk impact and that risk due to the DCIS platforms is driven by common cause failures.

For example, a digital trip module (DTM) is modeled with a failure rate of 6E-4/demand (NEDO-33201 Table 5.2-2, item 6.1.2.2). Any given safety-related function requires that two out of four divisions indicate a trip. This would require the failure of three DTM units, the probability of which is significantly lower than the modeled 1E-4 probability of software CCF (shown below).

Type of Failure	Method	Probability
Three individual failures	(6E-4)*(6E-4)*(6E-4)	2.6E-10/demand
CCF of three of four DTM units	CAFTA CCF Tool; group of four DTMs using Beta and Gamma	1.11E-5/demand (Generic MGL factors of Beta = 0.1, Gamma = 0.5)

Additionally, the postulated DTM failures only fail one function, whereas the CCF of safety-related software fails all safety-related actuations. As such, it can be concluded that the simplified models capture the risk-significant failure modes of the DCIS systems.

As the DCIS system design progress and further information on hardware is available the PRA will be updated accordingly. It is likely that individual Q-DCIS hardware components will not qualify as risk-significant for the reasons discussed regarding the safety-related UPS in response to RAI 17.4-35 (with CCF of Q-DCIS software being similar to CCF of all safety-related inverters).

Some N-DCIS hardware may qualify as risk significant, but at this point in the design with no actual specified hardware it is not beneficial to include generic "N-DCIS hardware" in the D-RAP. The D-RAP is implemented to maintain assumed risk significant reliabilities in the PRA; since there are no risk significant, assumed reliabilities for N-DCIS hardware, there is nothing to "maintain" with the D-RAP.

Once meaningful hardware design has been incorporated into the PRA, the risk significance of these components will be evaluated according to the methodology in NEDO-33411.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33411 changes will be made in response to this RAI.

NRC RAI 17.4-38

Basic event E50-SQV-CC-EQU_ALL represents common cause failure to open gravity driven cooling system (GDCS) equalizing line squib valves F006A,B,C,D (Section 4.6 of NEDO- 33201, Revision 2) and is considered risk-significant in Table 17.1-2 of NEDO-33201. It is unclear as to whether these valves appear in the list of risk-significant SSCs in Table 6 of NEDO-33411, Revision 0. These valves should be included in the list of risk-significant SSCs in Table 6 of NEDO-33411.

The staff requests that GEH include the GDCS equalizing line squib valves F006 A, B, C, D in Table 6 of NEDO-33411, Revision 0. Otherwise, provide the basis for not including these valves in Table 6 of NEDO-33411. Please include, in your discussion, the associated risk importance measures (e.g., RAWs and F-Vs), consideration of deterministic methods (e.g., defense-in-depth), and the expert panel's deliberation for not including these valves in RAP.

GEH Response

The GDCS equalizing squib valves should appear as risk significant based on the importance measures shown below.

Basic Event	Description	RAW	PRA Model
E50-SQV-CC-EQU_ALL	CCF of all GDCS equalizing squib valves to open	416.21	SD-Fire (1)
Basic Event	**Description**	**F-V**	**PRA Model**
E50-SQV-CC-EQU_ALL	CCF of all GDCS equalizing squib valves to open	1.03E-2	SD-IE (2)
		1.25E-1	SD-Fire
Notes: 2) Shutdown fire PRA model 3) Shutdown internal events PRA model			

The GDCS equalizing squib valves are risk significant based on the Revision 2 PRA results as indicated above. Revision 1 of NEDO-33411 will incorporate the GDCS equalizing squib valves if they continue to be risk significant based on Revision 4 PRA results.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

NEDO-33411 will be updated as discussed above in response to this RAI. No markup is provided at this time because the specific values listed in the response above may change due to the NEDO-33201 Revision 4 re-quantification. This response is being tracked by GEH as a commitment.

NRC RAI 17.4-39

Basic event E50-UV_OC-EQU_ALL represents common cause failure of GDCS equalizing line check valves F007 A, B, C, D to remain open or plugged (Section 4.6 of NEDO-33201, Revision 2) and is considered risk-significant in Table 17.1-2 of NEDO-33201. It is unclear as to whether these check valves appear in the list of risk-significant SSCs in Table 6 of NEDO-33411, Revision 0. These check valves should be included in the list of risk-significant SSCs in Table 6 of NEDO-33411.

The staff requests that GEH include the GDCS equalizing line check valves F007 A, B, C, D in Table 6 of NEDO-33411, Revision 0. Otherwise, provide the basis for not including these valves in Table 6 of NEDO-33411. Please include, in your discussion, the associated risk importance measures (e.g., RAWs and F-Vs), consideration of deterministic methods (e.g., defense-in-depth), and the expert panel's deliberation for not including these valves in RAP.

GEH Response

The GDCS equalizing check valves should appear as risk significant based on the importance measures shown below.

Basic Event	Description	RAW	PRA Model
E50-UV_OC-EQU_ALL	CCF of all GDCS equalizing check valves to remain open	415.24	SD-Fire (1)
Basic Event	**Description**	**F-V**	**PRA Model**
E50-UV_OC-EQU_ALL	CCF of all GDCS equalizing check valves to remain open	1.25E-2	SD-Fire
Notes: 4) Shutdown fire PRA model			

The GDCS equalizing check valves are risk significant based on the Revision 2 PRA results as indicated above. Revision 1 of NEDO-33411 will incorporate the GDCS equalizing check valves if they continue to be risk significant based on Revision 4 PRA results.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

NEDO-33411 will be updated as discussed above in response to this RAI. No markup is provided at this time because the specific values listed in the response above may change due to the NEDO-33201 Revision 4 re-quantification. This response is being tracked by GEH as a commitment.

NRC RAI 17.4-40

GEH did not include in Table 6 of NEDO-33411, Revision 0, the Low Voltage Distribution System (LVDS), which has an internal events RAW of about 400 (Tables 11.3-14 and 11.3-15 of NEDO-33201, Revision 2).

The staff requests that GEH include in Table 6 of NEDO-33411, Revision 0, the Low Voltage Distribution System (LVDS). Otherwise, provide the basis for not including this system in Table 6 of NEDO-33411. Please include, in your discussion, the associated risk importance measures (e.g., RAWs and F-Vs), consideration of deterministic methods (e.g., defense-in depth), and the expert panel's deliberation for not including LVDS in RAP.

GEH Response

The updated system importance study in Revision 3 of NEDO-33201 Section 11 (Tables 11.3-14 and 11.3-15) show that the LVDS (R12) has a RAW value of about 400. However, as described in Section 2.1.1 of NEDO-33411, basic events are used to determine risk significant components. System importance measures are not used as a basis for including components in Phase 1 of the D-RAP.

No individual or common cause LVDS component failures exceeded the risk-significance thresholds for either RAW or F-V. As such, LVDS components will not be included as risk significant in Revision 1 of NEDO-33411 unless Revision 4 PRA results show components as risk significant. The purpose of selecting risk significant SSCs is to maintain component reliability through Phase 1 of the D-RAP. In the case of the LVDS, no individual or common cause failure of components is risk significant; ESBWR risk is not sensitive to the assumed PRA reliability of LVDS components.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33411 changes will be made in response to this RAI.

NRC RAI 17.4-41

GEH did not include in Table 6 of NEDO-33411, Revision 0, the reactor water cleanup/shutdown cooling (RWCU/SDC) system. The evidence presented below suggests that the RWCU/SDC is risk-significant and should be included in RAP:

- *The internal events RAW for RWCU/SDC is about 350,000 (Tables 11.3-14 and 11.3-15 of NEDO-33201, Revision 2).*
- *Basic events G31-XHE-FO-SDC (Operator Fails to Actuate RWCU/SDC Mode) and R-M6-G31 (Failure to Recover RWCU/SDC) are considered risk-significant operator actions in Table 17.1-3 of NEDO-33201, Revision 2, which may suggest that RWCU/SDC is risk-significant.*
- *An important recovery action during shutdown is to recover at least one train after loss of both operating RWCU/SDCS trains.*
- *The occurrence of a loss of RWCU/SDC during Mode 6 when the cavity is unflooded is risk significant and has an internal events shutdown RAW of 479 (during Mode 6 with the vessel head removed, the ICS is not available for decay heat removal) (Table 16.6-4 of NEDO-33201, Revision 2).*

The staff requests that GEH include in Table 6 of NEDO-33411, Revision 0, the RWCU/SDC System. Otherwise, provide the basis for not including this system in Table 6 of NEDO-33411. Please include, in your discussion, the associated risk importance measures (e.g., RAWs and F-Vs), consideration of deterministic methods (e.g., defense-in-depth), and the expert panel's deliberation for not including RWCU/SDC in RAP.

GEH Response

The updated system importance analysis in Revision 3 of NEDO-33201 Section 11 shows that the RAW of RWCU/SDC relative to internal events CDF is actually approximately 1. Also relative to internal events CDF, the F-V value is 0.00.

The highest importance measures for the operator actions related to RWCU/SDC mentioned in this RAI are shown in the table below.

Basic Event	Description	RAW	PRA Model
G31-XHE-FO-SDC	OPERATOR FAILS TO ACTUATE SDC MODE NO MSL LOCA OUSIDE CONTAINMENT NO SLCS	2.53	SD-IE (1)
R-M6-G31	FAILURE TO RECOVER RWCU/SDC	4.47	SD-Flood (2)
Basic Event	**Description**	**F-V**	**PRA Model**
G31-XHE-FO-SDC	OPERATOR FAILS TO ACTUATE	2.77E-2	SD-IE

Basic Event	Description	RAW	PRA Model
	SDC MODE NO MSL LOCA OUSIDE CONTAINMENT NO SLCS		
R-M6-G31	FAILURE TO RECOVER RWCU/SDC	9.66E-1	SD-Flood
Notes: 5) Shutdown internal events PRA model 6) Shutdown flooding PRA model			

The significance criteria for these events is taken to be 0.1 for F-V and 50 for RAW based on the shutdown internal events and shutdown flooding CDF numbers (~E-9) and the methodology in NEDO-3411 Section 2.1.

As shown, only the F-V of operator action R-M6-G31 (failure to recover RWCU/SDC during shutdown mode 6) exceeds the risk significance thresholds. In the Revision 4 flooding PRA model, this recovery, as well as the Mode 5 recovery, of RWCU/SDC will actually be removed. Floods that serve as initiating events in the shutdown model are those that either fail RWCU/SDC directly, or fail one of the required support systems. Recovery of equipment failed by floods should not be credited. In addition, the number of flood scenarios considered as shutdown initiating events will be reduced because of overly conservative assumptions in the Revision 2 shutdown flood model.

A sensitivity study on the Revision 2 PRA model was quantified with the RWCU/SDC recoveries not credited. The only RWCU/SDC components to appear in the cutsets were check valves G31-F023A/B as a CCF event; the F-V is 5.72E-5 and the RAW is 2.9. The total shutdown flooding CDF increased to 2.50E-8/yr; the RWCU/SDC valves do not exceed the risk significance thresholds.

According to NEDO-33411, Section 2.1:

> *Initiating events are also evaluated to identify failure modes of SSCs that might be implicitly assumed in the failure probabilities. These SSCs are then evaluated to determine if they play a significant role in the failure mode for basic events meeting the F-V threshold. The RAW value measures the increase in risk if a basic event failure probability is taken to 1.0, and thus does not apply to initiating event frequencies.*

Only the F-V importance measure for initiating events is used to highlight potentially risk significant systems. It exaggerates the importance of systems if RAW values for initiating events are used because of the heavy dependence of PRA results on initiating event frequencies. The F-V value for initiating event "%M6U_G31" (loss of RWCU/SDC in mode 6 with the cavity un-flooded) is 8.21E-4. This is over an order of magnitude below the risk significance threshold for F-V, indicating that RWCU/SDC is not a risk significant contributor to ESBWR risk.

In summary:

- The revised system importance study in NEDO-33201 Section 11 shows that RWCU/SDC has a RAW value of approximately 1 and a F-V of approximately 0.00.
- The sensitivity study with no RWCU/SDC recovery shows that the system components are not risk significant. Revision 4 of the shutdown flooding PRA will also give no credit to recovery of flooded equipment.
- The importance of the "loss of RWCU/SDC in mode 6 with cavity un-flooded" shutdown initiating event has been analyzed within the methodology outlined in NEDO-33411 Section 2.1 and deemed non-risk significant (NRS).

The RWCU/SDC will remain categorized as NRS unless Revision 4 PRA results support its inclusion as a risk significant SSC.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33411 changes will be made in response to this RAI.

NRC RAI 17.4-42

The Leak Detection And Isolation System (LD&IS) is not considered risk-significant in Table 6 of NEDO-33411, Revision 0. The discussion presented below suggests that the LD&IS is risk significant and should be included in RAP:

- *The ESBWR Internal Events Low-Power and Shutdown PRA did not assess breaks outside containment (BOCs); therefore, they are not included in the importance analyses. BOCs can originate only in the ICS, RWCU/SDC system, fuel and auxiliary pools cooling system (FAPCS) piping, or instrument lines, which are the only systems that remove reactor coolant from the containment during shutdown. The rest of the RPV vessel piping is isolated. The RWCU/SDC system, FAPCS, and ICS containment penetrations have redundant and automatic power-operated, safety-related containment isolation valves that close upon signals from the leakage detection and isolation system in Modes 5 and 6. The high reliability of the leakage detection and isolation system provides the basis for the screening of (1) shutdown LOCAs outside of containment and (2) operator-induced losses of reactor vessel inventory during shutdown. Therefore, the high reliability of the leakage detection and isolation systems is a key risk assumption.*

The staff requests that GEH provide the basis for considering the LD&IS system as not risk significant. Please include, in your discussion, the associated risk importance measures (e.g., RAWs and F-Vs) as applicable, consideration of deterministic methods (e.g., defense-in-depth), and the expert panel's deliberation for not including LD&IS in RAP.

GEH Response

The Leak Detection and Isolation System (LD&IS) is not a traditionally defined system; it actually is comprised of pieces of various instrumentation and control systems throughout the plant. As discussed in DCD Tier 2 Chapter 7.3.3, the LD&IS has functions performed in various systems:

- MSIV isolation is performed in the Reactor Trip and Isolation Function (RTIF) platform
- All other containment isolation functions are performed in the SSLC/ESF platform (Q-DCIS)
- All nonsafety-related monitoring functions are performed in the N-DCIS

Due to the "virtual" nature of the LD&IS (i.e., more of a grouping of functions rather than actual hardware and software) its risk significant features are captured in the implementing systems. For example, the containment isolation functions that are performed in ESF is considered risk significant as part of "Q-DCIS Software" in Table 6 of NEDO-33411. Similarly, the safety-related MSIV isolation function is covered under RPS/RTIF components and nonsafety-related monitoring is covered by "N-DCIS Software".

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33411 changes will be made in response to this RAI.

NRC RAI 17.4-43

The Containment Isolation System (CIS) is not considered risk-significant in Table 6 of NEDO-33411, Revision 0. CIS provides: a) protection against release of radioactive materials to the environment as a result of accidents, and b) capability to isolate LOCAs outside containment due to breaks in ICS pipes, RWCU/SDC pipes, main steam pipes, and feedwater pipes (these are plausible breaks that could lead to a significant loss of RCS inventory outside of the containment building).

The staff requests that GEH provide the basis for considering the CIS as not risk-significant. Please include, in your discussion, the associated risk importance measures (e.g., RAWs and F-Vs) as applicable, consideration of deterministic methods (e.g., defense-in-depth), and the expert panel's deliberation for not including CIS in RAP.

GEH Response

The PRA logic for containment isolation (CIS) is composed of several functions associated with the ESBWR Leak Detection and Isolation System (LD&IS). The portions of the LD&IS that resides in RPS/RTIF (for MSIVs) and ESF (for all other containment penetrations) perform the containment isolation functions. The risk significance of the LD&IS is discussed in the response to RAI 17.4-42.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33411 changes will be made in response to this RAI.

NRC RAI 17.4-44

The Main Control Room (e.g., 1E display and system controls) and Remote Shutdown Panels necessary to initiate important operator actions (e.g., valve position verifications, actuation of fire protection in low pressure coolant injection mode) are not considered risk-significant in Table 6 of NEDO-33411, Revision 0.

The staff requests that GEH provide the basis for considering these SSCs as not risk significant. Please include, in your discussion, the associated risk importance measures (e.g., RAWs and F-Vs) as applicable, consideration of deterministic methods (e.g., defense-in-depth), and the expert panel's deliberation for not including these components in RAP.

GEH Response

The main control room (MCR) displays (which, being touch screens, are also the controls) are not modeled in the PRA. Failures of the displays/controls due to software are modeled when manual actions from the MCR are credited; software CCF events are considered as failure modes to manual actuations.

Individual panel failures are not modeled explicitly. However, it can be assumed that the failure rate of a display/control is insignificant compared to the bounding human error probabilities (HEP) used in the ESBWR design certification PRA. That is, compared to HEP values on the order of 0.01 and 0.1, the failure probability of the MCR panel itself does not contribute significantly to risk. For example, if the display/control panels are assumed to have the failure rate of a logic card (5.0E-6/hr per Revision 3 of NEDO-33201 Table 5.2-3), the 24-hour mission time failure probability would be 1.2E-4. This value is an order of magnitude less than the lowest HEP values, and two to three orders of magnitude lower than the most important operator actions. It is important to note that this is the failure probability of only one of many available display/control panels in the MCR.

In addition, the impact to risk assuming that the panels are highly unreliable is minimal according to the following RAW values (based on F-V for internal events CDF) of the most significant HRA contributors to risk:

- XXX-XHE-FO-DEPRESS (failure to recognize the need for RPV depressurization – also fails all active low-pressure injection); **RAW = 2.5**
- XXX-XHE-FO-LPMAKEUP (failure to recognize the need for low-pressure make-up after depressurization); **RAW = 2.08**
- B21-XHE-FO-6OPEN (failure to open 6 of 10 SRVs); **RAW = 1.69**

Out of all twelve PRA models, the only two operator actions that exceed the basic event risk significance threshold for RAW are from the shutdown fire PRA:

- XXX-XHE-FO-LPMAKEUP (failure to recognize the need for low-pressure make-up after depressurization); **RAW = 15.94**
- U43-XHE-FO-LPCI (failure to actuate FPS in LPCI mode); **RAW = 5.24**

Although initially screened as risk significant based on the thresholds for single failure events, these event can be deemed as NRS with respect to MCR displays / control panels. The information required to recognize the need for low-pressure make-up (i.e., low reactor water level – this includes FPS in LPCI mode) will be available through multiple systems and be retrievable on both safety related and nonsafety related displays. Therefore, multiple individual failures would have to occur (common cause failures between safety and nonsafety-related systems are not postulated) and the RAW threshold of 50 (used for common cause or multiple failures) is more appropriate.

Although the MCR display and control units are not explicitly modeled in the PRA, it can be extrapolated that they are not risk significant components from existing PRA results based on:

- HEP values that make display/control panel failure rates insignificant by comparison
- Low RAW values for currently modeled HRA values and the fact that multiple display/control panel failures would have to occur to lose functionality

The potential significance of MCR display/control panels will be considered again based on Revision 4 PRA results in Revision 1 of NEDO-33411.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33411 changes will be made in response to this RAI.

NRC RAI 17.4-45

Basic event B32-NONCONDENSE represents noncondensable gasses forming in ICS sufficiently to require venting (Section 4.2 of NEDO-33201, Revision 2). This is a phenomenological event and is assumed to occur with probability 1.0 in the ESBWR PRA. The ESBWR PRA fault trees show that this event can fail ICS if the ICS venting functions fail.

The staff requests that GEH provide the basis for considering the ICS vent valves as not risk significant. In your discussion, please provide the RAWs and F-Vs for operator action B32-OPERVENT (Operator fails to open vent). Also, discuss why common cause failures of the vent valves were not modeled across the vent lines. This common cause failure has the potential to fail multiple ICS loops, thus increasing the risk significance of these vent valves. Please include, in your discussion, the consideration of deterministic methods (e.g., defense-in-depth), and the expert panel's deliberation for not including ICS vent valves in RAP.

`GEH Response

Based on the Revision 2 shutdown high winds PRA model the ICS venting valves should be considered risk significant. The RAW value of CCF of two vent valves (B32-SOV-FE_**_**) is 108.53, which exceeds the risk significance threshold of 50 for CCF events. Common cause failures of vent valves across vent lines are modeled, but the Revision 2 PRA model did not model the "CCF of all vent valves" event.

In the Revision 3 PRA the ICS system model was updated to reflect design changes as discussed in NEDO-33201 Revision 3 Section 22.4.2.2.7. Vent valve CCF is now modeled more inclusively to include all valves within each CCF group; the "energize-to-open" (fail closed) vent valves F009 and F010 are grouped together, while the "de-energize-to-open" (fail open) F012 is grouped separately. As such, it requires two failure events to fail the ICS venting function with the updated design.

The Revision 2 ICS system model actually modeled the secondary vent path as automatic with manual back up; the actual design is manual-only for the secondary flowpath. As such, the operator action to vent ICS (B32-XHE-FO-VENT) does not appear in the Revision 2 PRA results. The RAW and F-V values from the Revision 3 PRA (at-power internal events Level 1 and Level 2), which corrects the secondary vent flowpath modeling, are shown below.

Basic Event	Description	RAW	PRA Model
B32-XHE-FO-VENT	Operator fails to vent ICS	1.02	L1-AP-IE (1)
		1.00	L2-AP-IE (2)
Basic Event	**Description**	**F-V**	**PRA Model**
B32-XHE-FO-VENT	Operator fails to vent ICS	5.23E-3	L1-AP-IE
		1.80E-4	L2-AP-IE

Basic Event	Description	RAW	PRA Model
Notes: 7) Level 1 at-power internal events PRA (Revision 3) 8) Level 2 at-power internal events PRA (Revision 3)			

According to these Revision 3 results, the operator action to back up automatic ICS venting is not risk significant.

The Revision 2 shutdown high winds PRA results show that the vent valves are risk significant. If the Revision 4 PRA results continue to show risk significance, the ICS vent valves will be included in Table 6 of NEDO-33411, Revision 1.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

NEDO-33411 will be updated to incorporate Revision 4 PRA results as discussed in the RAI response. This response is being tracked by GEH as a commitment.

NRC RAI 17.4-46

The Standby Liquid Control System (SLC) electrical heaters are not included in Table 6 of NEDO-33411, Revision 0. The SLC electrical heaters provide defense-in-depth to ensure that the SLC room temperatures are maintained at or above the minimum required temperature in the event of the failure of the primary heating system.

The staff requests that GEH provide the basis for considering the SLC electrical heaters as not risk-significant. Include, in your discussion, how the SLC electrical heaters are actuated (e.g., are the electrical heaters manually actuated or auto-actuated on low room temperature), and where is the SLC low room temperature alarmed (e.g., at a local panel, in the main control room).

GEH Response

The SLCS primary heating system and electrical heaters are not modeled in the PRA for the following reasons:

1) It is assumed that the SLCS sodium pentaborate solution and associated accumulators, piping, etc are within the required temperature range for operability as part of the PRA initial conditions. This assumption is supported by surveillance requirement (SR) 3.1.7.2, which is performed every 24 hours. Per condition "E" of LCO 3.1.7, the temperature must be corrected within 8 hours if found outside the operability range.
2) The amount of time from initiating event to SLCS RPV injection during ATWS scenarios is very short. Per DCD Tier 2 Revision 5 Section 7.4.1.2, the SLCS design basis is to actuate based on an ATWS signal present for 180 seconds.

Given that the SLCS equipment is within the operability range for temperature as an initial condition, the SLCS will actuate after the ATWS signal is present for three minutes. Assuming a worst-case scenario in which the temperature is at the low end of operable and the heaters fail coincident with an ATWS initiating event, the SLCS sodium pentaborate solution will not experience appreciable precipitation within the three-minute delay to system actuation.

Based on the two reasons listed above, the SLCS heating equipment is not modeled within the PRA mission time and is not considered to be risk significant.

DCD/NEDO-33411 Impact

No DCD changes will be made in response to this RAI.

No NEDO-33411 changes will be made in response to this RAI.

NRC RAI 17.4-47

In general, risk-significant passive SSCs (e.g., piping, tanks, fire barriers) were not included in Table 6 of NEDO-33411, Revision 0. The Reliability Assurance Program (RAP), in principle, applies to risk-significant active and passive systems, structures, and components (SSCs). During the design phase of RAP risk-significant SSCs are identified for inclusion in the program by using probabilistic, deterministic, and other methods (e.g., industry experience, expert panel). The purposes of RAP are to provide reasonable assurance that (SECY-95-132, May 22, 1995):

1) *A reactor is designed, constructed, and operated in a manner that is consistent with the assumptions and risk insights for these risk-significant SSCs.*
2) *The risk-significant SSCs do not degrade to an unacceptable level during plant operations.*
3) *The frequency of transients that challenge SSCs are minimized.*
4) *These SSCs function reliably when challenged.*

The staff requests that GEH provide the basis for not including in Table 6 of NEDO-33411, Revision 0, these risk-significant passive SSCs (e.g., piping, tanks, fire barriers). Include, in your discussion, how the purposes of RAP are met through other programs/requirements (e.g., inspections, monitoring) for these risk-significant passive SSCs.

GEH Response

NEDO-33411 does include some risk significant passive SSCs such as ICS/PCCS condensers, the PCCS and GDCS filters/strainers, and the BiMAC device, to name a few. Other passive components/structures are excluded from the list of risk significant SSCs for the following reasons:

1) Large, structural tanks (such as GDCS and ICS/PCCS pools) are excluded because they are physically incorporated with safety-related, seismic category 1 buildings. The failure probabilities for these structures, if modeled, are based on traditional tanks or accumulators; the actual probability of failure for building structures is negligible compared to active component failures.

2) The failure probabilities during the mission time for passive components such as tanks and piping are typically on the order of ~E-6 or less. Reference 5-1 for NEDO-33201 shows the generic "piping section" failure rate to be 8.5E-9/hr; due to the redundancy in ESBWR design and the fact that CCF is not normally modeled for passive failures, the contribution of piping failures can be considered negligible.

3) As stated in the methodology in NEDO-33411 Section 2.1.1, there are typically other programs for monitoring piping and pressure vessels:

   If a basic event is found to be not risk significant, it is deleted from the list with a justification in Table 4. For example, the PRA model includes low *probability component failures, such as tank ruptures, in some sequences to account for losses of water inventory or flooding. These vented tanks are inherently reliable, and are inspected and maintained through appropriate programs for monitoring piping and pressure vessels. Because they have prescribed levels of monitoring and their failure probabilities are low, they are considered not risk significant.*

The risk significance determination process is used to identify SSCs that should be included in the DRAP so that their reliability can be kept consistent with the PRA assumptions throughout the design process. This process is especially important for new or uncommon components, such as the WW to DW vacuum breakers or ADS/GDCS/SLCS squib valves because their reliability is relatively uncertain and could have an effect on overall plant risk.

ESBWR SSCs such as the GDCS pools or condensate storage tank have significantly less design "volatility" as far as reliability is concerned (i.e., they have much less potential to become significantly less reliable during the detailed design process) and, as such, are deemed non-risk significant for this task.

<u>DCD/NEDO-33411 Impact</u>

No DCD changes will be made in response to this RAI.

No NEDO-33411 changes will be made in response to this RAI.

Enclosure 2

MFN 08-639

Mark-ups to NEDO-33411, "Risk Significance of Structures, Systems, and Components for the Design Phase of the ESBWR" in Response to NRC Request for Additional Information Letter No. 206

1.0 INTRODUCTION

1.1 Objective

The objective of this report is to determine ~~the structures, systems and~~the components ~~(SSCs)~~ that are considered risk significant in the design phase of the ESBWR. The list of these components ~~SSCs~~ is required for Phase 1 of the Design Phase Reliability Assurance Program (D-RAP) and is based on results from the ESBWR design certification Probabilistic Risk Analysis (PRA).~~,~~ The D-RAP is described in DCD Section 17.4.

1.2 Scope

The scope of this assessment is in accordance with Phase 1 of the Reliability Assurance Program, as described in DCD Section 17.4 and NEDO 33289. The objective is to capture components modeled in the PRA whose assumed reliability is risk significant. Phase 1 of the D-RAP maintains the assumed reliability throughout the detailed design process. A blended approach is used for identifying and prioritizing risk significant SSCs. The analysis is comprehensive because it is based on operating and shutdown conditions for internal and external events resulting in core damage and large radiological releases to the environment. Risk significance for Phase 1 of the D-RAP is defined relative to the importance of modeled components ~~SSCs~~ to core damage frequency (CDF) and large release frequency (LRF).~~,~~ Components that are judged to be risk significant by deterministic means are controlled by other programs throughout the design process.~~and is defined qualitatively for seismic risk based on the Seismic Margins Analysis.~~ RAI 17.4-20

Review of operating experience from currently operating reactors is also in the scope of this assessment as it applies to identifying additional initiating events or operator errors that may have a significant effect on the Probabilistic Risk Assessment (PRA) results.

The sources of information for this assessment are the PRA models for at-power and shutdown; ~~Seismic Margins Analysis;~~ DCD Section 19, Table 19.2-3, "PRA Insights and Assumptions;" NEDO 33201 Section 2.0, "Initiating Events"; Operating Experience Reports – INPO Databases; and DCD Chapter 19 Appendix A, "Regulatory Treatment of Non-Safety Systems."

2.0 RISK SIGNIFICANCE METHODOLOGY

This report identifies the SSCs that are considered risk significant in the ESBWR design phase. As illustrated in Figure 1, the methodology for determining risk significance relies on several factors to provide a comprehensive assessment. In addition to the quantitative results from each PRA model that are evaluated relative to risk significant thresholds, several qualitative factors are considered. This includes the focused analyses that are performed to identify Regulatory Treatment of Non Safety Systems (RTNSS) SSCs. The insights from the Seismic Margins Analysis are considered for risk significance. The key insights from the PRA and industry operating experience are also evaluated to identify SSCs that should be risk significant. This compilation of information is evaluated by an expert panel to validate the results. The steps in the identification process are described below.

2.1 Risk Significant Thresholds

The comprehensive PRA model results (at-power and shutdown; internal, fire, flooding, high winds; CDF and LRF) are compared to the threshold values of Fussell-Vesely (F-V) and Risk Achievement Worth (RAW) importance. These results are based on NEDO 33201 Revision 2. The common industry practice is to apply recommended thresholds for plants with CDFs in the 1 E-4/yr to 1 E-6/yr range (F-V greater than or equal to 0.005 at the component level, 0.05 at the system level, and RAW greater than or equal to 2.0). RAI 17.4-18 However, this practice does not apply to plants with significantly lower CDF and LRF values. Instead, the criteria for defining risk significance should be a function of the baseline CDF and LRF. For the purpose of this study, the method described in NEDO 33201 Section 17.1.2 is used to apply the following thresholds for identifying potentially risk significant basic events:

- F-V greater than or equal to 0.01
- RAW greater than or equal to 5.0 for individual events
- RAW greater than or equal to 50 for common cause failures

These thresholds are applied to the PRA models with CDF and LRF values of approximately 1 E-8/year. For the PRA models with CDF and LRF values a factor of 10 lower, the thresholds are increased by a factor of 10 so that the relative risk values are evaluated on the same basis. For example, the High Winds CDF is 1.3 E-9/year and the thresholds for risk significance are 0.1 for F-V and 50 for RAW. The common cause failure (CCF) threshold is maintained at 50 to account for uncertainties inherent in the CCF methodology. In addition, F-V values for basic events representing the same component are summed and then compared to the threshold. Basic events that do not meet the threshold values are considered not risk significant. The issue of identifying the appropriate numerical range of risk significance continues to be examined and, as such, is subject to refinement as more experience is gathered in this area.

2.1.1 Identifying Applicable SSCs

Applying these risk significance thresholds to the PRA results yields the basic events in Table 1 that are used to determine the final list of risk significant SSCs. Each basic event is evaluated to identify the specific SSCs that it represents. Some SSCs have a higher importance for one train than the other because of PRA modeling conventions. For example, if the PRA model assumes that train A is always operating and train B is in standby, then the risk significance will be different between the two trains because failure to start is only modeled on the standby train. In these cases, the identical SSCs are treated with the same, highest risk significant value.

Human error basic events are evaluated to identify failure modes of SSCs that might be implicitly assumed in the failure probabilities. These SSCs are then evaluated to determine if they play a significant role in the failure mode for basic events meeting the risk thresholds.

Initiating events are also evaluated to identify failure modes of SSCs that might be implicitly assumed in the failure probabilities. These SSCs are then evaluated to determine if they play a significant role in the failure mode for basic events meeting the F-V threshold. The RAW value measures the increase in risk if a basic event failure probability is taken to 1.0, and thus does not apply to initiating event frequencies.

If a basic event is found to be not risk significant, it is deleted from the list with a justification in Table 4. For example, the PRA model includes low probability component failures, such as tank ruptures, in some sequences to account for losses of water inventory or flooding. These vented tanks are inherently reliable, and are inspected and maintained through appropriate programs for monitoring piping and pressure vessels. Because they have prescribed levels of monitoring and their failure probabilities are low, they are considered not risk significant.

2.1.2 Evaluating Undeveloped Events

The design phase PRA model uses undeveloped basic events to provide high-level functional information for SSCs that do not yet have design details available. As such, these undeveloped events often represent more than a single component and their importance values are therefore not consistent with the other basic events. Undeveloped events will initially be evaluated against the single failure risk importance thresholds for RAW and F-V to ensure that all potentially significant events are identified. Once identified, the undeveloped events are evaluated on a case-by-case basis to determine risk significance. For example, undeveloped events that require multiple failures may be measured against the CCF risk significance thresholds. The most updated design information will be used by the expert panel to make the final risk significance determination.~~with high risk importance values are evaluated to determine if they truly provide a risk significant contribution. For example, a system that has an undeveloped basic event above the risk thresholds is evaluated in a sensitivity study by quantifying the effect of deleting that system entirely. If the revised CDF is less than 1 E-6/yr and if the revised results do not introduce any new systems above the risk thresholds, then the system is considered not risk significant. Undeveloped events representing functions that are safety-related or RTNSS are retained and evaluated with respect to other basic events representing those functions.~~

RAI 17.4-25

2.2 Seismic Margins Analysis

The Seismic Margins Analysis results are detailed in NEDO 33201 Section 15. The SSCs in Table 2 are considered significant in the SMA and are based on deterministic criteria identifying SSCs that must maintain a high confidence low probability of failure (HCLPF) to withstand a safe shutdown earthquake. –Because components that are considered risk significant in the SMA are not necessarily risk significant based on their PRA-modeled failure modes, they are not required to be included as risk significant in Table 6. The inclusion of SMA-significant components in Phase 1 of the D-RAP does not address the truly risk significant performance requirement of the components.~~Due to lack of numerical results to compare against risk thresholds, all SSCs requiring a HCLPF value in the SMA are conservatively included as risk significant, except for piping, which is passive in nature and is inspected and tested in accordance with ASME requirements~~. RAI 17.4-20

2.3 Regulatory Treatment of Non Safety Systems

Two of the RTNSS criteria, described in DCD Section 19 Revision 4, Appendix A, are based on probabilistic criteria. Criterion C pertains to SSC functions relied upon under power-operating and shutdown conditions to meet the NRC safety goal guidelines of a CDF of less than 1.0 E-4/year and LRF of less than 1.0 E-6/year. Criterion D pertains to SSC functions needed to meet the containment performance goal, including containment bypass, during severe accidents. For the purpose of this report, SSCs meeting RTNSS Criterion C or D are considered risk significant. Table 3 is a list of risk significant RTNSS systems and functions and applicable SSCs. Several SSCs are listed at the train level because design details are not available. In these cases, the components that fulfill the RTNSS functions will be RTNSS (and risk significant) components.

2.4 PRA and Severe Accident Insights

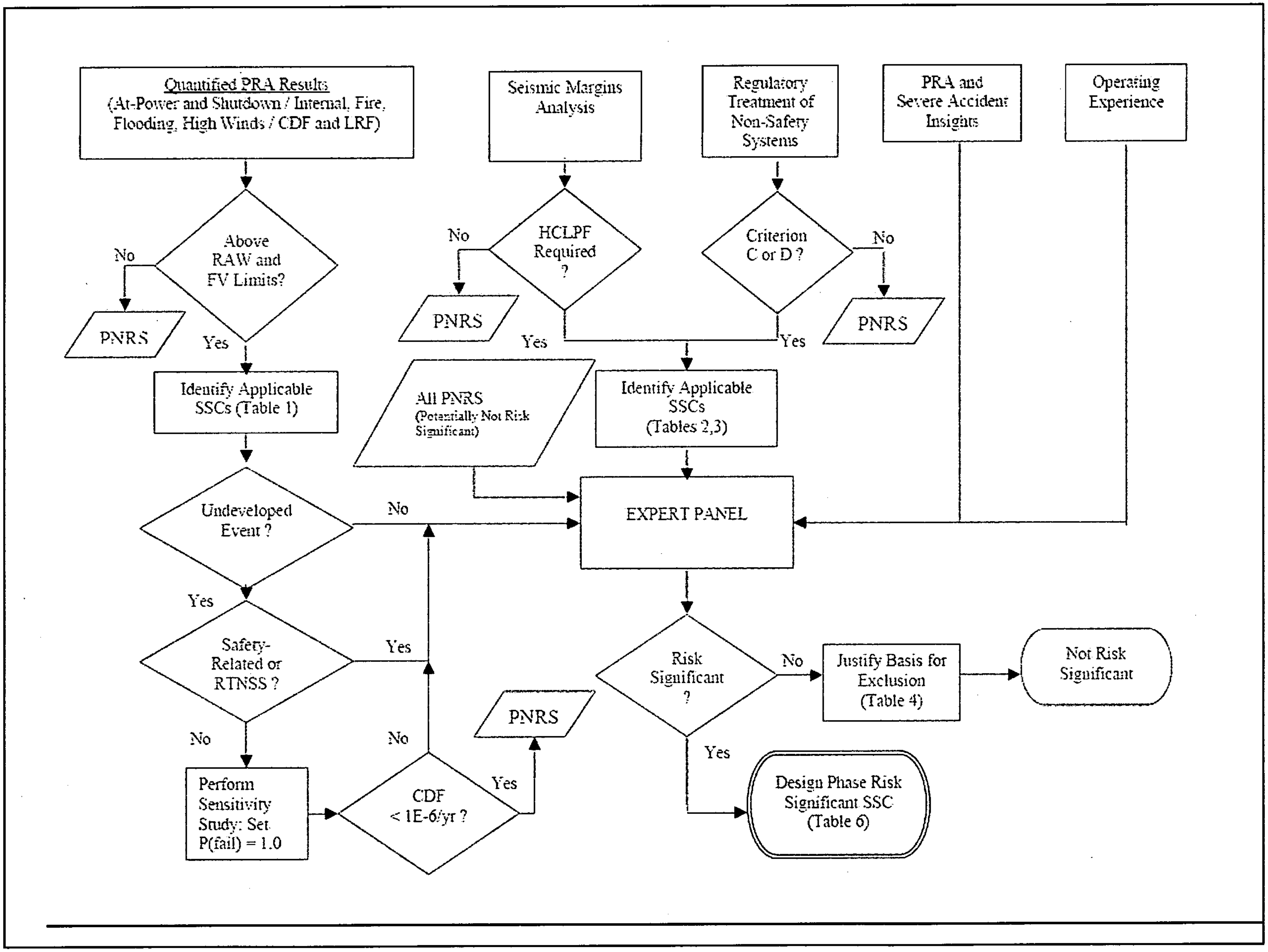
These risk insights and assumptions are provided in DCD Section 19 Table 19.2-3. They are qualitative attributes that describe important aspects of the PRA model and severe accident analysis. They are evaluated by the Expert Panel to identify failure modes of SSCs that might be implicit within the insight or assumption, and thus should be considered risk significant.

2.5 Operating Experience

Operating experience is collected from the INPO Operating experience databases to determine if there are SSCs that are not modeled explicitly, but could contribute significantly to either initiating a core damage event, or causing an adverse operator interaction at an ESBWR. A collection of relevant operating experience is evaluated by the Expert Panel to identify failure modes or human errors that could produce risk significant results.

2.6 Expert Panel Process

An expert panel is assembled to assess the collective information for this analysis. The team members have experience in the areas of operations, engineering, and PRA and have been selected to provide a thorough review of the analysis (see Table 5). The


Quantified PRA Results
(At-Power and Shutdown / Internal, Fire, Flooding, High Winds / CDF and LRF)
Seismic Margins Analysis
Regulatory Treatment of Non-Safety Systems
PRA and Severe Accident Insights
Operating Experience
Above RAW and FV Limits?
No
PNRS
Yes
HCLPF Required ?
No
PNRS
Yes
Criterion C or D ?
No
PNRS
Yes
Identify Applicable SSCs (Table 1)
All PNRS
(Potentially Not Risk Significant)
Identify Applicable SSCs (Tables 2,3)
Undeveloped Event ?
No
EXPERT PANEL
Yes
Safety-Related or RTNSS ?
Yes
Risk Significant ?
No
Justify Basis for Exclusion (Table 4)
Not Risk Significant
No
No
PNRS
Yes
Yes
Perform Sensitivity Study: Set P(fail) = 1.0
CDF < 1E-6/yr ?
Design Phase Risk Significant SSC (Table 6)

RAI 17.4-24

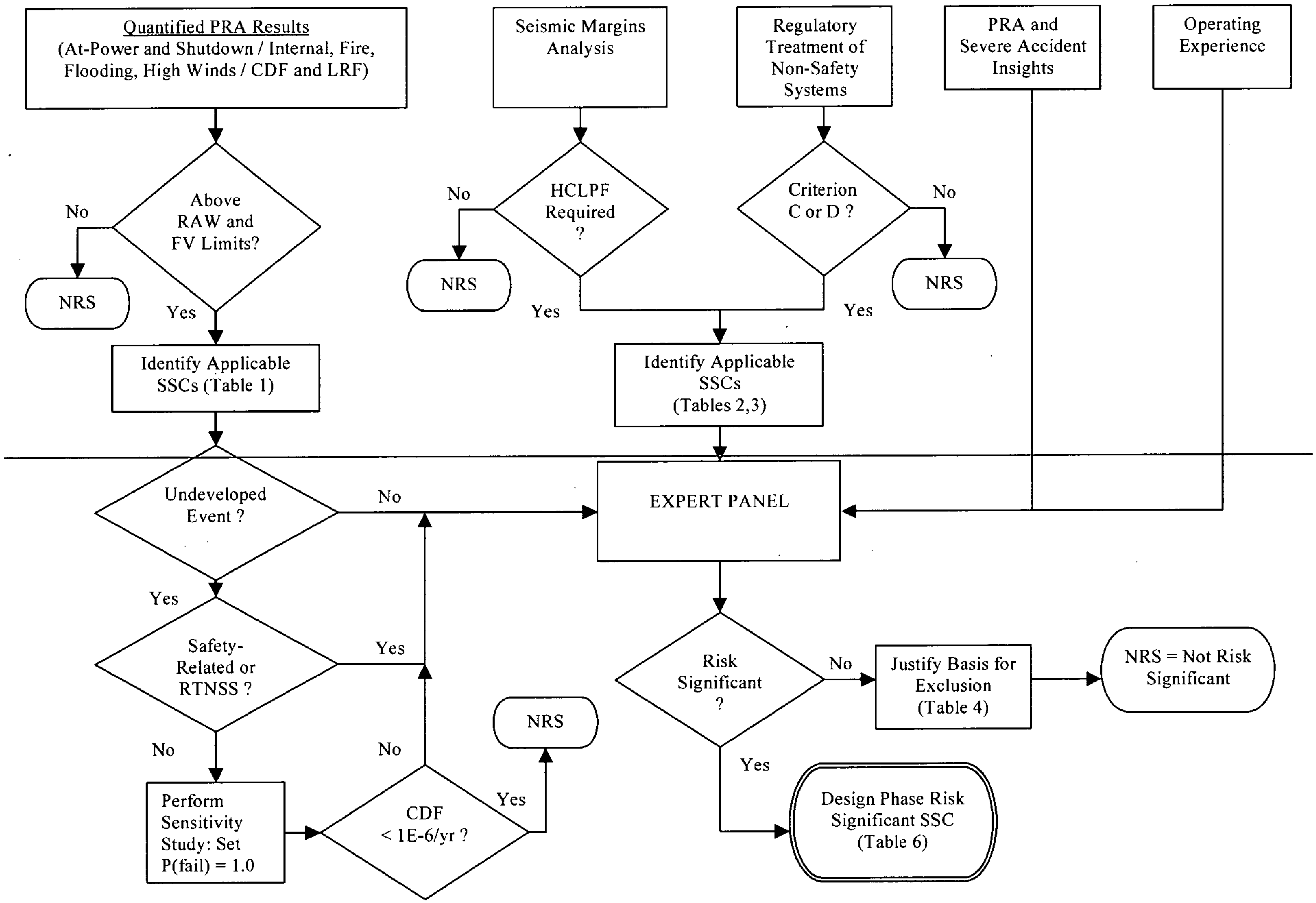


Figure 1 – Process for Identifying Risk Significant SSCs

RAI 17.4-24