January 31, 2007

Mr. David H. Hinds, Manager, ESBWR
General Electric Company
P.O. Box 780, M/C J70
Wilmington, NC 28402-0780

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 91 RELATED TO ESBWR DESIGN CERTIFICATION APPLICATION

Dear Mr. Hinds:

By letter dated August 24, 2005, General Electric Company (GE) submitted an application for final design approval and standard design certification of the economic simplified boiling water reactor (ESBWR) standard plant design pursuant to 10 CFR Part 52. The Nuclear Regulatory Commission (NRC) staff is performing a detailed review of this application to enable the staff to reach a conclusion on the safety of the proposed design.

The NRC staff has identified that additional information is needed to continue portions of the review. The staff's request for additional information (RAI) is contained in the enclosure to this letter. This RAI concerns NEDO-33201, Revision 1, ESBWR Probabilistic Risk Assessment.

RAIs: 19.1-117 through 148 and 19.2-69 through 79.

To support the review schedule, you are requested to respond to this RAI by March 15, 2007.

If you have questions or comments concerning this matter, please contact me at (301) 415-0224 or tak@nrc.gov or you may contact Amy Cubbage at (301) 415-2875 or aec@nrc.gov.

Sincerely,

/RA/

Thomas A. Kevern, Senior Project Manager
ESBWR/ABWR Projects Branch 1
Division of New Reactor Licensing
Office of New Reactors

Docket No. 52-0010

Enclosure: As stated

cc: See next page

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ACCESSION NO. ML070310036

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Requests for Additional Information (RAIs)
NEDO-33201, Revision 1, "ESBWR Probabilistic Risk Assessment"

RAI Number	Reviewer	Summary	Full Text
19.1-117	Pohida M	Explain why modeling Mode 6 conditions with the reactor vessel head removed is sufficient (Section 16).	Shutdown event trees in Mode 6 cover conditions with the reactor vessel head removed and with the head on (but with one or more of the head closure bolts less than fully tensioned). In the Mode 6 event trees, the assumption is made that the head is removed and, therefore, no RCS pressure control is needed for RCS injection and gravity driven cooling system (GDCS). Please explain in the PRA why modeling of Mode 6 with the head on is not needed.
19.1-118	Pohida M	Provide shutdown fault trees (Section 16).	For the shutdown PRA, the staff is unable to determinate what mitigating systems are automated and what mitigating systems require manual action. Since shutdown risk is driven by human error for current plants, the staff needs to review the shutdown fault trees to understand required human actions during shutdown modes. Please provide the shutdown fault trees.
19.1-119	Pohida M	Evaluate diversion of reactor vessel inventory into an empty feedwater line during shutdown (Section 16).	The shutdown PRA does not evaluate loss of reactor vessel inventory through human error. Since automatic isolation of reactor water cleanup/shutdown cooling system (RWCU/SDC) on low reactor vessel level is not required by Technical Specifications in Modes 5 and 6, please explain how loss of inventory through an empty feedwater line has been evaluated during shutdown.
19.1-120	Pohida M	Address the passive containment cooling system with an open containment (Section 16)	Please explain whether the Passive Containment Cooling System (PCCS) is functional with an open containment. Containment integrity is not required in Modes 5 and 6 and, if PCCS is not functional, credit for PCCS should be removed from the shutdown event trees for Modes 5 and 6.

RAI Number	Reviewer	Summary	Full Text
19.1-121	Pohida M	Explain the factor of ten reduction in shutdown LOCA frequencies compared to full power LOCA frequencies and evaluate RWCU/SDC piping for thermal fatigue (Section16).	Please explain the factor of ten reduction in shutdown LOCA frequencies compared to full power LOCA frequencies. The staff notes that shutdown LOCA frequencies were not reduced by a factor of 10 in the AP1000 PRA, and the staff is not aware of any operating data that support the factor of 10 reduction. Please evaluate the RWCU/SDC heat exchanger bypass flow line to determine whether the line is susceptible to thermal fatigue.
19.1-122	Pohida M	Provide a shutdown PRA sensitivity study crediting only the systems required to be operable according to Technical Specifications.	Please provide a sensitivity study in the shutdown PRA that credits only the systems required to be operable according to Technical Specifications. This request is related to SECY 97-168, in which the staff concluded that the current level of shutdown safety was achieved by voluntary measures that are not required by current regulations, and that these measures could be withdrawn by licensees without NRC approval.
19.1-123	Pohida M	Explain whether the ESBWR design has considered the Shutdown Management Guidelines in NUMARC 91-06.	Please explain in the shutdown PRA whether the ESBWR design has considered the Shutdown Management Guidelines in NUMARC 91-06, including: (1) how the automatic isolation function of the DHR system (on low RPV level) should be maintained during shutdown cooling periods (NUMARC 91-06 guideline 4.2.3); and, (2) how containment closure can be achieved in sufficient time to prevent potential fission product release (NUMARC Guidelines 4.5).
19.1-124	Pohida M	Provide the definition of "shutdown initiating event" related to internal events, fire, and flooding.	Please provide the definition of a shutdown initiating event in the shutdown PRA sections that address internal events, shutdown fire, and shutdown flooding.

RAI Number	Reviewer	Summary	Full Text
19.1-125	Pohida M	Explain why a postulated fire causes an SRV to open.	Please explain in the shutdown fire assessment why the assumption that a postulated fire causes an SRV to open is conservative given that the SRVs must open for low pressure injection via feedwater or control rod drive hydraulic systems.
19.1-126	Pohida M	Explain in the shutdown fire PRA the definition/capability of a fire watch when fire barriers are not intact.	Please explain in the shutdown fire PRA the definition and capability of a fire watch when fire barriers are not intact. The staff needs additional information to assess the fire propagation failure rate of .0074 between barriers when fire watches are used instead of fire barriers.
19.1-127	Pohida M	Explain in the shutdown fire PRA whether a fire watch is a "roving" or "continuous" watch.	Please clarify whether the referenced fire watch in the shutdown fire PRA is a roving watch or a continuous watch with capability to communicate to the control room. If the fire watch is a roving fire watch, please specify in the shutdown fire PRA the frequency the fire watch will monitor fire areas with breached barriers.
19.1-128	Pohida M	Clarify units for Table 12-9, Table 12-12 and Table 12-16	Please clarify the units in NEDO-33201, Revision 1, Table 12-9, Table 12-12, and Table 12-16. For example, when frequencies are referenced as per year, explain whether it is a shutdown year (where the plant is in the shutdown mode for a calendar year) or a calendar year (where the plant is expected to be full power most of the time).
19.1-129	Pohida M	Please explain how the shutdown control room fire risk analysis considers TS regarding the operability of automatic systems.	The shutdown technical specifications do not require operability of automatic systems, with the exception of GDCS. Please explain how the shutdown control room fire risk analysis considers that the operability of automatic systems is not required, with the exception of GDCS on low reactor vessel level.
19.1-130	Pohida M	Provide an evaluation that credits only safety-related equipment for accident mitigation in the shutdown fire PRA (Section 12).	Please perform a sensitivity study which credits only safety-related equipment for accident mitigation in the shutdown fire PRA and provide the top 100 cutsets. This information is needed to support the RTNSS process.

RAI Number	Reviewer	Summary	Full Text
19.1-131	Pohida M	Justify the assumption that flooding scenarios through open containment hatches are non-significant. .	In the shutdown flooding PRA (general assumption 29), it is assumed that the flooding duration through open hatches is sufficiently short such that Containment flood scenarios involving an open Containment are non-significant. Containment integrity is not required during Modes 5 and 6. Therefore, containment can be open the entire duration of Modes 5 and 6. Current BWR licensees de-inert and open containment early to stage equipment maintenance. Please justify in the shutdown flooding PRA how the duration of time that the equipment hatches and personnel hatches are opened is sufficiently short such that containment flood scenarios involving an open containment are non-significant.

RAI Number	Reviewer	Summary	Full Text
19.1-132	Pohida M	Revise the shutdown flooding PRA to address automatic isolation of RWCU/SDCS in Modes 5 and 6.	In the shutdown flooding PRA, it is stated that a line break in the RWCU/SDC system outside Containment, combined with failure of automatic isolation of the break, will result in flooding the lower floor of the Reactor Building and the lower floor of the Fuel Building via the door separating the two areas. Please revise the shutdown flooding PRA to reflect that automatic isolation of RWCU/SDCS is not required in Modes 5 and 6, or explain why the shutdown flooding PRA should not be changed.
19.1-133	Pohida M	Evaluate the risk impact of a shutdown LOCA and the propagation of that flood via an opened equipment hatch to other flood areas during Modes 5 and 6.	Please evaluate the risk impact of a shutdown LOCA during Modes 5 and 6 and the propagation of that flood via an opened equipment hatch to other flood areas (such as the reactor building). In the flooding PRA, it is stated that, during shutdown conditions, LOCA frequencies are much lower than at-power conditions, and as such, shutdown LOCAs are non-significant risk contributors and are not analyzed further in this analysis. However, the staff has found that LOCAs at shutdown with an open containment dominate the total ESBWR release frequency risk.
19.1-134	Pohida M	Address inconsistencies in the shutdown internal events PRA and the shutdown flooding PRA regarding the feedwater system.	In the shutdown flooding PRA (general assumption 30), the feedwater and condensate systems are assumed to be unavailable during Modes 5 and 6. This assumption is inconsistent with the internal events shutdown PRA which credits feedwater for RCS injection. Please revise the PRA to explain which assumption is correct.
19.1-135	Pohida M	Address inconsistencies between the shutdown flooding PRA and Technical Specifications.	In the shutdown flood PRA (general assumption 31), it is assumed that both manual and automatic depressurization (ADS) of the reactor vessel are available while the vessel head is in place. This assumption is inconsistent with Technical Specifications which do not require the operability of ADS during Modes 5 and 6. Please explain why this inconsistency exists between the PRA and Technical Specifications.

Requests for Additional Information (RAIs)
NEDO-33201, Revision 1, "ESBWR Probabilistic Risk Assessment"

RAI Number	Reviewer	Summary	Full Text
19.1-136	Pohida M	Provide additional information regarding areas considered in the shutdown flooding PRA (Section 13).	For each flooding area considered in the flooding risk analysis, please provide the maximum expected flood height, flood propagation potential (e.g., wall penetrations, doors open for maintenance, under doors, and down stairwells), and the location of equipment with respect to the maximum expected flood height.
19.1-137	Pohida M	Explain interaction of fire protection system with reactor component cooling water system in shutdown flooding PRA.	In the shutdown flooding PRA (general assumption 32), it is assumed that none of the fire protection system piping located in the Electrical or Turbine Buildings have the capacity to affect operation of the RCCWS. Please explain why this assumption is valid.
19.1-138	Pohida M	Provide an evaluation which credits only safety-related equipment in the shutdown flooding PRA (Section 13).	Please provide a sensitivity study which credits only safety-related equipment for accident mitigation in the shutdown flood PRA and provide the top 100 cutsets. This information is needed to support the RTNSS process.
19.1-139	Pohida M	Evaluate the impact of flooding on RCS pressure control in the shutdown flooding PRA.	In the shutdown flood PRA, the accident sequence modeling considers the flood impacts on two critical safety functions during shutdown: 1) decay heat removal (DHR) and 2) RCS inventory control. However, the critical safety function of RCS pressure control is necessary for low pressure RCS injection and gravity driven injection. Please evaluate the impact of flooding on RCS pressure control in the shutdown PRA, or please explain why this evaluation is not needed.
19.1-140	Pohida M	Address use of temporary penetrations in the shutdown flooding PRA.	Please address the potential risk associated with flooding that could result from the use of temporary penetrations associated with refueling (e.g., refueling cavity seal failure).
19.1-141	Pohida M	Describe the top events used in the shutdown flooding event trees in the PRA.	Please describe the top events used in the shutdown flooding event trees in the PRA.

RAI Number	Reviewer	Summary	Full Text
19.1-142	Pohida M	Provide P&IDs for the reactor water cleanup/shutdown cooling system.	The staff was recently informed that the Technical Specifications will be revised to require RWCU/SDC Isolation during Modes 5 and 6 on low reactor vessel level. However, it appears that there are numerous piping connections upstream of the RWCU/SDC containment isolation valves and the opening of valves in such piping could drain the vessel since the drain path would not be isolated by the proposed RWCU/SDC isolation. The staff notes that loss of reactor vessel inventory caused by human error is not currently addressed in the shutdown PRA. Please provide P&IDs for the RWCU/SDC to enable the staff to evaluate shutdown risk estimates for human error induced vessel diversion paths.
19.1-143	Pohida M	Provide additional information regarding RCS venting for GDCS operation I during Modes 5 and 6.	RCS pressure control is not required by Technical Specifications (TS) in Modes 5 and 6 (when the reactor vessel head is on). However, the ability to vent the RCS is necessary to use low pressure injection (via fire water or FAPCS) and to use GDCS. The staff notes that the TS bases for the operability of GDCS during Modes 5 and 6 state, "The RPV must have or have the ability to establish sufficient RPV venting capacity to maintain the RPV depressurized following loss of decay heat removal capability for a GDCS injection branch line to be capable of injecting into the RPV." However, no vent size is specified in the TS bases and, with insufficient vent size, GDCS could be inoperable. Please provide the following: (1) specify in the TS bases for GDCS operability at shutdown the vent size necessary for GDCS to function and (2) calculations that support the specified RCS vent size.
19.1-144	Pohida M	Provide additional information regarding isolation condenser system operation for cold shutdown conditions.	Please provide calculations to demonstrate that short term and long term core cooling can be provided by isolation condenser system operation following an extended loss of the RWCU/SDC function from a cold shutdown condition. This information will assist the staff to address thermal-hydraulic uncertainty in the ESBWR passive design regarding shutdown success criteria.

RAI Number	Reviewer	Summary	Full Text
19.1-145	Pohida M	Explain why modeling Mode 6 conditions with the reactor vessel head removed is sufficient for the shutdown seismic risk analysis.	The shutdown seismic event tree for Mode 6 (unflooded condition) includes conditions with the reactor vessel head removed and with the head in place (but one or more of the closure bolts less than fully tensioned). The evaluation assumes that the head is removed and, therefore, no RCS pressure control is needed for RCS injection and GDCS. Please revise the evaluation to model Mode 6 conditions with the head on and with the head removed, or please explain why modeling of Mode 6 with the vessel head on is not needed.
19.1-146	Pohida M	Address passive containment cooling system operation for an open containment in the shutdown seismic risk analysis.	Please discuss in the shutdown seismic risk analysis whether the passive containment cooling system (PCCS) is functional with an open containment. If PCCS is not functional, credit for PCCS should be removed from the shutdown seismic event trees for Modes 5 and 6, since containment integrity is not required in Modes 5 and 6
19.1-147	Pohida M	Address the use of temporary penetrations associated with refueling in the shutdown seismic risk analysis.	Please (1) address the fragility of temporary penetrations that may be used during refueling (e.g. refueling cavity seal) and (2) assess their fragility in the seismic event trees.
19.1-148	Pohida M	Evaluate in shutdown PRA the consequences of a drained suppression pool during Modes 5 and 6.	The shutdown PRA credits SRV actuation with relief to the suppression pool during Modes 5 and 6 following an extended loss of RWCU/SDC and, additionally, it appears that suppression pool level is necessary for GDCS operation at shutdown for long term cooling. However, suppression pool level is not required by Technical Specifications in Modes 5 and 6. Please evaluate in the PRA: (1) consequences of relieving steam to an empty suppression pool (e.g. suppression pool over-pressurization) and (2) consequences of an empty suppression pool on GDCS operation.
19.2-69	Palla R	Include probability of hydrogen combustion when containment is not inerted.	Reference: PRA Revision 1, Section 8.1 The probability of hydrogen combustion during the periods when the containment is not inerted (typically 24 hours) prior to and following shutdown needs to be included within the risk profile.

RAI Number	Reviewer	Summary	Full Text
19.2-70	Palla R	Assess contribution to LERF from events occurring during inerted operation.	Reference: PRA Revision 1, Section 8.1 In Section 8.1.3, GE justifies not addressing the potential for containment failure due to combustible gas deflagration on the basis that the containment would remain inerted for significantly greater than 24 hours following an accident. However, the potential for combustion related containment failures in accidents occurring during the period of de-inerted operation prior to and following shutdown was not addressed. Provide an assessment of the contribution to large release frequency from events occurring during the period of de-inerted operation.
19.2-71	Palla R Fuller E	Discuss changes to the MAAP parameter file.	Reference: PRA Revision 1, Section 8.3.1 Confirm whether the MAAP parameter file reflects the current design. Identify any design changes that have not yet been incorporated and discuss the impact of these changes on the PRA, and the schedule for incorporating these changes into the ESBWR analysis. Please explain how the chimney region above the core is modeled in MAAP, or, if no model enhancements were made, how it is treated in the MAAP parameter file.
19.2-72	Palla R Fuller E	Provide details on accident progression and chronology for <u>all</u> representative sequences.	Reference: PRA Revision 1, Sections 8.3.2 and 9.0 (A) With the exception of release category "FR", there is essentially no information provided on accident progression and chronology, containment response, and source term release magnitude and timing for any of the release categories and representative sequences. Provide such additional details for each of the representative sequences listed in Table 9-1. (B) Of particular interest is Sequence T_nDP_nIN_VB in Section 8.3.2.3, for cases where vacuum breaker failure has occurred (release category OPVB; Section 9.8). Please provide <u>detailed</u> accident chronology and pressure and temperature plots for this sequence in Section 8.3.2.3. (C) It would be very useful if the representative sequences included one where neither the deluge system nor the BiMAC were functional. Moreover, sequences where CCI occurs should be included (one with wet CCI and one with dry CCI). Please include such sequences. (D) For all sequences presented, please include plots of the upper drywell temperature and lower drywell temperature in addition to the plots already presented.

RAI Number	Reviewer	Summary	Full Text
19.2-73	Palla R	Provide justification for probability values in CSETs on vent valve operability.	Reference: PRA Revision 1, Section A.8.2 The probability of successful containment vent operation is assumed to be independent of initiating event and support systems. Provide justification for the probability value and for the use of the same value for all CSETs. Include a description of the vent valves, their associated support systems, and the operator actions required to open and to reclose the valves, and the locations and environmental conditions where these actions would be taken.
19.2-74	Palla R	Assess impact if containment isolation/bypass is questioned earlier in the event tree.	Reference: PRA Revision 1, Section A.8 Given the structure of the CPETs and CSETs in Appendix A.8 of the PRA, Containment Isolation/Bypass is not questioned in the CPETs, and is only questioned in the CSETs (i.e., for those events which transfer from the CPET to the CSET.) The consequences for all of the release categories assigned in the CPET (e.g., CCI-W, CCI-D, EVE, and DCH) are less severe than for the Bypass release category considered in the CSET. As such, the decision to question Containment Isolation/Bypass only for those events that transfer to the CSET (rather than addressing this question for all events) results in an under-estimate of the frequency and risk of bypass events. Provide an assessment of the impact on LRF and risk results if Containment Isolation/Bypass was questioned earlier in the event tree.
19.2-75	Palla R	Discuss need for venting as part of containment flooding strategy.	Reference: PRA Revision 1, Sections 8.2.1.3.6 and A.8.2 Although operator guidance for controlled venting may not be fully developed at this time, it appears that operator actions to flood containment in accordance with Step RC/F-1 or RC/F-2 of the Severe Accident Guidelines for ESBWR may result in a need to vent the primary containment. Venting as part of the containment flooding strategy does not appear to be addressed in the Level 2/3 PRA analysis. Confirm whether implementation of the containment flooding strategy may result in the need to vent the ESBWR containment. If so, provide an assessment of: (1) the time at which this would occur in the frequency-dominant sequences, (2) the impact of venting on the Level 2 and 3 PRA results, and (3) the need for further revisions to the ESBWR risk model to address venting during containment flooding.

RAI Number	Reviewer	Summary	Full Text
19.2-76	Palla R	Address operator actions to flood containment in accordance with the Severe Accident Guidelines.	Reference: PRA Revision 1, Section A.8.2.6 Confirm whether operator actions to flood containment in accordance with Step RC/F-2 of the Severe Accident Guidelines (including maximizing injection into the RPV and primary containment from sources external to the primary containment when water level cannot be maintained above top of active fuel) have been explicitly considered in GE's probability estimates for a deeply flooded LDW at the time of reactor vessel breach. If not, provide an assessment of: (1) the impact of the containment flooding guidelines on the Level 2 and 3 PRA results, and (2) the need for further revisions to the ESBWR risk model to address operator actions to flood containment.
19.2-77	Fuller E	Describe radionuclide transport and deposition from the lower drywell to the environment.	Reference: PRA Revision 1, Section 9.5 In Section 9.5, it is stated that damage to the lower drywell liner would not result in a direct release path to the environment, even though the failure area would be much larger than that associated with normal leakage. To justify this statement, please describe the pathway from the lower drywell to the environment, and document radionuclide deposition along this pathway.
19.2-78	Palla R	Explain how meteorological and population data bounds the site-specific data.	Reference: PRA Revision 1, Section 10.2 Provide an explanation of how a COL applicant would demonstrate that their site-specific meteorological and population data is bounded by the meteorological and population data assumed in the ESBWR design certification analyses. Provide either a reference for the specific data or the actual data files.
19.2-79	Palla R	Assess the sensitivity of risk results regarding release elevation and energy of release.	Reference: PRA Revision 1, Section 10.3.3 The assumption of ground level releases with thermal content equivalent to ambient is conservative for early fatalities, but non-conservative for population dose and latent fatalities. Provide an assessment of the sensitivity of risk results to alternative assumptions regarding release elevation and energy of release.

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