September 16, 1992

Docket 52-001

NOTE TO: J. Fox

FROM: C. Poslusny

SUBJECT: SUMMARY OF OPEN ITEMS FOR SSAR SECTIONS 3.7 AND 3.8

Enclosed is a summary of the open items resulting from the staff review of the above noted SSAR sections and resulting from the staff' audits conducted at GE's San Jose office. The structural engineering staff plans to conduct two follow up audits at Bechtel's office in San Francisco, one in October, and one in November. These audits will focus on the closure of these open items. Please call me if you have any questions in these items.

Chet Poslusny

cc G. Bachi
T. Cheng
D. Terao
J. Wilson
PDST Reading File

170042

D050 1/1 for C. Poslusny

GE found the torsional effect resulting from the eccentricity between the center of mass and center of rigidity of the seismic Category I structures on the seismic responses is negligible because of the symmetry in the geometrical layout of the buildings. The staff agrees. For the seismic design of structures, GE followed the SRP guidelines and applied an accidental eccentricity equal to five percent of the maximum building dimension at each floor when the seismic shear was distributed to the lateral load resisting structural elements. GE evaluated the stability of the structure against seismic overturning by requiring a minimum factor of safety of 1.5 between the potential energy needed to overturn the structure and the maximum kinetic energy of the structure during the SSE. These approaches are acceptable. The SSAR, however, did not describe the procedure for determining the stability of the structure against seismic sliding. It is the staff's position that GE should perform an analysis against seismic sliding. This concern is Open Item 3.7.2-1.

From the review of the SSAR and the piping design audit conducted on March 23 through 27, 1992, the staff found that GE did not consider the flexibility effect of the drywell equipment and piping support structure (DEPSS) when generating the FRS for the seismic input to the design of subsystems supported by the DEPSS. According to GE, the DEPSS was not included either in the structural model of the reactor building for generating the FRS at subsystem support locations or in the subsystem model as part of the supporting system. GE indicated that the COL applicant should be responsible to account for the dynamic effect of the DEPSS. Because of the exclusion of the DEPSS' flexibility effect, which might cause additional amplification of the FRS, the staff believes that such subsystems supported on the DEPSS as piping and equipment could be underdesigned based on the existing FRS. This is Open Item 3.7.2-2.

In the SSI analysis, GE did not consider the structure-structure interaction effect between the control building and adjacent buildings such as the reactor building and turbine building. The energy feedback from the adjacent buildings during an earthquake could significantly affect the seismic response of the control building because these adjacent buildings are much heavier. GE should consider the effect of structure-structure interaction in the SSI analysis of the control building. This is Open Item 3.7.2-3.

GE used a 2D SSI model to perform the SSI analysis. As shown in the SSAR, GE's parametric studies for the reactor building indicated that the 2D SSI analysis typically underestimated both the horizontal and vertical spectral peak accelerations at higher elevations of the building for medium-stiff-soil sites and hard-rock sites. During the second design calculation audit, the staff raised this concern about the significance of the difference between 2D and 3D SSI analyses of the control building. This issue is Open Item 3.7.2-4

From the review of Appendices 3A and 3G of SSAR Chapter 3 and GE's "Tier 1 Design Certification Material for the GE ABWR Design (Stage 2 Submittal)," dated March 1992, the staff observed that the building dimensions are inconsistently specified in these documents. For example, the dimensions of the control building are specified to be 16 meters x 45 meters (52 ft x 147 ft) in plan and 12.2 meters (40 ft) in embedment depth according to SSAR Section 3A.2, 22 meters x 56 meters (72 ft x 184 ft) in plan and 25.7 meters (85 ft) in embedment depth according to SSAR Section 3G.3.2, and 24 meters x 56 meters (79 ft x 184 ft) in plan and 23.1 meters (75 ft and 9 in) in embedment depth according to the Tier 1 design certification material. GE should verify the accuracy of all dimensions of the control building, including the embedment depth, used in the final seismic analysis of the seismic Category I structures shown in the SSAR and the Tier 1 document. This concern also applies to the dimension of all other seismic Category I building structures, including the reactor building. This is Open Item 3.7.2-5.

In SSAR Table 3.2-1, footnote "r," GE committed to perform a dynamic analysis for the portion of the MSL inside the turbine building. However, neither the FRS for use as the seismic input for the MSL analysis nor the procedure to generate the FRS was provided in the SSAR. During the second seismic design audit and on the basis of SRP Sections 3.7.2 and 3.7.3, the staff requested GE to perform a dynamic analysis of the turbine building and condenser to generate a set of FRS as the seismic input for the MSL analysis. According to GE, the FRS generated at the containment shell will be used as the input motion at the end of MSL anchored to the containment, and the ground motion response spectrum multiplied by an amplification factor will be the input at the end of MSL (including branch lines) anchored to the turbine building and condenser. To use the containment FRS as the input at the containment side for the MSL analysis is acceptable. The staff raised a concern regarding the adequacy of using the amplified ground response spectrum as the other input for the MSL analysis. GE agreed to provide a basis for justifying the adequacy of the amplified ground response spectrum for the MSL seismic analysis, the final FRS and the procedure for the FRS generation to the staff for review.

In the revised SSAR Section 3.7.3.16, GE proposed to perform the seismic design of the turbine building using the Uniform Building Code (UBC) approach for seismic zone 2A. The staff is concerned that the UBC approach of seismic design does not ensure that the turbine building will structurally withstand an SSE to protect the safety function of the portion of the MSL inside the turbine building. In its submittal dated May 21, 1992, GE provided a response to this issue. The staff's evaluation will be included in the FSER.

The staff's concerns with the seismic input to the MSL analysis and the structural integrity of the turbine building to withstand the SSE loading are Open Items 3.7.2-6 and 3.7.2-7, respectively.

(1) For a shallow soil site, to confirm that site-specific conditions 1 and 2 are satisfied and the standard plant design is adequate for the specific site, the COL applicant may define the site-specific ground motion (ground response spectra) at the ground surface in the free field if this ground motion is developed from a statistical analysis of a sufficient number of recorded ground motions. These recorded ground motions must be chosen based on their similarity in source, path, and site characteristics as well as magnitude, fault type, and tectonic environment, and must qualify as a site-specific (shallow soil site) surface ground motion. In all cases the appropriate level of the site-specific ground response spectrum for comparison with the design

certification spectrum is the 84th percentile of the statistical analysis of the recorded earthquake data. However, if the surface motion for the shallow-soil site cannot be developed according to this criteria, the COL applicant should follow the steps shown below to confirm the design adequacy of the standard plant:

- develop the site-specific ground motion (ground response spectra)
- define the site-specific ground motion as the free field motion at a level that complies with SRP Section 3.7.1 (e.g., at rock outcrop or a hypothetic rock outcrop)
- calculate the site-specific surface motion (ground response spectra) through soil layer amplification
- compare the site-specific surface motion with the standard design ground motion (i.e., 0.3g RG 1.60 response spectra, which was defined at ground surface in the free field for the standard plant design)
- determine if the site-specific surface motion exceeds the standard design ground motion

This is Open Item 3.7.2-8.

(3) In its letter dated August 19, 1991, and the revised SSAR Section 2.3.1.2, Amendment 18, GE proposed that COL applicants consider site-specific conditions 6 and 7 as two individual evaluation parameters when confirming the adequacy of the standard plant design for a specific site. The effect of soil layer depth was not considered or included in the evaluation. The staff is concerned that to compare site-specific conditions 6 and 7 with the site-specific design parameters separately is not sufficient to confirm the design adequacy of the standard plant. It is the staff's position that these two conditions should be considered together with the depth of soil layers. In addition, the site-specific responses (structural member forces and FRS) should be compared with the response envelopes used for the standard plant design unless it can be demonstrated that the site-specific parameters (shear wave velocity, number of soil layers, and depth of soil layers) are comparable to one of the 14 generic site conditions. This is Open Item 3.7.2-9.

Buried seismic Category I piping systems and tunnels are analyzed using techniques that account for the effects of seismic wave travel, differential movements of pipe anchors, bent geometry and curvature changes, local soil settlements or soil arching. The SSAR, however, did not describe in detail the procedure for the analysis of buried piping and tunnels. Similarly, the SSAR did not provide any description of the procedure for the dynamic analysis and evaluation of above-ground tanks. For the staff to draw the final conclusion, GE should include in the SSAR a description of the procedure for the seismic analysis and evaluation of buried piping and tunnels and above-ground tanks. This is Open Item 3.7.3-1.

The containment is designed as a reinforced-concrete cylindrical shell structure with an internal steel liner made of carbon steel, except for wetted surfaces where stainless steel or carbon steel with stainless steel cladding will be used. It is divided by the diaphragm floor and the reactor pedestal into an upper and a lower drywell chamber and a suppression chamber. The containment will be surrounded by and structurally integral with the reactor building. The containment wall will be 2.0 meters (6 ft 7 in) thick with an inside radius of 14.5 meters (47 ft 7 in) and height of 29.5 meters (96 ft 9 in). The containment design pressure is 31.7 tons/m**2 [45 psig]. The containment is designed to resist various combinations of dead loads; live loads; environmental loads, including those resulting from wind, tornadoes, and earthquakes; normal operating loads; and loads generated by a postulated loss-of-coolant accident (LOCA). According to GE, the concrete containment has been designed, and will be fabricated, constructed, and tested, in accordance with Subsection CC of ASME Code, Section III, Division 2. However, GE did not specify the edition of ASME Code. This is Open Item 3.8.1-1.

The major steel components of the concrete containment will consist of personnel air locks, equipment hatches, and the drywell head. These components will be designed for the same loads and load combinations as those used in the design of the concrete containment shell to which these components will be attached. These components will be designed, fabricated, and tested as Class MC components in accordance with Subsection NE of ASME Code, Section III, Division 1. However, GE did not specify the edition of ASME Code. This is Open Item 3.8.1-2.

In SSAR Section 3.8.1.7.1, GE agreed that the COL applicant will perform the structural integrity test (SIT) of the ABWR containments in accordance with the provisions of Article CC-6000 and Subarticle CC-6230 of the ASME Code, Section III, Division 2. However, GE did not specify which edition of this code is to be used for the design. This is Open Item 3.8.1-2.

In the ABWR design, the internal structures inside the containment include the reinforced-concrete diaphragm, the reactor pedestal, the reactor shield wall, and other structural components. The diaphragm will separate the upper drywell from the suppression pool. The reactor pedestal will consist of a ledge on a cylindrical shell that will form the reactor cavity, extending from the bottom of the diaphragm to the top of the containment foundation slab. The space enclosed by the cylindrical shell under the reactor is the lower dry well, which will be connected to the suppression pool through a series of vertical and horizontal vents in the shell wall. A steel equipment platform will be located in the lower drywell and accessible through a steel personnel tunnel and a steel equipment tunnel from outside the containment. Other internal structures will include the drywell equipment and pipe support structure (DEPSS), miscellaneous floors, and the reactor shield wall stabilizer. The major code used in the design of concrete internal structures is ACI 349. GE plans to use American National Standards Institute/American Institute of Steel Construction (ANSI/AISC) N690 for the design of all steel internal structures. However, NRC staff has not approved ANSI/AISC N690, and its acceptability is conditional on a satisfactory resolution of this concern. This is Open Item 3.8.3-1.

The design and analysis procedures used for the internal structures are essentially th same as those approved for previous license applications and are in accorda ; with procedur delineated in the codes mentioned above.

The materials of construction and their fabrication, construction, and installation are in accordance with ACI 349 and ANSI/AISC N690 for the concrete and steel structures, respectively, with the exception of the concrete diaphragm floors, for which ASME Code, Section III, Division 2, is used. However, GE did not specify the edition of ASME Code. This is Open Item 3.8.3-2.

As discussed in Section 3.7.2 of this report, the turbine building is not seismic Category I but must be capable of withstanding the SSE so as not to impair the safety function of the portion of the MSL and condenser (when used as an alternate leakage path) housed within the turbine building. On May 21, 1992, GE submitted its justification for demonstrating that the turbine building will not fail during and after an SSE. The staff's safety evaluation of the turbine building will be included in the FSER. This is Open Item 3.8.4-1.

In the SSAR, GE did not account for the effect of the hydrodynamic load on the reactor building as a result of a safety relief valve (SRV) discharge or a loss-of-coolant accident (LOCA) in the containment. Since the reactor building encloses and is structurally integral with the containment shell, the effect of the hydrodynamic load on the reactor building as a result of a SRV discharge or a LOCA in the containment should be factored into the design. This is Open Item 3.8.4-2. Consideration of this effect for systems and components is discussed in SSAR Section 3.9.2.2.

The seismic Category I structures for the ABWR standard plant were initially designed to withstand a maximum tornado wind speed of 418 km/hour [260 mph]. The staff expressed in the DSER its concern with the acceptance of this design tornado wind speed (Outstanding Issues 4, 8, and 9). In response, GE agreed to increase the design tornado wind speed to 483 km/hour [300 mph]. GE also agreed to revise the tornado-generated missile spectrum, specified in ANSI/ANS 2.8, to the Spectrum I specified in SRP Section 3.5.1.4. On May 29, 1992, GE informed the staff that based on its preliminary evaluation of the effect of the revised tornado loadings, the reactor building superstructure and roof design will require additional thickness and the roof purlins will require strengthening. These structural changes will affect the seismic model and hence the seismic response of the reactor building. According to GE, the revised tornado loadings will affect the seismic analysis and design results contained in several sections and appendices in Chapter 3 of the SSAR. The staff understands that GE is finalizing its evaluation of the reactor building and will inform the staff of the final structural modifications and the effect on the existing seismic analysis and design results. This is Open Item 3.8.4-3.

According to SRP Section 3.8.4, a sufficient amount of descriptive and design information for the seismic Category I structures should be provided in the SSAR and this information should meet the minimum requirements set forth in Section 3.8.4.1 of RG 1.70. This requirement typically includes such information as the floor plans, roof plan, vertical sections, structural models used in the static analysis to calculate element forces and moments, configurations of major structural components, and arrangements of reinforcements in major concrete structural members. For the reactor building structure, SSAR Figures 3.8-1 through 3.8-9 and Section 3H.3 show the required design information that meets the SRP guidelines. For the control building and radwaste building substructure, however, the SSAR did not provide the required descriptive and design information, as required by 10 CFR 52.47, similar to that provided for the reactor building. This is Open Item 3.8.4-4

In the ABWR design, GE employed separate reinforced-concrete mat foundations for major seismic Category I structures. The reactor building foundation, which is integral with the containment foundation, supports the containment structure, reactor pedestal, other internal structures, and the balance of reactor building structure. Even though the containment structure foundation is integral with the reactor building foundation, GE defines it as the portion of the foundation within the perimeter of the containment structure. Therefore, the foundation was designed as a part of the containment boundary. The concrete foundations were designed to resist various combinations of dead loads, live loads, environmental loads (including winds, tornadoes, OBE, and SSE), and loads generated by postulated ruptures of high-energy pipes. Detailed design information such as the factor of safety against sliding, overturning, and flotation (buoyancy) for the reactor building is calculated and provided in SSAR Appendix 3H. However, no such information is given in the SSAR for the control building and the radwaste building substructure. This is Open Item 3.8.5-1.

The major code used in the design of concrete mat foundations is ACI 349, except for the portion of the foundation within the containment boundary for which ASME Code, Section III, Division 2, is used. The design and analysis procedures, the materials of construction and their fabrication, construction code, and installation used for the seismic Category I foundations, are in accordance with the procedures in ACI 349 and ASME Code, Section III, Division 2. The seismic Category I foundations were designed and proportioned to remain within the limits of these design codes for the applicable load combinations, including those that were considered extreme. GE did not specify the edition of the ASME Code. This is Open Item 3.8.5-2.

The staff reviewed Sections 2.15.10 through 2.15.14, 2.16.1, and 5.0 of GE's "Tier 1 Design Certification Material for the ABWR Design - Stage 3 Submittal," dated May 30, 1992, which includes design descriptions and ITAAC material for the reactor building, turbine building, control building, radwaste building, service building, stack system (yard structure), and site parameters. The staff's generic concerns related to all ABWR buildings and building-specific findings are summarized below.

The staff identified five generic ABWR building concerns. This is Open Item 3.8.7-1.

(1) The purpose and scope of the plant walkthrough and visual inspection should be provided. Inspection should not be limited to visual inspection. Dimensional measurements also should be performed as well as checking concrete cracking.

(2) Minimum thickness of roof and interior walls should be provided in addition to wall, floor, and basemat thicknesses. The concrete pipe chase should be defined in appropriate figures.

(3) Minimum requirements for HVAC damper tornado missile barriers should be provided.

(4) As discussed in Section 3.7.2 of the report, site-specific seismic analysis should be performed if the site-specific soil condition is not 1 of the 14 generic site conditions.

(5) GE should provide the concrete properties (e.g., shear modulus and Poisson's ratio) in the SSAR because they are needed for developing the dynamic model for the seismic analysis.

The staff's structure-specific concerns for the design descriptions and the ITAAC of the individual seismic Category I and other ABWR structures including the site parameters are listed below.

Reactor Building This is Open Item 3.8.7-2

(1) GE should resolve the discrepancy between the directions of the planar dimensions (59 meters x 56 meters) specified in the "Design Descriptions" are different from those specified in the "Major Nominal Dimensions of Seismic Category I Structures."

(2) GE should resolve the discrepancy between the directions (0-180 degree direction and 90-270 degree direction) specified in this document and the directions (N-S direction and E-W direction) specified in Amendment 6 of the SSAR.

(3) GE should resolve the discrepancy between the thicknesses of the exterior walls at the first and third through eighth levels shown in Figures 2.15.10c through 2.15.10n.

(4) GE should design the exposed exterior walls and roofs of the reactor building as well as the tornado dampers for a pressure drop of 1.4 tons/meter**2 [2.0 psi] as specified in the revised SSAR Section 3.3.2 and Table 2.0-1 instead of 1.0 tons/meter**2 [1.46 psi].

(5) GE should protect the divisional diesel generators and supporting equipment located at grade level from such external missiles as aircraft and moving vehicles.

Control Building This is Open Item 3.8.7-3

(1) GE should verify the accuracy of the planar dimensions and the soil embedment depth shown in SSAR Sections 3A.2 and 3G.3.2 and in this document. This concern has previously been raised in Sections 3.7.2 and 3.8.4 of this report.

(2) GE should resolve the discrepancy between the building directions

referenced in this document and those referenced in Amendment 6 of the SSAR.

(3) GE should consider the thickness of the basemat as one of the major nominal dimensions because this dimension is needed to develop the dynamic model for the seismic analysis.

(4) GE should update the design basis tornado wind loads (e.g., maximum wind speed and pressure drop) for consistency with those specified in the revised SSAR Section 3.3.2 and Table 2.0-1.

Radwaste Building This is Open Item 3.8.7-4

(1) GE should verify the accuracy of the planar dimensions of 54.2 meters x 41.2 meters [178 feet x 135 feet] as shown in this document are different from the planar dimensions of 53 meters x 40 meters [174 ft x 131 ft] as specified in Amendment 7 of the SSAR.

(2) GE should clarify if the building height of 13.8 meters [45 ft] is measured from the top of the basemat or from the bottom of the basemat to the roof.

Yard Structure - Stack System This is Open Item 3.8.7-5

(1) GE should provide the analysis approach, input data, and design requirements in the SSAR before confirming that the design, fabrication, and installation meet the design requirements.

(2) GE should take a measurement instead of visual inspection to verify that the stack height is 76 meters [249 ft] above grade.

(3) GE should provide Tier 1 information for the field-erected tanks if they are classified as seismic Category I.

Site Parameters - Table 5.0 This Open Item 3.8.7-6

GE should update the design basis tornado and tornado missile loads for consistency with those specified in the revised SSAR Section 3.3.2 and Table 2.0-1.