Request for Additional Information No. 130 (1430, 1461), Revision 0

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U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 03.07.01 - Seismic Design Parameters
SRP Section: 03.07.02 - Seismic System Analysis
Application FSAR Section: 03.07

QUESTIONS for Structural Engineering Branch 2 (ESBWR/ABWR Projects) (SEB2)

03.07.01-1

In FSAR Section 3.7.1.1.1 it states that for seismic analysis the point of seismic input for the CSDRS is an outcrop or hypothetical outcrop at the foundation elevation of the Nuclear Island basemat which is at -12.60 meters (-41.33 ft) below the surface of the ground. The determination of seismic input for other Seismic Category I structures is determined from the CSDRS modified to account for structure-soil-structure interaction (SSSI) between the NI common basemat structures and the Emergency Power Generating Buildings (EPGBs) and the Essential Service Water Buildings (ESWBs). In this SSSI analysis, described in FSAR Section 3.7.2.4.4, the foundations of both the EPGB and the ESWB are taken to be at the same elevation as the NI common basemat foundation as shown FSAR Figure 3.7.2-63. The actual elevation for the EPGB is at grade and the ESWB is embedded at -6.70 m (-22 ft) below grade. Provide the basis for not accounting for the differences in elevations of these structures and address the impact on the development of the modified CSDRS.

03.07.01-2

In Section 3.7.1, the proposed U.S. EPR certified seismic design response spectra (CSDRS) (in two horizontal and one vertical direction) consist of three individual design response spectra for three EUR control motions corresponding to hard, medium, and soft sites. However a COL applicant will need to compare site specific ground motion response spectra (GRMS) with one set of the EUR control motions depending on whether the specific site is a hard, medium, or soft soil site. As such, include in Tier 1 Section 5.0 separate figures depicting the three individual CSDRS for 5% damping (including the design peak ground acceleration level and the spectral shape) corresponding to hard, medium, and soft sites.

03.07.01-3

In FSAR 3.7.1, the U.S. EPR CSDRS is not based on a single control motion which envelopes all the individual design response spectra (DRS) for hard, medium, and soft sites. As such, a COL applicant has to make a determination as to which category (i.e., hard, medium, or soft) the local site falls into and then to meet the acceptance criteria of the SRP and verify that site specific GMRS is enveloped by the corresponding CSDRS.

Provide specific criteria in a COL information item for categorizing a site as hard, medium, or soft.

03.07.01-4

In FSAR 3.7.1, Standard Plant Generic soil parameters (i.e., shear wave velocity and damping values) used for the SSI analysis are considered to be the final strain compatible values. Thus, a COL applicant needs to compare its final iterated site soil parameters (when calculating GMRS) with the standard plant generic soil parameters when categorizing the site as hard, medium, or soft. Provide this clarification in the appropriate COL information item.

03.07.01-5

The SRP 3.7.1 ii SAC 3 states that in addition to the information provided for the supporting media in FSAR Section 3.7.1, the dimensions of the structural foundations, total structural height, design ground water elevation and soil properties such as Poisson’s ratio should also be provided. Include in FSAR Section 3.7.1 a reference table which provides the design values used for these parameters.

03.07.01-6

The SRP acceptance criteria 3.7.1 ii SAC 2 states that the material soil damping for foundation soils must be based upon validated values or other data considering variation in the soil properties and strain levels within the soil. In addition, the maximum soil damping value acceptable to the staff is 15 percent per SRP acceptance criteria in SRP3.7.1. In FSAR Table 3.7.1-6, specify the damping values used in the SSI analysis for the corresponding generic soil profiles. Indicate that these values are strain compatible values and do not exceed 15 percent for a damping value.

03.07.01-7

On FSAR Page 3.7-12 last line, the reference Table Number 3.7.2-7 appears not to be correct. Include correct Table Number.

03.07.01-8

Related to FSAR 3.7.1.1.2, the 3.7.1 ii SRP Acceptance Criteria 1B states that “artificial time histories which are not based on seed recorded time histories should not be used.” As such, in Section 3.7.1.1.2 of the FSAR, confirm that the synthetic time histories are based on seed recorded time histories.

03.07.01-9

On FSAR Page 3.7-9 in the last paragraph, it is stated that the characteristics (V/A & AD/V^2) of synthetic time histories are generally consistent with the characteristic values for the magnitude and distance of “the appropriate controlling” events defined for the

UHRS. These characteristics are one of the review requirements of the SRP. Therefore, provide further clarification with regard to the magnitude and distance of the controlling event. Alternatively, this should be a COL information item requiring a COL applicant to respond to as part of the site specific analysis.

03.07.01-10

FSAR Table 3.7.1-1 listed the damping value of piping systems in uniform support motion response spectrum analysis as 5 percent. This damping value is different from the value accepted by the staff in RG 1.61, Rev. 1. Technical justification was provided in the AREVA response to RAI, dated November 20th, 2007, on the AREVA NP Piping Analysis Topical Report ANP-10264NP. However, on April 18th, 2008, AREVA provided its second revised response to the RAI of ANP-10264NP, in which AREVA committed to use damping values given in RG 1.61, Rev. 1 for uniform support motion response spectrum analysis. As such, revise Table 3.7.1-1 to confirm the commitment of using the damping value listed in RG 1.61, Rev. 1. In addition, the EXCEPTION in the row "1.61, R1" of the Table 1.9-2 - U.S. EPR Conformance with Regulatory Guides should also be updated to reflect the commitment.

03.07.01-11

In Section 3.7.1.2 of the FSAR (first paragraph on pg 3.7-11), it states that in-structure response spectra (ISRS) for the NI common basemat structures are generated using SSE damping values. RG 1.61 requires that the damping values used need to be consistent with the level of stress. Provide the computed stress level (attributed to load combinations using the SSE) for major load carrying members such as walls, columns, floors, etc. of the NI common basemat structures to justify the use of SSE structural damping for the development ISRS.

03.07.01-12

In FSAR Section 3.7.1.2 (First Paragraph on Page 3.7-11), it is stated that the ISRS generated for the Emergency Power Generating Buildings and the Essential Service Water Buildings are based on OBE structural damping. The staff agrees with this approach but would like to include in an appropriate Table (as part of the FSAR) of the specific OBE level structural damping values used for the analysis. Provide such a table.

03.07.01-13

FSAR Table 3.7.1-1 lists damping values for the reactor coolant system. A damping value of 7 percent is listed for the RPV closure head equipment tie rods. Verify that the tie rod connection represents a bearing connection as opposed to a friction connection.

03.07.01-14

In FSAR Section 3.7.1.2 (Last Paragraph on Page 3.7-10), it indicates that the Rayleigh mass and stiffness weighted damping coefficients for the reactor coolant systems are selected to provide generally conservative damping across the frequency range of interest relative to the values in Table 3.7.1-1. Specify the frequency range of interest for the calculations to assure that the frequency range is sufficient.

03.07.01-15

FSAR Table 3.7.1-1 specifies the damping value for cable trays with flexible support systems as no more than 20%. While RG 1.61, Rev. 1 lists a 10% damping value for cable tray systems, it permits the use of higher damping values subject to obtaining NRC review for acceptance on a case by case basis. As such, provide the technical basis (including actual test data and studies and their applicability and limitations, etc) of using a damping value of no more than 20% for cable trays with flexible support in the EPR application.

03.07.01-16

The FSAR Section 3.7.1.3 (Last Paragraph on Page 3.7-12) indicates that soil densities in the SSI analysis vary from 1760 to 2000 kg/cubic meter (110 to 125 pcf). However, Table 3.7.2-9 indicates a weight density of 2496 kg/cubic meter (156 pcf) for soil case with a shear wave velocity of 4000 m/sec (13123 ft/sec) (soil case no. 5a). Confirm that the soil weight density of 2496 kg/cubic meter (156 pcf) was used for Soil Case No. 5a in the SSI analysis in Section 3.7 and make appropriate corrections in FSAR page 3.7-12 last paragraph.

03.07.01-17

FSAR Section 2.5.2.6 indicates that the COL applicant will confirm that the value of shear wave velocity at the bottom of the foundation basemat of the NI common basemat structure is 304 m/sec (1000 ft/sec) or greater. However, similar commitment for other Seismic Category I Structures not located on the common basemat is not provided. According to the acceptance criteria of SRP Section 3.7.1.II.3, potential impact on soil-structure interaction and settlement must be addressed if the minimum shear wave velocity is less than 304m/sec (1000 ft/sec). Initiate appropriate COL information item that requires addressing by a COL applicant the aforementioned potential impact for other Seismic Category I structures not located on the common basemat.

03.07.01-18

Appendix S to 10 CFR Part 50 states that the horizontal component of the SSE ground motion occurring at the foundation level in the free field must be an appropriate response spectrum with a peak ground acceleration of at least .1g. For the U.S. EPR standard plant, the required minimum design basis spectra for the NI common basemat structures is provided by an envelope of the three EUR design response spectra modified to reflect a peak ground acceleration of .1g. In FSAR Figure 3.7.1-2, a comparison is made showing the CSDRS bounding the minimum required spectra anchored at .1g. Response spectra meeting the requirements of Appendix S for appropriate response spectra with a peak ground acceleration of at least .1g has not been provided for either the Emergency Power Generating Buildings (EPGBs) or the Essential Service Water Buildings (ESWB). Provide and include in the FSAR a minimum response spectra meeting, and its basis for meeting, the requirements of Appendix S for these safety-related structures.

03.07.02-1

In FSAR Section 3.7.2.1.3 (pg 3.7-69, 2nd paragraph), it indicates that the complex frequency response analysis method is used in the seismic SSI analysis of all Seismic Category I structures. AREVA computer code SASSI, Version 4.1B, is used in the SSI analysis of the NI common basemat structures and NAB. Bechtel computer code SASSI 2000, Version 3.1, is used in the SSI analysis of the EPGBs and ESWBs. Describe the differences between these two versions of the SASSI Code, the reason for implementing two versions of the code and provide a comparison of results from a building seismic analysis using each version of the code.

03.07.02-2

In FSAR Section 3.7.2.1.3 (pg 3.7-69, 4th paragraph), it indicates that the complex frequency response analysis method is also used in the soil column analysis using Bechtel computer code SHAKE2000, Version 1.1, to compute the free-field “in-ground” motion at the foundation level of ESWBs, for use as the input motion to the SSI analysis. This is indicated to be needed to incorporate the effects of embedment in the SSI analysis of the ESWBs. The input ground motion specified in Section 3.7.1 corresponds to a hypothetical free-field “outcrop” motion at the foundation level of ESWB. Bechtel code SASSI 2000 requires that the input motion, when specified at the foundation level, must be an “in-ground” motion converted from the “outcrop” motion through a soil column analysis. Please indicate if, in generating “outcrop” motions using the SHAKE Code whether the soil column above the foundation level (a depth of about 6.7 m (*22* ft)) below grade) is removed from the soil column as required by both the SRP and the ISG. The “outcrop” must be defined assuming no soil above the level of the “outcrop” depth and all potential effects of down-coming waves need to be removed from the computation. Provide analytic modeling, outcrop and in-ground spectra, FIRS, soil conditions and numerical results to indicate how the SHAKE computations are performed.

03.07.02-3

Starting on FSAR page 3.7-103, Table 3.7.2-1 through 3.7.2-8 provides information on the modal characteristics of the various stick models included in the SSI model. The frequencies listed indicate frequencies below 50 Hz. FSAR Section 3.7.2.2 (page 3.7-70) indicates that the stick model development was based on comparison of modal responses between the FEMs and the stick models. Considering that the Interim Staff Guidance (COL/DC-ISG-01) indicates that acceptable models, both FEM and equivalent sticks, must be able to capture adequately responses to at least 50 Hz, provide information on the frequency transmission characteristics of the stick models as well as the FEMs used for seismic analysis.

03.07.02-4

In FSAR Section 3.7.2.3.1 (pg 3.7-71), it indicates that the SASSI SSI model is performed assuming a rigid basemat model. Even with a thick basemat, the flexibility of the mat as well as that of the connecting walls can have an impact on local SSI pressure distributions as well as on moment and shear development in the exterior structural elements. What is the impact of this simplifying assumption on the calculation of seismic design loads, as well as on the generation of in-structure response spectra, particularly at higher frequencies?

03.07.02-5

In FSAR Section 3.7.2.3.1 (pg 3.7-73), it indicates that the effects of floor and wall flexibilities are not included in the stick models but are accounted for in subsequent analyses following the performance of the modal time history analyses using SDOF models. SRP 3.7.2-SAC-3.C.iii states that local vibration modes should be adequately represented in the dynamic response model. Since what is described in the FSAR is basically a decoupling procedure, provide the basis for this decoupling approach and provide verification that the determination of structural loads and the development of in-structure response spectra are not compromised by the use of this method.

03.07.02-6

In FSAR Section 3.7.2.3.1 (pg 3.7-73), it indicates that adjustments to properties are used to ensure compatibility between the stick models and the FEM results, and indicates that the process provides a "reasonable dynamic compatibility". The comparisons of in-structure response spectra indicated in the figures attached to this section (Figs. 3.7.2-14 through 3.7.2-55) often show significant differences between spectra peaks as well as frequency shifting between peaks.

a. Provide a basis for the acceptance of the results from the simplified stick models.

b. Address the discrepancy between the stick model ISRS and the FEM ISRS and the impact on the subsequent analysis of supported systems and equipment.

c. SRP 3.7.2-SAC-3.C.ii states that a finite element model must demonstrate that further refinement of the model has only a negligible effect on the solution results. Since the FEM is being used to determine acceptability of the stick models, provide the results of a refinement analysis on the FEMs that meets the acceptance criteria of the SRP and which demonstrate that the FEMs used are adequate to represent the dynamic characteristics of the structure. This discussion should include refinement analyses for the seismic models of the EPGBs and the ESWBs.

03.07.02-7

In FSAR Section 3.7.2 (pg 3.7-66), it states that the impact of changes to the design during the detailed design phase are evaluated and that the combined deviations are acceptable if the amplitudes of the in-structure response spectra increase by less than 10 percent. Provide the technical basis for these statements to include the impact on code allowables, and provide justification for not performing reanalysis under the conditions described.

03.07.02-8

In FSAR Section 3.7.2.1.1 (pg 3.7-67), it states that when nonlinearities occur in the stiffness matrix or damping matrix, the direct integration technique is used. It states that this technique is used for the time history analysis of the NI common basemat structures to determine their stability against seismic sliding or overturning and their potential for seismic structural interaction.

a. Provide the basis and values used for the stiffness and damping matrices.

b. Describe the design motion time histories that are used in the nonlinear structural analysis and the basis for their selection.

c. Describe how the soil springs are modeled in this analysis.

d. Provide the relationship between this analysis and the seismic analysis conducted to determine structural loads and ISRS.

03.07.02-9

In FSAR Section 3.7.2.1.1 (pg 3.7-68), it states that flexible walls and slabs are accounted for by using a modal time history analysis of single degree of freedom oscillators representing the flexible slabs and walls. In Section 3.7.2.3.1 (pg 3.7-73), it describes how the out-of-plane frequency for flexible slabs and walls is determined using either manual methods or by modal analysis using a local FEM model of the floor or wall. There are two issues to be considered with flexible walls and slabs. The first issue is how to determine the amplified structural response and its impact on the seismic design loads. The second issue is how to develop floor ISRS that adequately account for the local structural flexibility. It is not clear from the several descriptions in Section 3.7.2 which methods are used and if the methods described adequately address these two issues. Using examples provide additional detail on the methods of analysis used for flexible slabs and walls and the validity of these methods to address both the response of the flexible structure and the amplified response for supported systems.

03.07.02-10

In FSAR Section 3.7.2.1.2 (pg 3.7-68), it states that the response spectrum method is used in the NAB for local seismic analysis of certain slabs to determine their out of plane seismic loads. What is the basis for determining which slabs in the NAB use this method of analysis and how is the local analysis performed?

03.07.02-11

In FSAR Section 3.7.2.3.1 (pg 3.7-71), it states that seismic response loads generated include amplified ISRS at representative locations and amplified ISRS at representative flexible slabs. Describe on what basis these representative slabs are selected. Also, for each structure provide the basis and location of response spectra that are developed for both the stick models and the FEMs and identify any locations where response spectra are not generated and the reason for not doing so.

03.07.02-12

In FSAR Section 3.7.2.3.1 (pg 3.7-78), it describes how the properties were determined for the RCB stick model. Describe to what extent cracking of the concrete in the RCB needs to be considered in seismic modeling and its impact on the dynamic response of this structure.

03.07.02-13

In FSAR Section 3.7.2.3.1.2 (pg 3.7-76, 2nd paragraph), it states that tuning of the composite stick model is done by first adjusting the total concrete mass of each individual stick model to correlate with the total mass of the FEM. Provide the basis for an acceptable correlation of mass between the two models and provide some examples of this in your response. Provide the basis for concluding that the FEM properly accounts for the total mass of the structure including dead loads, live loads, snow loads, equipment loads, etc. as specified in the acceptance criteria of SRP 3.7.2-SAC 3.D. If there are other adjustments performed to the stick model, provide a discussion of what these are.

03.07.02-14

In FSAR Section 3.7.2.4.4 (pg 3.7-86), it states that the NAB is embedded only on its south side and therefore, for the purposes of seismic analysis, it is sufficient to take the NAB as a surface grounded structure. As SRP 3.7.2 requires that embedment effects be considered in an SSI analysis, the basis for this conclusion should be provided.

03.07.02-15

In FSAR Section 3.7.2.4.4 (pg 3.7-86), it states that the footprint of the NI model was transformed into an equivalent circle by calculating the radius of the circle that would provide the same area as that of the NI footprint. The computed radius for this circle is 47.70 m (156.52 ft). However, comparing the moment of inertia of the circle to that of the NI footprint will not give equivalent results.

a. Provide an assessment of other equivalent foundation footprints that might have been used and the possible impact of considering only an area equivalency on the results of the SSI analysis.

b. Will the location of the stick model relative to its coordinate location on the actual footprint be different from its coordinate location on the circle? If it is what is the impact on the results of the analysis?

03.07.02-16

In FSAR Section 3.7.2.4.7 (pg 3.7-89), it states that a concrete slab or wall is considered flexible when the frequency of its first out-of-plane frequency mode is less than 40 Hz. The frequency is calculated by assuming un-cracked concrete for section properties. What is the basis for using 40 Hz as the cut-off frequency and why are un-cracked properties assumed in determining whether or not flexibility must be considered in their seismic response? What method is used to determine the out-of-plane frequencies?

03.07.02-17

In FSAR Section 3.7.2.4.7 (pg 3.7-90), it states that for the EPGBs and the ESWBs, the 3D FEM of the structures is sufficient to represent the flexible slabs and wall in cracked conditions, while the SDOF oscillators added to the 3D FEM represent the un-cracked condition. Are all walls and floors in the FEM assumed to be in the cracked condition? How are the cracked properties represented in the FEM? How do SDOF oscillators get represented in the model? Normally, a cracked condition and then an un-cracked condition would be analyzed and an envelope of results selected for further analysis and design. How does the modeling described accomplish this? How are the results applied to determine the structural design loads and the development of ISRS?

03.07.02-18

In FSAR Section 3.7.2.5 (pg 3.7-90), it describes the development of floor response spectra and states that the ISRS from all SSI analysis cases are enveloped and the envelope is peak broadened by +/- 15 percent to account for uncertainty in structural modeling and SSI analysis. Describe the process that is used to develop the ISRS for flexible walls and floors and provide examples of these in the response.

03.07.02-19

In FSAR Section 3.7.2.7 (pg 3.7-95), it addresses the combination of modal responses when the response spectrum method is used and references RG 1.92, Section C. Discuss how the combination of modal responses specifically addresses each of the methods specified in Section C of RG 1.92, Revision 2. FSAR Section 3.7.2.7 describes a method for calculating the effect of the missing mass on seismic analysis results. Discuss and confirm that what is described meets the requirements of RG 1.92 and include such a statement in the FSAR.

03.07.02-20

In FSAR Section 3.7.2.8 (pg 3.7-95), it discusses the interaction of non seismic with seismic Category I Structures.

a. For the NAB, it states that a reduction in forces is taken for critical structural elements. Are these forces taken from the seismic analysis of the full stick model of the NAB? What is the reduction that is taken?

b. Since the NAB is designed not to collapse on a seismic Category I structure, SRP 3.7.2-SAC-8 states that the non-Category I structure will be analyzed and designed to prevent its failure under SSE conditions, such that the margin of safety is equivalent to that of Category I structure. Describe how the method proposed meets this requirement.

c. Describe the development of the non linear models for the NAB and NI common basemat structures used to determine the potential for seismic interaction and provide the results of the analysis. Identify the elements that are considered to be nonlinear and provide the basis for determining the non-linearity. Since the NAB and NI common basemat structures were analyzed using full stick models, describe why it is now necessary to use a nonlinear analysis employing finite element models with reduced degrees of freedom?

In this same FSAR Section on page 3.7-98, it also states that the NAB shields the NI common basemat structures from collapse of the Radioactive Waste Processing Building (RWPB). However, it does not appear that the NAB is designed to withstand a collapse of the RWPB. Section 3.7.2.8 states that the NAB is designed to allow distortion short of collapse under an SSE event. The basis for stating that the NAB shields the NI common basemat structures from collapse of the RWPB needs to be justified.

03.07.02-21

Because a number of computer codes are discussed in FSAR Section 3.7.2, the staff is requesting that all computer codes used in the seismic analysis of seismic Category I structures be identified including those used in soil-structure interaction analysis, in developing ISRS, and in determining seismic loads on structures. In addition, descriptions of the programs, program validation, and the extent of application of the programs should be provided. This information should also be included in the FSAR.

03.07.02-22

In FSAR Section 3.7.2.14 (pg 3.7-100), it states that the overturning of the common basemat of the NI structures due to a seismic event does not occur due to its inherent stability. In this regard, describe the analytical model for assessing building stability during a seismic event and provide the corresponding factors of safety against potential sliding (including maximum absolute displacement of NI common basemat structure) and overturning during the design basis seismic event. Also, what is the assumed minimum coefficient of friction used for evaluation of the translational stability of the NI structures? Is there a requirement for a COL applicant to meet a minimum coefficient of friction to be available at the soil/basemat interface? If so, specify this information in Table 2.1-1 of the FSAR. Similar information should be provided for the EPGBs and the ESWBs.

03.07.02-23

The acceptance criteria of SRP 3.7.2-SAC-3.D states that in addition to the structural mass, equivalent floor load of 243.5 kg/m^2 (50 psf) should be added to represent miscellaneous dead weights and that a mass equivalent to 25 percent of the design live load and 75 percent of the roof design snow load should be included in the dynamic model. In FSAR Section 3.7.2.3-1, the description of the stick models meets the SRP acceptance criteria for live load and snow load, but the provision for the dead load is not addressed. The discussion of the FEM dynamic models does not address any of these additional loads. The additional loads identified in the SRP acceptance criteria should be added to the FSAR and the impact on the results of the seismic analysis should be addressed if these loads were not accounted for in the seismic analysis.

03.07.02-24

In FSAR Section 3.7.2.4.4 (Line 7 from bottom of Page 3.7-86), it is stated that the SSI of the NI common basemat structures will have some effect on EPGBs and ESWBs. It states that this effect has been captured by modeling the surrounding footprints on the soil surface along with the NI common basemat SSI model. Accordingly, confirm that the modified CSDRS used for the analysis of the surrounding category I structures represent the envelope of soil surface response spectra calculated from each of ten generic soil profile SSI analyses (NI common base mat and NAB) at the EPGB and ESWB footprints.

03.07.02-25

In FSAR Section 3.7.2.5, the methods for developing in-structure response spectra (ISRS) are described. It is stated that these follow the guidance of RG 1.122. SRP 3.7.2-SAC-5.C(2) states that guidance of RG 1.122 is augmented by the following: The 3 Hz frequency increment in the last row of RG 1.1.22, Table 1 applies up to the highest frequency of interest. This typically will be the PGA frequency of the design ground response spectrum, which in some cases may significantly exceed 33 Hz. In FSAR 3.7.2.5 on page 3.7-90, there is a table that shows the frequency increment for sets of frequency ranges at which ISRS acceleration values are computed. From 22 Hz to 40 Hz, the frequency increment is 3 Hz which agrees with the RG. From 40 Hz to 50 Hz, a frequency increment has not been provided. From 50 Hz to 100 Hz, a frequency interval of 50 Hz is indicated. The table should be revised to meet the guidance provided in the SRP acceptance criteria for a 3 Hz increment up to the highest frequency of interest and to also add the frequency increment used from 40 to 50 Hz. Also, the highest frequency of interest should be indicated and the basis for its selection should be provided. FSAR Section 3.7.2.5(2) (pg 3.7-91) describes the development of response spectra for the EPGB and ESWB. It states that response spectra are calculated at a total of 241 frequencies from .2 to 50 Hz with 100 frequencies per decade that are uniformly spaced in the log scale. A table of frequency increments and frequency ranges should be provided similar to that provided for the NI common basemat structures on page 3.7-90 and if different than the requirements of RG 1.122 those differences should be justified.

03.07.02-26

In FSAR Section 3.7.2.6(1) (pg 3.7-94) for the NI common basemat structures, it states that for member forces and moments, the STRESS module of the SASSI code outputs the maximum member force/moment due to each component of earthquake motion. It further states that these member forces and moments are combined by the SRSS. This effectively eliminates the sign of the force (compression or tension) and of the bending moment (positive or negative). In concrete design, the sign or direction of a force or moment is important in properly sizing the member and in determining the correct amount of reinforcement. The amount of shear reinforcement that is required will also be affected by the direction of the axial force and bending moment. Thus, the staff is asking how the method described in the section of the FSAR properly accounts for the sign of the force or moment and how this is used in the design of concrete members. In addition, describe how the multiple sets of input motion time histories are accounted for in determining the maximum member forces and moments. As there are twelve cases analyzed for the NI structures, how the maximum design values are determined should also be described.

03.07.02-27

The last paragraph FSAR Section 3.7.2.4.6(2) (Page 3.7-89) indicates that subsequent analysis will incorporate certain design details for the EPGBs and ESWBs that are not reflected in the existing respective SASSI model used for SSI analyses described in FSAR Section 3.7.2. The design details not yet included are discussed in FSAR Section 3.8.4.4.3 for the EPGBs and FSAR Section 3.8.4.4.4 for the ESWBs. As the effects of these details have not been included in the application for design certification, establish a COL information item to address this issue.

03.07.02-28

In FSAR Section 3.7.2.8 (Third Bullet), it is stated that “conventional seismic structures that have the potential to interact with Seismic Category I structures are assessed for collapse potential under SSE and tornado loading (acting independently). Seismic demand for the SSE is computed in accordance with ASCE 4-98, Reference 1 and the methodologies in Section 3.7.2. Seismic load combinations are developed in accordance with ASCE 43-05 ….” ASCE 4-98 has not been accepted by the Staff as a guidance document. In addition, SRP acceptance criteria 3.7.2 –SAC-8C requires that “the non-Category I structure will be analyzed and designed to prevent its failure under SSE conditions, such that the margin of safety is equivalent to that of Category I structures.” As such, in addition to the NAB which was addressed in **RAI 3.7.2-20**, demonstrate that non-Category I structures (not analyzed and designed as seismic Category II structures) having the potential of interaction with Category I structures will not slide or overturn during a SSE level earthquake and will have the margin of safety equivalent to that of Category I structures as stated by the acceptance criteria of SRP-SAC-8.C. Address how the NAB, Access Building, Turbine Building, Radioactive Waste Processing Building (RWPB), Fire Protection Storage Tanks and Buildings satisfy the SRP guidance.

03.07.02-29

In FSAR Section 3.7.2.8 (fourth bullet), it is stated that “for Conventional Seismic structures that have the potential to interact with Seismic Category I structures, the combined seismic deflection is less than the separation distance (i.e., gap) between the structures.” Calculation of the combined seismic deflection involves seismic analyses of both the Category I structure in question, as well as the conventional seismic structures having the potential to interact with the Category I structure. While the Category I structure is analyzed and designed to seismic Category I requirements, the conventional seismic structures may not be analyzed to Category I seismic requirements. Accordingly, confirm that seismic analysis of conventional seismic structures that have the potential to interact with Category I structures is based on the same criteria as seismic Category I structures.

03.07.02-30

In FSAR Section 3.7.2.3.1.2(2), the second paragraph of this section states that “a single-mass rigid stick, of which the base is connected to the main stick at elevation 37.6 m (123 ft, 4-1/4 in) where the crane rail is located, is used to represent the polar crane.” This implies that the polar crane subsystem in the parked position has been considered to be rigid compared to the supporting system, and also to be rigidly connected to the supporting system. A parametric study was performed (refer to second paragraph on FSAR Page 3.7-79) to verify sufficiency of this representation by comparing response spectra generated from the stick model where the crane is represented by a single rigid mass with the corresponding spectra generated from a modified stick model in which the rigid single-mass stick for the crane assembly is replaced by a flexible one. However, the parametric study considered only one condition where the crane assembly is assumed to have a resonant frequency coincident with the fundamental frequency of the containment. No additional parametric studies covering other potential frequency ranges for the crane assembly were provided to demonstrate that the selected condition for the parametric study is conservative. As such, provide additional justification to demonstrate that the parametric study performed will envelop all potential frequencies of the polar crane assembly (consisting of Crane Rail, Crane Bridge, Trolleys, etc) in the parked position.

03.07.02-31

In FSAR 3.7.2.1.1, the last paragraph of this section states that “As a general rule, the value for the maximum time step is no larger than one-fifth of the lowest natural period of interest.” However, for most of the commonly used integration methods, the maximum time step is limited to one-tenth of the smallest period of interest, which is generally the reciprocal of the cutoff frequency. In addition, in accordance with industry practice and as described in Section 3.2.2.1(c) of ASCE 4-98, an acceptable approach for selecting the actual time step (Δt) is that the Δt used shall be small enough such that the use of one-half of Δt does not change the response by more than 10 percent. As such, the staff requests AREVA provide a technical justification for not considering common industry practices in this regard.

03.07.02-32

In the acceptance criteria of SRP 3.7.2-SAC-3.E, it states that the method for transferring the seismic response load from the dynamic model to the structural model used for the detailed design should be reviewed for technical adequacy. What is the process that is used to accomplish the load transfer from the seismic analysis models to the analysis and design models? Include this information in the FSAR.

03.07.02-33

In FSAR Section 3.7.2.3.1 on page 3.7-72, it states that for pools the frequency of the water sloshing is typically low compared to the first horizontal mode frequency of the structure housing the pool. Therefore, the water sloshing has a negligible effect on the response of the structure and can be ignored in the development of the stick model. The effect is considered in the local analysis and detailed design of the pool. The staff would like examples of the sloshing frequency provided and compared with the fundamental mode of the structural frequency. In addition, describe the model and process for taking sloshing into account in the local analysis of the pool.

03.07.02-34

In FSAR Section 3.7.2.6(2) (pg 3.7-94) for the EPGBs and ESWBs, it states that the three components of earthquake motion are combined using the (1.0, .4, .4) rule. This meets the requirements of RG 1.92, revision 2 and is acceptable for determining the response of the structure. In FSAR Section 3.7.2.4.6 on page 3.7-89, it states that for each of the ten generic soil cases, the extracted maximum nodal accelerations are used to compute the weighted average maximum nodal accelerations in each direction due to each ground motion component. The weighting factors are the applicable nodal masses. Then in each direction the averaged maximum nodal accelerations due to the three components of earthquake motion are combined using the (1.0, .4, .4) rule as stated above. Table 3.7.2-27 and 3.7.2-28 show the worst case maximum ZPA accelerations for the EPGBs and the ESWBs, respectively. It is not clear how the maximum ZPA accelerations are used from the ten generic soil cases to determine member forces and moments and how the weighted average maximum nodal acceleration is calculated. The staff requests that the procedure and basis for calculating the weighted average maximum nodal accelerations be provided, as well as how the member forces and moments are determined once the maximum ZPA accelerations have been calculated from the ten soil cases.