Question 210.6N

In Table 3.2.B-1, page 3.2-50, the code edition and addenda of Section III of the ASME Boiler and Pressure Vessel Code reactor coolant pressure boundary (RCPB) components are inconsistent with those identified in Table 5.2-1 for RCPB components. Resolve this inconsistency.

Response

The ASME Code editions and addenda dates listed in Table 5.2-1 are the versions used in the design and fabrication of the components as identified on the Code Data form. The Code edition and addenda mentioned in note 12, page 3.2-50, represent the earliest version of the Code to which the STPEGS RCPB equipment could have been designed and fabricated in accordance with the appropriate regulations and HL&P/Westinghouse requirements. Note that this does not limit the Code versions to those specifically mentioned in note 12 as the last sentence of the note indicates. This is consistent with the NRC regulation, 10CFR50.55a, which allows the use of Code Editions and Addenda that are later versions than those established by the regulation. The Code Edition and Addenda mentioned in note 12 meet 10CFR50.55a and the actual ones used for the equipment also meet the regulation by virtue of their component order dates. However, note 12 has been revised to eliminate the apparent discrepancy.

Question 210.7N

Identify all ASME Code Cases including those that are listed as acceptable in Regulatory Guides 1.84 and 1.85 that are used in the construction of each Quality Group A (Safety Class 1) component within the reactor coolant pressure boundary. These code cases should be identified by code case number, revision, and title for each component to which the code case has been applied. A number of Code Cases in Regulatory Guides 1.84 and 1.85 are identified as conditionally acceptable to the NRC staff. Verify that in those instances where conditionally acceptable coded cases have been applied in the construction of components you are in compliance with the additional conditions applicable to each conditionally approved Code Case.

Response

Table Q210.07N-1 lists the code cases used on NSSS Class 1 components with their revision. Table Q210.07N-2 lists the cases' titles. Three of the code cases, 1528, N-242-1 and 1423, have NRC conditional approval and those conditions have been met. Note that the NRC condition for use of N-242-1 is to identify the paragraphs used. For code case N-242-1 paragraphs 1.0 through 4.0 were used.

Tables Q210.07N-3 and Q210.07N-4 list the code cases used on non-NSSS Class 1 systems and components and the code case titles. The NRC conditional approval for code cases N-242, N-242-1, N-274, N-275, all revisions of 1644 (N-71), 1734 (N-116), 1818 (N-175), N-249-1, and N-411, have been met. For code case N-242 and N-242-1, paragraphs 1.0 through 4.0 were used.

TABLE Q210.7N-1

ASME CODE CASES USED ON NSSS CLASS 1 COMPONENTS

Component	Unit 1	Unit 2
Steam Generator	2142-1, 2143-1, N-20-3, N-474-1	2142-1, 2143-1, N-20-3, N-474-1
Pressurizer	1528	none
RC Pump	1739*	1739*
CRDM	none	none
RC Pipe	1423-2	1423-2
Reactor Vessel	1557, 1605, N-514	1557, 1605, N-514
Valves	N-242-1, 1553-1, 1649, 1769	N-242-1, 1567, 1649, 1769

* Refer to Note 42 from Table 3.12-1. The applicable code cases for the reactor coolant pumps will be confirmed upon finalization of the ASME III documentation for the pumps.

TABLE Q210.7N-2

CODE CASE TITLES FOR ASME CODE CASES
USED ON NSSS CLASS 1 COMPONENTS -

1423-2	Wrought 304 and 316 with Nitrogen Added, Sections I, III, VIII
1484	SB-163 Nickel-Chromium-Iron Tubing at Specified Minimum Yield Strength of 40.0 Ksi Section III, Division 1, Class 1
1528	High Strength SA-508 cl 2 and SA-541, cl 2 forgings, Section III, Class 1
1553-1	Upset Heading and Roll Threading of SA-453 for Bolting, Section III
1557	Steel Products Refined by Secondary Remelting
1567	Testing Lots of Carbon and Low Allow Steel Covered Electrodes
1605	CR-Ni-Mo-V Bolting Material for Section III, Class 1 Components
1649	Modified SA 453-GR660 for Class 1, 2, 3 and CS Construction
1739	Pump Internal Items, Section III, Division 1, Class 1, 2, and 3
1769	Qualification of NDE Level III Personnel, Section III Division 1
N-242-1	Materials Certification, Section III, Division 1, Classes 1, 2, 3, MC, CS
2142-1	F - Number grouping for Ni-Cr-Fe, Classification UNS N 06052 Filler Metal, Section 1X (Applicable to all Sections including Section III, Division 1, and Section XI).
2143-1	F - Number grouping for Ni-Cr-Fe, Classification UNS W 86152 Welding Electrode, Section IX (Applicable to all Sections including Section III, Division 1 and Section XI).
N-514	Low Temperature Overpressure Protection, Section XI, Division 1.

TABLE Q210.7N-3

ASME CODE CASES FOR NON-NSSS CLASS 1 SYSTEMS AND COMPONENTS -

System or Component	Code Case No.
● RHRS	N-242
● SIS	N-242-1
● RCS	N-274
● CVCS	N-275
ASME III	
● Gate/Globe/Check	N-242
● Steel Plug Valves	N-242-1
ASME III	
● Butterfly Valves	N-242
● Steel Ball Valves	N-242-1
ASME III	
● Butterfly Valves	1733 (N-115)
● Pipe Supports for ASME III Piping	1644-5
	1644-6
	1644-7 (N-71-7)
	1644-8 (N-71-8)
	1644-9 (N-71-9)
	N-71-10
	N-71-11
	N-71-12
	1683-1
	1686 (N-86)
	1729 (N-111)
	1734 (N-116)
	1741-1 (N-120)
	1818 (N-175)
	N-225
	N-242-1
	N-247
	N-249-1
	N-249-2
	N-309
	N-413
● RCS Component Supports and Other NF Steel Items	1644-5
	N-71-9
	N-71-10
	1741
● ASME III Piping	N-411

TABLE Q210.7N-4

CODE CASE TITLES FOR ASME CODE CASES USED ON NON-NSSS CLASS 1 COMPONENTS 4 -

N-242	Material Certification, Section III, Division 1, Classes 1, 2, 3, MC and CS Construction
N-242-1	Material Certification, Section III, Division 1, Classes 1, 2, 3, MC and CS
N-274	Alternative Rules for Examination of Weld Repairs Section III, Division 1
N-275	Repair of Welds, Section III, Division 1
1733 (N-115)	Evaluation of SSE Loadings for Section III, Division 1, Class MC Containment Vessels
1683-1	Bolt Holes for Section III, Class 1, 2, 3 and MC Component Supports
1686	Furnace Brazing, Section III, Subsection NF, Component Supports (N-86)
1644-5	Additional Materials for Component Supports and Alternate
1644-6	Design Requirements for Bolted Joints Section III, Division 2, Subsection NF Class 1, 2, 3 and MC Construction
1644-7 (N-71-7)	Additional Materials for Component Supports Section III, Division 1, Subsection NF, Class 1, 2, 3, and MC (Component Supports)
1644-8 (N-71-8)	Additional Materials for Component Supports Section III, Division 1, Subsection NF Class 1, 2, 3, and MC (Component Supports)
1644-9 (N-71-9)	Additional Materials for Component Supports Section III, Division 1, Subsection NF Class 1, 2, 3, and MC (Component Supports)
N-71-10	Additional Materials for Component Supports Fabricated by Welding Section III, Division 1, Subsection NF Class 1, 2, 3, and MC (Component Supports)
N-71-11	Additional Materials for Component Supports Fabricated by Welding Section III, Division 1, Subsection NF Class 1, 2, 3, and MC (Component Supports)
N-71-12	Additional Materials for Component Supports Fabricated by Welding Section III, Division 1, Subsection NF Class 1, 2, 3, and MC (Component Supports)

TABLE Q210.7N-4 (Continued)

CODE CASE TITLES FOR ASME CODE CASES USED ON NON-NSSS CLASS 1 COMPONENTS

1729 (N-111)	Minimum Edge Distance - Bolting for Section III, Division 1, Class 1, 2, 3 and MC Construction of Component Supports
1734 (N-116)	Weld Design for Use for Section III, Division 1, Class 1, 2, 3 and MC Construction of Component Supports
1741-1 (N-120)	Interim Rules for the Required Number of Impact Tests for Rolled Shapes, Section III, Division 1, Subsection NF, Component Supports
1818 (N-175)	Welded Joints in Component Standard Supports, Section III, Division 1
N-225	Certification and Identification of Material for Component Supports, Section III, Division 1
N-247	Certified Design Report Summary for Component Standard Supports, Section III, Division 1, Class 1, 2, 3, and MC
N-249-1, 2	Additional Materials for Subsection NF Class 1, 2, 3, and MC Component Supports Fabricated without Welding Section III, Division 1
N-309	Identification of Material for Component Supports, Section III, Division 1
N-411	Alternative Damping Values for Seismic Analysis of Classes 1, 2, and 3 Piping, Section III, Division 1, Class 1, 2, and 3 Construction
N-413	Minimum Size of Fillet Welds for Linear Type Supports, Section III, Division I, Subsection NF

Question 130.2

Justify the use of a maximum (70 mph) and minimum (5 mph) translational velocity for the tornado wind load criteria. Specifically, state why you propose a maximum and minimum value and how you arrived at the quantitative values for the two limits.

Response

Maximum (70 mph) and minimum (5 mph) translational velocities for the tornado are obtained from NRC Regulatory Guide 1.76, Table I, for tornado intensity Region I. Reasons for the use of these values are discussed in the Regulatory Guide. For structural design, the maximum translational velocity of 70 mph is used.

Question 130.6

State how the tornado wind, pressure effects and missiles will be combined directly in a manner such as to be conservative for the structural element being considered.

Response

The tornado wind, pressure effects, and missiles are combined in such a manner that the effect of any compensating loads that reduce the missile loads is deleted from the combination.

Question 220.2N

Confirm that the transformation of tornado parameters into effective loading has been done according to SRP Section 3.3.2.II.3. If not, justify the deviation.

Response

A review of the design of the structures has confirmed that the transformation of tornado parameters into effective loading has been done in accordance with Standard Review Plan (SRP) Section 3.3.2.II.3.

Question 010.16

Your response to our Request 010.3 is not complete. Figure 1.2-3 indicates that the Essential Cooling Water Piping System is located outdoors. Provide a discussion to show how this safety-related piping system is protected from tornado missiles. If this piping is located underground, state how deep it is buried.

Response

The Essential Cooling Water Piping System is protected from tornado missiles, being buried below grade between the Mechanical Auxiliary Building and the Essential Cooling Water System Intake and Discharge Structures. The burial depth is approximately 14 ft at the Mechanical Auxiliary Building and approximately 6 ft outside the Essential Cooling Pond dike.

The pipes enter the Essential Cooling Water Intake Structure horizontally 6 ft below grade. The pipes rise vertically to centerline El. 31 ft-9 in. at the Essential Cooling Water Discharge Structure. The grade is at El. 26 ft-0 in. The raised portion is protected from tornado missiles by a concrete structure entirely enclosing the pipes. The structure is designed in accordance with Regulatory Guide 1.76 as described in Section 3.8.4. Furthermore, the pipes are embedded in granular backfill material within the protective structure.

Question 220.4N

For concrete barriers against turbine generated missile, the modified Petry formula is used. Compare the penetration depths using modified NDRC formula and make sure that you have provided barriers having equivalent conservatism to that required by the modified NRC formula. A copy of the revised SRP Section 3.5.3 covering the subject (Attachment 1) is provided for your information.

Response

The modified Petry formula is not utilized in the STPEGS to establish the thicknesses or probability of failure of concrete barriers against turbine-generated missiles. In the STPEGS the Chang Semi-Analytical Formula (SAF) for scabbing and the CEA-EDF Formula for perforation were used for the evaluation of barriers against the turbine-generated missiles. As explained in the following paragraphs, that approach is consistent with the intent of SRP Section 3.5.3, II.1.a which states that "For turbine missile barriers, penetration and scabbing predictions should be based on empirical equations such as the modified NRC formula or the results of a valid test program".

The Chang SAF for predicting scabbing resistance is based upon the principles of engineering mechanics with coefficients which are determined from test data. Reference 1 provides detailed information regarding the derivation of the formula and the determination of the coefficients used with the formula. The accuracy of the CEA-EDF formulations for perforation resistance are evaluated in Reference 2.

The test data used in Reference 1 were the only suitable data available at the time. These data were obtained based on cylindrical steel missiles impacting on concrete barriers. Later, full scale and reduced scale turbine missile tests were conducted by Sandia Laboratories and SRI International, in France were utilized in an independent assessment of the accuracy of the existing formulas. The results were reported in Reference 2 where it is concluded that the Chang SAF and the CEA-EDF formulas provide accurate predictions of scabbing and perforation, and that any deviation from the test results are on the conservative side.

Recently the authors of Reference 2 investigated the damage probability of turbine missile impact as reported in Reference 3 and selected the Chang SAF as the most applicable formula for concentrate scabbing prediction and quantified the conservatism contained in the SAF.

For information purposes the STPEGS has performed supplementary analyses to determine the probability of damage to concrete barriers of the entire plant using the modified NDRC formulas for scabbing and perforation prediction. The resulting critical probability from those analyses would be 1.26×10^{-7}. The governing walls and roof slabs of the Diesel Generator Building were considered to be 29 in. instead of the actual 24 inches.

Response (Continued)

This recalculated probability is introduced simply as a reference value to assess implications of using the alternate NDRC formula which has been demonstrated by tests to be conservative. The critical probability using the Chang SAF and the CEA-EDF formulations as reported in the Section 3.5, Table 3.5-8 is 0.83×10^{-7}. This probability value is maintained as the design basis for STPEGS since the value is determined on a sound analytical basis through accepted formulations proven to be reliable by observed test results and it satisfies the prescribed limit of 1.0×10^{-7}.

References

1. Chang, W.S., "Impact of Solid Missiles on Concrete Barriers", Journal of the Structural Division, ASCE, February, 1981.

2. Wolde-Tinsae, A.M., et al., "NRC Review of Impact Damage", Proceedings of Seminar on Turbine Missile Effects in Nuclear Power Plants, published by Electrical Power Research Institute, Palo Alto, Calif., October 1982.

3. Gopalakrishna, H.S. and Wolde-Tinsae, A.M., "Damage Probability of Turbine Missile Impact", Journal of the Structure Division, ASCE, December 1984.

Question 410.1N

The FSAR states that the auxiliary and main feedwater pump turbines are protected from overspeed by redundant overspeed trips and that neither turbine is considered to be a source of missiles. Regardless, provide the results of an analysis which shows safe shutdown will not be affected by such missiles.

Response

If the efficacy of the overspeed trips on the auxiliary and main feedwater pump turbines is disregarded there are nevertheless sufficient barriers to protect essential equipment from postulated turbine fragment missiles. Missiles arising from a postulated failure of the auxiliary feedwater pump turbine wheel due to 120 percent overspeed would not have enough energy to penetrate the turbine housing. In addition, each train of main steam, main feedwater, and auxiliary feedwater equipment in the isolation valves cubicle (including the auxiliary feedwater pump) is separated from the other trains by 2-ft-thick concrete walls. Turbine blades postulated to be ejected from the main feedwater pump turbine wheel due to 120 percent overspeed and to penetrate the turbine housing would not have sufficient energy remaining to penetrate or spall the exterior walls of Category I structures. Therefore, the ability to shutdown safely would not be affected by postulated missiles from these turbines.

Question 210.23N

Discuss how jet impingement effects on target piping systems and components were evaluated, specifically the criteria used in determining the acceptability of the target piping systems and components.

Response

Section 3.6.2.3.1 addresses methods of analysis for jet impingement. A detailed explanation of analyses performed for the reactor coolant loop (RCL) is included in Section 3.6.2.3.2. Regarding RCL breaks, please refer to the response to Question 210.20N.

The effects of jet impingement on safety-related piping other than the RCL are analyzed using criteria established in References 3.6-5, 3.6-6, and 3.6-9. The following sentence has been added to item 14 of Section 3.6.1.1:

"For essential piping, jet impingement loads are evaluated regardless of the ratio of impinged and postulated broken pipe sizes."

Once target piping systems and components have been identified and jet impingement loads have been calculated, the piping is statically analyzed under two conditions:

1. Transient loading using a dynamic load factor of 2.0 and incorporating the effects of any dynamic supports attached to the piping.

2. Steady state loading using a dynamic load factor of 1.0 and neglecting the effects of any dynamic supports.

Piping response (stresses, deflections, and support reaction loads) generated using these two conditions are enveloped and compared to the appropriate faulted allowables as defined in Section 3.9.1.1.4 and Tables 3.9-7, 3.9-7A, 3.9-7B, and 3.9-7C. Load combinations for this event are presented in Tables 3.9-2.3, 3.9-2.3A, and 3.9-2.4.

Direct jet impingement on valves and other components connected to a piping system is identified and essential targets are either requalified for jet impingement or protected for the jet impingement. Reaction end loads on valves and components due to jet impingement on piping are calculated and combined with other appropriate loads in qualifying the valves or components to the vendor's allowables.

Question 210.24N

The staff finds that there is insufficient information describing the jet expansion model used for evaluation of jet impingement effects of steam, saturated water or steam-water mixtures. Provide additional information to assure that the criteria described in SRP 3.6.2 Section III.3 have been met for analysis of jet impingement forces.

Response

The jet expansion model used for the evaluation of impingement effects of steam, saturated water or steam-water mixtures is described in "Design for Pipe Break Effects", Topical Report BN-TOP-2, Rev. 2, May 1974, Bechtel Power Corporation, San Francisco, California as indicated in Section 3.6.2.3. The NRC staff has previously evaluated and accepted Topical Report BN-TOP-2, Revision 2, May 1974 as documented in the staff's letter dated June 17, 1974 from R.W. Klecher to R.M. Collins of Bechtel Corporation.

Following is a brief description of the analytical methods used in generation of the BN-TOP-2, Rev. 2 jet expansion model.

1. Discharging fluids with superheated, two-phase, saturated or subcooled conditions at the exit plane of the pipe are expanded with the Moody model. The distance to the asymptotic plane is calculated according to the Moody methodology. However, this distance is limited to no less than five pipe diameters for longitudinal and full-separation circumferential breaks, and five times the axial separation distance for limited separation circumferential breaks.

2. Subcooled fluid with a small void fraction (α<0.001) or cold water (enthalpy less than the enthalpy of a saturated liquid at ambient pressure) conditions at the exit plane of the pipe are expanded at a uniform 100 half-angle.

Question 210.27N

Provide a listing of those postulated pipe breaks where limited displacements have been used to reduce break areas.

Response

Limited displacements have not been used to reduce break areas for piping on STPEGS.

Question 210.29N

Provide the loads, load combinations, and stress limits that were used in the design of pipe rupture restraints. Include a discussion of the design methods applicable to the auxiliary steel used to support the pipe rupture restraint. Provide assurance that the pipe rupture restraint and supporting structure cannot fail during a seismic event.

Response

Refer to paragraph 3.6.2.1.1.1a. RCL pipe breaks have been eliminated thereby eliminating the need for RCS loop restraints.

Pipe whip restraints are designed as a combination of an energy-absorbing element (EAE) and a supporting (auxiliary) structure capable of transmitting the resistance load from the EAE to the main building structures (concrete walls, slabs, and steel structures). The EAE usually is either thin gauge cellular crushable material (energy-absorbing material, [EAM]) or stainless steel U-bars. The design limits for EAEs are specified in Section 3.6.2.3.4.1.2.

The supporting structures are designed to the loads, load combinations, and stress limits as specified in Section 3.8.3.3 and Tables 3.8.3-2 and 3.8.4-2. For supporting structures designed to respond elastically, stress limits are set in accordance with Part I of the AISC specification with stress increase factors as given under the STRENGTH heading of Tables 3.8.3-2 and 3.8.4-2. Alternatively, supporting structures may be designed to respond inelastically as stated in Note (f) of the Tables 3.8.3-2 and 3.8.4-2. In this case, the design is limited by the ductility ratios given in Tables 3.5-13, items 5, 6, and 7.

Both the Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE) seismic events are specifically included in the loading combinations prescribed for the structural integrity of the pipe whip restraints. The restraints and their structures are treated as structural subsystems whose seismic response is determined from their frequency characteristics and the appropriate floor response spectra. In all cases, the design for load components due to seismic response is subject to stress limits set in accordance with Part I of the AISC specification as described above. For the cases where pipe rupture loads force the structure into the inelastic range and the SSE loading is a non-governing component, the stress limits are not applicable and the ductility factors as described above are used to control the design.

Question 210.32N

No discussion could be found in the FSAR regarding design stress limits for Class 1 piping in the break exclusion zone. If there are any Class 1 lines in the break exclusion zone, provide the required design limits.

Response

There is no Class 1 piping in the break exclusion zone for STPEGS.

Question 210.34N

Provide assurance that 100 percent volumetric inservice examination of all pipe welds in the break exclusion zone will be conducted during each inspection interval as defined in IWA-2400, ASME Code, Section XI.

Response

As discussed in Section 6.6.8, circumferential and longitudinal pipe welds within the break exclusion zone of high energy fluid system piping at containment penetrations will either be 100 percent volumetrically examined during the preservice examination and during each inspection interval of the inservice inspection program in accordance with ASME Code Section XI and SRP 6.6 or exceptions (e.g., due to access limitations) will be documented in the ISI program.

Question 130.11

Compare the response of the simplified finite element structural model incorporated in soil-structure interaction analysis with the detailed lumped mass mathematical models of Category I structures used to obtain time histories at floor elevations.

Response

In the soil-structure interaction analysis, structures are first modeled by simplified finite elements to be incorporated in the integrated soil-structure model. This overall integrated model is then subjected to seismic excitation to obtain the motion of the foundation, including the soil-structure interaction effect. The purpose of this step of analysis is to include the essential dynamic characteristics of the structure in the calculation of the foundation motion, but not the response of the structure at higher elevations. The response of the structure at various elevations is obtained by subjecting the detailed three-dimensional lumped mass structural model to the calculated foundation motion. In the detailed structural model, torsional soil springs and eccentricities are incorporated and the structure is represented by a more refined mathematical model. Only results from the analysis of the detailed model are used in the structural design and in the qualification of safety-related equipment. Since the response of the detailed three-dimensional model includes many additional effects (e.g., torsional response and localized amplification [or reduction]), no direct comparison should be made between the two responses.

Question 130.14

State if rocking is a general consideration for all seismic Category I structures. Also, described the manner in which you have accounted for any accidental torsional effects of earthquakes for the Category I structure that you considered as axisymmetric.

Response

Rocking degrees of freedom have been taken into account in the analysis of the lumped mass model of each structure. Thus, rocking is a general consideration for all Category I structures including rocking motion at the base of the structures.

Of all the Category I structures, only the auxiliary feedwater tank is axisymmetric. No accidental torsional effects of earthquake have been considered in the design of the tank since the structure and the loads are both axisymmetric.

Question 130.15

State your criteria for the determination of an adequate selection of the number of lumped masses based on their relationship with any change in the response of a system with a greater number of masses from that of a system with fewer lumped mass representation.

Response

The following are our criteria for the determination of adequacy in selection of number of lumped masses:

1. Total number of degrees of freedom is more than twice the number of modes with frequencies less than 33 cycles per second.

2. The inclusion of additional modes does not result in more than a 10 percent increase in responses.

Question 130.16

State if the fundamental frequency of the subsystems is controlled to be greater than twice or less than one-half the dominant frequency of the supporting system.

Response

The subsystems are designed to avoid resonance with the supporting structure, to the extent possible. In any case, the subsystems and components are analyzed and designed so that the resulting stresses are within allowable limits dictated by the applicable codes.

Question 220.6N

Confirm that the frequency intervals used for floor spectra generation are small enough that their reduction does not result in more than ten (10) percent change in the computed spectral values.

Response

Response spectra calculations parallel to the original Brown & Root (B&R) calculations, incorporating the prescribed frequency intervals per Regulatory Guide (RG) 1.122 and other minor modifications, were performed in order to resolve the frequency-interval concern and to evaluate the original seismic dynamic analyses. The results indicate that the only significant difference associated with the frequency interval pertains to the sparseness of the intervals used for the spectral response calculation detected at frequencies below 2.5 Hz and only for the Reactor Containment Building (RCB). For the higher frequency range, the frequency intervals used are adequate and the original response spectra is conservative; refer to Figures Q220.6N-1 through Q220.6N-4. For a comparison of the frequency intervals per RG 1.122 with those used in the original calculation, refer to Table Q220.6N-1. From the tabulation the sparseness of the original frequency intervals is evident.

The UFSAR does not define the frequency intervals used for the calculation of floor response spectra. In Section 3.7.1.2 the frequency range/no. of points data tabulated pertains to the calculation of spectra performed to confirm the artificial spectra. The tabulated data does not apply to floor response spectra calculations. In Section 3.7.2.5 only the frequency range for floor response spectra calculations was stated as 0.1 Hz to 33 Hz, which subsequently has been corrected to 0.5 to 33 Hz.

The distinctly higher peaks of the B&R solution compared to the Bechtel solution are attributed to (1) the method used by B&R to combine response spectra along parallel directions due to orthogonal input, and (2) slight variations in the structural model configurations. However, for response spectra comparisons, the fact that there are no frequency shifts and that similar high-frequency range and zero-period accelerations are preserved is a more meaningful basis for comparison than on the basis of similitude of peak values.

The sparseness of the frequency intervals of the original calculations diminished the resolution of the spectral calculation and contributed to the under-representation of spectral response in the low frequency range identified in the response to Q220.8N pertaining to the elastic-half-space (EHS) method for soil/structure interaction (SSI). The spectral response calculated using the RG 1.122 frequency intervals exceeds slightly the original spectra and extends the range of resolution into the low frequency range. The resultant spectra, however, is consistently enveloped by the EHS spectra addressed in the cited response; refer to Figure Q220.6N-1. Therefore, the frequency-interval implications on the spectral response are analogous and bounded by the EHS implications and are similarly dispositioned.
Also see UFSAR Section 3.7.2.5.

TABLE Q220.6N-1

FREQUENCY INTERVALS USED TO CALCULATE FLOOR RESPONSE SPECTRA -

NRC RG 1.122 (used by Bechtel)	B&R	NRC RG 1.122 (used by Bechtel)	B&R	NRC RG 1.122 (used by Bechtel)	B&R
.2		3.8		16.0	
.3		4.0	4.0	17.0	17.0
.4		4.2		18.0	
.5	.5	4.4			19.0
.6			4.5	20.0	
.7		4.6			21.0
.8		4.8		22.0	
.9		5.0	5.0		23.0
1.0	1.0	5.25		25.0	25.0
1.1		5.5	5.5		27.0
1.2		5.75		28.0	
1.3		6.0	6.0		29.0
1.4		6.25		31.0	31.0
1.5	1.5	6.5	6.5		33.0
1.6		6.75		34.0	
1.7		7.0	7.0		35.0
1.8		7.25		TOTAL 75.0	TOTAL 36.0
1.9		7.5	7.5		
2.0	2.0	7.75			
2.1		8.0	8.0		
2.2		8.5	8.5		
2.3		9.0	9.0		
2.4		9.5	9.5		
2.5	2.5	10.0	10.0		
2.6		10.5	10.5		
2.7		11.0	11.0		
2.8		11.5	11.5		
2.9		12.0	12.0		
3.0	3.0	12.5			
3.15		13.0	13.0		
3.30		13.5			
3.45		14.0			
	3.5	14.5			
3.60		15.0	15.0		

Figure Q220.06N-1

Figure Q220.06N-2

Figure Q220.06N-3

Figure Q220.06N-4

Question 220.7N

You have mentioned that l0 percent damping value was used in the qualification of safety-related cable trays in some instances. Give more detail of those instances and justify the use of 10 percent damping. Note that the staff position as reflected in the RG 1.61 suggests use of lower damping value.

Response

The 10 percent damping mentioned for the qualification of safety-related cable trays in some instances pertains to the reduction of data obtained as part of the tests performed for the seismic justification. Trays fully loaded with cable, supported at 6-ft and 10-ft spans were subjected to dynamic testing by harmonic motion input. The response recorded from the test was used to derive equivalent damping ratios from 3 percent to 14 percent in vertical direction and 6 percent to 37 percent in lateral direction. These damping values were compiled for information only, and were not used as a basis for seismic qualification of the tray system by analysis. The seismic qualification of the tray system was accomplished by equivalent static analysis utilizing the seismic accelerations dictated by the floor response spectra (at 4 percent maximum damping) for the corresponding natural frequencies determined from dynamic testing of trays. Therefore, the given damping values are simply a report of test findings, and are not subject to the damping limits per RG 1.61 since the given damping values were not used in dynamic analyses for seismic qualification of the cable trays and support structures. The seismic analysis and design of cable trays and supports as an integrated structural system incorporates damping values ranging from 7 percent to 15 percent depending on the zero-period acceleration at the locations within structures. Currently the generic design of typical cable tray supports is in progress and a maximum damping value of 7 percent has been used for SSE. Nongeneric designs of supports for specific cases may involve damping values near the maximum of 15 percent. The stated damping values are consistent with the cable tray support design practice based on experimental research advocated by Bechtel and submitted to the NRC for consideration.

See Sections 3.7.1.3 and 3.7.3B.15.

Question 220.8N

In the meeting of August 7, l971 on SSI of STPEGS, after having explained the technical basis for the SEB SSI related position and discussed with the applicant on South Texas SSI issues, the SEB staff suggested that among various options available to the applicant for the resolution of the SSI issue, the use of the following approach to meet the intent of the SEB SSI position would be acceptable:

Use Elastic Half Space Method of Analysis without reducing the input motion due to embedment of structure in soil. Apply the RG 1.60 motion properly anchored at the OBE/SSE "g" values in the free field at the foundation level and compare the resulting response spectra with those of Finite Element Method. The applicant should demonstrate that at least the intent of the following position is fully met:

> Methods for implementing the soil structure interaction analysis should include both the half space and finite element approaches. Category I structures, systems, and components should be designed to responses obtained by any one of the following methods:
>
> (a) Envelop the results of both EHS and FEM;
>
> (b) Results of one method with conservative design considerations of effects from use of the other method; and
>
> (c) Combination of (a) and (b) with provisions of adequate conservatism in design.

The above mentioned comparison of floor response spectra needs to be done only for key structures at key levels e.g., 6 key levels of Reactor Containment Building, 4 key levels of auxiliary building, etc.

The SEB staff mentioned that if the actual design floor response spectra are compared with those obtained by enveloping the spectra resulting from the FEM and EHS methods of analysis, there may not be any appreciable change in the design of structural elements, because HL&P and Brown & Root have mentioned that enough conservatism is already built in the design by using Finite Element Method. However, there may be cases where the components and equipments may not meet the seismic criteria based upon the enveloped response spectra. HL&P may need to look into these cases and study the specific impact of NRC's current position on the cases in order to qualify them for the seismic criteria.

If the floor response spectra obtained by enveloping are higher than those used for actual design, HL&P still has a choice to justify that the additional stresses resulting from the enveloped spectra are acceptable and overall design adequacy is maintained by considering the actual as-built-strength of the structure. For concrete structures, the as-built yield strength will be the average of compressive strength established by tests. For both reinforcing and structural steel, the as built yield strength will be the average of the actual tested yield strength, but in no case shall it be greater than 70 percent the ultimate strength. The scope and the extent of

Question 220.8N (Continued)

test program and resulting test data shall be submitted for review and approval by the staff.

Other approaches for demonstrating the seismic design adequacy of Category I structures and systems which meet the intent of this position are also acceptable if reviewed and accepted by the staff. For example, if enough seismic data for the South Texas site and other sites having similar regional and local seismicity characteristics are available, then the site specific spectra approach may be a viable option to be considered.

Response

A study of the STPEGS design-basis seismic response spectra was performed to compare the soil/structure interaction (SSI) analyses by the two-step finite element method (FEM) with the elastic-half-space (EHS) method. The results of this study were summarized in Reference (l).

Specific responses addressing the concerns and suggestions stated in NRC Question 220.8N are presented herein. This response also updates the response to previous NRC Ql30.l2.

> The free-field input motion used by Bechtel in the EHS SSI analyses was applied at the base of all structures without resorting to any reduction due to the embedment of structures in soil, which is consistent with the NRC's position.
>
> The FEM spectra envelopes the EHS spectra for the frequency range that is relevant for the design and/or qualification of structural elements, and essentially all equipment and components. The most significant difference is restricted to the low frequency range (f<4 Hz, generally), corresponding to SSI frequencies where the EHS spectral response for horizontal directions in some buildings is distinctly higher than the FEM spectra. This difference prevails and is significant only in the Reactor Containment Building (RCB). In the Fuel Handling Building (FHB) and the Diesel Generator Building (DGB) the difference is evident to an insignificant extent, and in the Mechanical Electrical Auxiliaries Building (MEAB) it is essentially nonexistent (see Figures Q220.8N-1, Q220.8N-2, Q220.8N-3, and Q220.8N-4). Therefore, the difference is well bounded and suitable for systematic assessment by natural-frequency segregation of the limited number of items susceptible to the higher seismic response developed exclusively in the low frequency range.
>
> A program for the systematic segregation and evaluation of affected equipment and components is defined in Attachment (1). The program has been implemented as a specific task to verify the adequacy of all the prior and future seismic designs and/or qualifications based on the original STPEGS floor response spectra augmented by the EHS solution in the low frequency range. The results of the initial implementation of the program on a selected sampling of susceptible items is presented in Table Q220.8N-1. The results confirm the anticipated trend that very few items have natural frequencies within the low range of concern, and

Response (Continued)

that the limited number of items in that range have sufficient design margin to accommodate the moderately higher seismic load predicated by the EHS-augmented spectra.

The comparison of FEM and EHS response spectra has been performed for the RCB, MEAB, FHB, and DGB for the Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE) events for all levels and locations.

The EHS spectra do not result in higher zero-period accelerations nor in higher peak amplifications than those obtained from the FEM spectra. Therefore, the seismic designs of all the superstructures and most of the structural subsystems, which invariably have frequencies higher than 4 Hz or are already designed for near peak seismic response, are not affected by the EHS-augmented spectra. Accordingly, there is no need to rely on a justification of structures by means of existing design margins nor by means of the actual as-built material strengths as suggested in Q220.8N.

Supplementary information pursuant to the presentation of Reference (1) material to the NRC is also submitted herein as follows:

The original FEM response spectra calculated by Brown & Root (B&R) included parametric studies involving the average, upper and lower bound soil properties. The response spectra, issued as the seismic design basis, represent the envelope of the three soil-property solutions and include a ±l0 percent frequency-based broadening to further account for uncertainties in structural materials and modelling techniques. It is noted that the enveloping of soil properties was specifically performed only for the OBE along the finite element model cross-sections 1 and 2 as defined in Figure Q220.8N-l0. For the OBE along cross-section 3 and for the SSE analysis, the soil property parametric study was not performed. Instead, a higher broadening of ±15 percent was applied to the spectra calculated on the basis of average soil properties.

The EHS response spectra calculated by B&R and by Bechtel for comparative purposes are based on average soil properties and include a ±15 percent frequency-based broadening in lieu of a soil property parametric study. It was considered that the full scope parametric study, while warranted for the design-basis spectra, was not necessary for the comparative-study spectra and, accordingly, it was not incorporated in the EHS solutions.

As stated previously, in the EHS solution performed by Bechtel the free-field surface ground motion was applied directly as input without any reduction to account for the embedment depth of the RCB and FHB structures. This direct application is conservative and avoids the controversial reduction of surface input motion. Accordingly, the Bechtel EHS response spectra solutions are consistently higher than the B&R solutions which are based on reduced input motions; refer to Figures Q220.8N-4 through Q220.8N-9 for

Response (Continued)

typical comparisons. Aside from input motion, the Bechtel and B&R EHS solutions are nearly identical in method. Both solutions are based on the same structural model, which has been reviewed by Bechtel, and utilize the same soil impedances (springs and dampers) developed by Woodward-Clyde Consultants (WCC) as described in Reference (2). The equivalent springs and dampers used are a frequency-independent mechanical analog of the foundation impedances based on EHS theory.

In conclusion, the original seismic response spectra calculated by two-step FEM SSI are reaffirmed to be adequate seismic design bases for the STPEGS, subject to verification of the related seismic design and/or qualification of the limited number of items affected by the discrepant spectral response confined to the low frequency range.

Also see UFSAR Section 3.7.2.4.

References

1. Soil-Structure Interaction Outline-A presentation by HL&P and Bechtel delivered to the NRC on December 7, 1982.

2. "Computations of Spring and Damping Coefficients for Category I Structures, STPEGS, Units 1 and 2", by Woodward-Clyde Consultants, April 1980.

TABLE Q220.8N-1

PROGRAM FOR THE EVALUATION OF
AFFECTED EQUIPMENT AND COMPONENTS -

Equipment or System	Fundamental Frequencies (Hz)/ Method of Seismic Qualification	Remarks (see sheet 3 for code number definition)
Diesel Generator and Diesel Generator Control Panels	17.0; 17.5; 22.0/Test	1
Hydrogen Monitoring System; Remote Control Panel	29.2; 34.4/Test & Analysis	2
Electrical Panels MCC	8.75; 10/Test	2
Containment Electrical Penetration	11.0; l6/Test & Analysis	1
Load Center Enclosed Switchgear Assembly	10.0; 11.3; 13.4; 15.5; 15.7/Test & Analysis	2
1000 & 2000 kVA Transformers Load Center	2.0; 2.5; 3.5/Test	2
Low Head Safety Injection Pump	Higher than 33/Test & Analysis	1
2" & 3" dia. RTD Lines Loop 2 & 3	8.903; 12.903; 13.510; 14.167; 15.464/Analysis	1
2" dia. Seal Water Injection Loop 2	12.120; 12.457; 15.266 15.477; 15.741/Analysis	1
12" & 14" dia. RHR/SI Suction Line	11.886; 14.549; 18.931 19.597; 21.390/Analysis	1
2" & 4" dia. Normal Letdown	15.200; 16.206; 17.155; 17.37; 17.599/Analysis	1
16" dia. RCS Pressurizer Surge Line	9.514; 13.876; 16.464 21.063; 26.393/Analysis	1
8"; l0" & l2" dia. RHR/SI Cold Leg Injection Lines	7.l53; 11.857; 12.323 12.902; 13.599/Analysis	1
6" & 8" dia. SI Cold Leg Injection Line and CS Pump Discharge Line	4.203; 5.064; 5.431 6.562; 8.844/Analysis	1

TABLE Q220.8N-1 (Continued)

PROGRAM FOR THE EVALUATION OF
AFFECTED EQUIPMENT AND COMPONENTS

Equipment or System	Fundamental Frequencies (Hz)/ Method of Seismic Qualif.	Remarks
HVAC Ducts a) MEAB b) FHB	21.0/Analysis	1
Duct Supports a) MEAB b) FHB, DGB & RCB	4.89; 9.28/Analysis	3
Cable Tray Support	4.8; 5.3; 3.3; 4.1/Analysis	3
Cable Trays	15 (Vert); 13.2 (Trans)/Test	3
Existing Cable Tray System in Switchgear Rooms	5.4/Analysis	2
RCB Polar Crane Runway Girder and Bracket	1.64; 2.21; 5.61; 6.84/Analysis	4
RCB Orbital Service Bridge	1.55 (Radial); 2.8 (Tang.); 6.0 (Tang.)/Analysis	5
FHB 150 Ton Crane	0.28; 2.95; 6.48; 9.81; for out-of-plane motion, of supporting wall: about 6 Hz/Analysis	4

1. Frequency above 4 Hz, out of range - No effect.

2. FEM spectra envelopes the EHS spectra for MEAB, where equipment is located - No effect.

3. Generic design is based on seismic acceleration levels in the range of peak amplification, which is not increased by EHS spectra - No effect.

4. Enough margin in existing design - No effect.

5. Enough margin was found in the existing support embedment - No effect. A definitive analysis has confirmed that the members are adequate, and that the structural integrity of the equipment is not compromised by the EHS augmented seismic response spectra.

Figure Q220.08N-1

Figure Q220.08N-2

Figure Q220.08N-3

Figure Q220.08N-4

Figure Q220.08N-5

Figure Q220.08N-6

Figure Q220.08N-7

Figure Q220.08N-8

Figure Q220.08N-9

Figure Q220.08N-10

<u>Criteria for the Verification of Seismic Qualification and/or Design of Equipment and Components with Respect to the Floor Response Spectra Augmented by Elastic-half-space (EHS) Soil-structure Interaction (SSI) Analysis</u>

References: (A) Floor Seismic Acceleration Response Spectra Design Basis for STPEGS, Bechtel Drawings indexed in Drawing No. 4N16-9-S-39150 and listed in Table 1.

(B) Floor Seismic Acceleration Response Spectra augmented by EHS SSI Analysis for STPEGS, Sketches No. SKC-5 through SKC-254.

1.0 The seismic qualification and/or design of all seismic Category I equipment, components and piping shall be reviewed and verified, if required, in accordance with the steps defined in this criteria.

2.0 Establish the latest and governing seismic qualification and/or design document for the equipment/component/piping. Verify that the seismic qualification and/or design document is based on the appropriate response spectra selected from Reference (A) in accordance with the installed location(s) of the equipment/component/piping with the respective building(s).

Any seismic qualification and/or design which is found to be based on response spectra other than that of Reference (A) shall be referred to the Seismic Group of the Civil/Structural Discipline for specific evaluation and disposition.

3.0 The floor seismic acceleration response spectra as modified by the EHS SSI analysis are characterized with respect to the design-basis spectra by five cases defined below. When the EHS-modified spectra exceed the design-basis spectra, the EHS spectra hereafter will be referred to as the EHS-augmented spectra defined by Reference (B).

(1) The EHS-modified spectra are essentially enveloped by the design-basis spectra over the whole frequency range. The instances where the EHS-modified spectra exceed the design-basis spectra are restricted to the vertical response in the RCB, for which some spectral response peaks exceed the design-basis spectra by no more than 10 percent at isolated frequency points of less than 5 Hz.

(2) Design-basis spectra were not previously issued for the basement locations of the Reactor Containment Building (RCB), the Mechanical Electrical Auxiliary Building (MEAB), and the Diesel Generator Building (DGB), as well as El. 83 ft of the RCB interior structure, the pressurizer support points in the RCB and the enveloped spectra for the power block buildings. Therefore the EHS-modified spectra are henceforth adopted as the design-basis spectra for these locations.

(3) The EHS-augmented spectra exhibit a narrow frequency band where a distinct spectral response peak exceeds the design-basis spectra. The peak is confined to the low frequency range, and in all instances the EHS-augmented spectra exceed the design-basis spectra only at frequencies below 4 Hz.

(4) The EHS-augmented spectra exhibit a narrow frequency band where the spectral response exceeds the design-basis spectra defined by a "valley" between two peaks on the design-basis spectra. This trait is confined to the low frequency range, below 8 Hz, and is in addition to the Case (3) trait.

(5) The EHS-augmented spectra exceed the design-basis spectra over a wide frequency range. This case is restricted to the basement locations of the Fuel Handling Building, where a very limited number of equipment/component/piping are housed.

Table 1 is a listing by drawing number of the Reference (A) design-basis spectra. In the last column of the table the case number, as defined above, is given for each spectra drawing.

4.0 Select the next step of this criteria that must be implemented in accordance with the case number assigned in Table 1 to the spectra that governs the seismic qualification and/or design of the equipment/ component/piping.

4.1 If the installed location(s) of the equipment/component/piping dictates Case (1) spectra, the equipment/component/piping are not affected by the EHS-augmented spectra; proceed to Section 8.0. This is the case for all equipment/component/piping located in the MEAB and several other locations as designated in Table 1.

4.2 If the installed location(s) of the equipment/component/piping dictates Case (2) spectra, start a data sheet (Form A) for the equipment/ component/piping if it was subject to prior seismic qualification and/or design. If the spectra used in the prior seismic qualification and/or design of the equipment/component/piping envelop the design-basis spectra per Reference (A), proceed to Section 8.0. If the prior seismic qualification and/or design of the equipment/component/piping was based on spectra different than the corresponding spectra from Reference (A), and the differences are characterized as in Case (3) or Case (4), proceed to scrutinize the natural frequencies reported in the seismic qualification and/or design in accordance with Section 4.3 or Section 4.4, respectively. Otherwise, if the differences between the spectra used for seismic qualification and/or design and the Reference (A) spectra are more pronounced or over a broad frequency range, refer the case to Civil/Structural for specific evaluation and disposition.

4.3 If the installed location(s) of the equipment/component/piping dictates Case (3) spectra, the equipment/component/piping may be affected by the EHS-augmented spectra, depending on the natural frequency range of the equipment/component/piping. Scrutinize the natural frequencies reported in the seismic qualification and/or design for the equipment/component/ piping. Establish the nature and direction of the modal response corresponding to the low frequency range (less than 4 Hz*) if such information is available from the seismic qualification and/or design. Ascertain that the low frequencies as reported are (1) representative and valid for the equipment/component/piping system, (2) correspond to horizontal direction of response for the installed position of the equipment/component/piping, and (3) are not related to irrelevant subsystems within the equipment/component/piping.

If the lowest natural frequency is 4 Hz* or higher, the equipment/ component/piping is not affected by the EHS-augmented spectra; proceed to Section 8.0. Equipment/component/piping's with natural frequencies lower than 4 Hz* are potentially affected; proceed to Section 5.0.

It must be noted that for the cases where devices (such as switches, relays or breakers) are mounted within control panels or cabinets, and the natural frequencies associated with the mounting and/or functionality of the devices are not specifically defined in the seismic qualification and/or design of the panel or cabinet, it is appropriate to consider such frequencies to be above the governing limit of 4 Hz*. This onsideration is based on (1) the inherent frequency characteristics of these internally-mounted devices typically higher than 4 Hz*, and (2) the observation that for low frequencies the corresponding free oscillation amplitudes are beyond the range anticipated for such devices; i.e., 0.6 inch amplitude for 4 Hz, 2.4 inches for 2 Hz (the peak-response frequency). However, if specific frequency data from the seismic qualification and/or design of the panel, cabinet or device indicates mounting and/or functionality frequencies below 4 Hz*, such cases should be referred to Civil/Structural for specific evaluation and disposition on the possible need for requalification.

4.4 If the installed location(s) of the equipment/component/piping dictates Case (4) spectra, the equipment/component/piping may be affected by the EHS-augmented spectra, depending on the natural frequency range of the equipment/component/piping and the seismic qualification and/or design method used. Scrutinize the natural frequencies reported in the seismic qualification and/or design for the equipment/component/piping. Establish the nature and direction of the modal response corresponding to the low frequency range (less than 8 Hz*) if such information is available from the seismic qualification and/or design. Ascertain that the low frequencies as reported are (1) representative and valid for the equipment/component/piping system, (2) correspond to horizontal direction of response for the installed position of the equipment/ component/piping, and (3) are not related to irrelevant subsystems within the equipment/component/piping.

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* When scrutinizing seismic qualifications performed by a test utilizing the TRS method, these frequency limits should be adopted as 5 Hz instead of 4 Hz and as 10 Hz instead of 8 Hz. These broadenings allow increase of the cut-off frequencies by at least 1/3 octave.

If the lowest natural frequency is 8 Hz* or higher, the equipment/ component/piping is not affected by the EHS-augmented spectra; proceed to Section 8.0. Equipment/component/piping's with natural frequncies lower than 8 Hz* are potentially affected; proceed to Section 5.0.

It must be noted that for the cases where devices (such as switches, relays or breakers) are mounted within control panels or cabinets and the natural frequencies associated with the mounting and/or functionality of the devices are not specifically defined in the seismic qualification and/or design of the panel or cabinet, such frequencies cannot be properly considered to always be higher than the governing limit of 8 Hz*. However, for the cases of seismic qualification of panels or cabinets with internal devices, it is anticipated that the seismic qualification, including the devices, was performed by test utilizing the test response spectra (TRS) method. The TRS is based on the original design basis spectra and normally does not represent the "valleys" between peaks of the design-basis spectra. Therefore, since the TRS does not include the low-points of the "valleys", it will invariably envelope the EHS spectra augmented at the "valleys" in between peaks of the design-basis spectra. Such observation, applicable only to seismic qualification by TRS, must be specifically confirmed in order to designate the equipment/component corresponding to this Case (4) as not affected by the EHS-augmented spectra.

The foregoing simplification applies only to seismic qualification performed by test utilizing a TRS that envelop the EHS-augmented spectra. Other cases should be referred to Civil/Structural for specific evaluation and disposition on the possible need for requalification.

4.5 If the installed location(s) of the equipment/component/piping dictates Case (5) spectra, the equipment/component/piping is anticipated to be affected by the EHS-augmented spectra. Start a data sheet (Form A) for the equipment/component/piping, fill in data for columns (A) thru (D), and submit to Civil/Structural for specific evaluation and disposition.

5.0 Start a data sheet (Form A) for the equipment/component/piping, fill-in data for columns (A) thru (C) and/or a checklist (Form B) for the equipment/component only. If the seismic qualification and/or design of the equipment/component/piping is by analysis proceed to Section 6.0, if by test equipment/component only proceed to Section 7.0. For the case of piping system, where testing normally is not applicable for seismic qualification and/or design, disregard Section 7.0. However, for piping-mounted devices or components (valves), proceed to Section 7.2.

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* When scrutinizing seismic qualifications performed by a test utilizing the TRS method, these frequency limits should be adopted as 5 Hz instead of 4 Hz and as 10 Hz instead of 8 Hz. These broadenings allow icnrease of the cut-off frequencies by at least 1/3 octave.

6.0 Establish frequency bands of $0.9f_n$ to $1.1f_n$ for each natural frequency below the lower limit frequency (4 Hz for Case (3); 8 Hz for Case (4)). Read the spectral acceleration corresponding to the established frequency band(s) from the selected Reference (B) spectra. If, at corresponding frequencies, any spectral acceleration derived from Reference (B) spectra is higher than the acceleration by Reference (A) spectra, proceed to Section 6.1; otherwise, if none is higher, the equipment/component/piping is not affected by EHS-augmented spectra; proceed to Section 8.0.

6.1 By review of the analysis, establish the maximum lateral acceleration value for which the equipment/component/piping was qualified and/or designed; denote the value as S_{amax} and enter in column (D) of Form A. Establish the augmented spectral acceleration level from the Reference (B) spectra by performing the square root of the sum of the squares (SRSS) of each of the maximum spectral accelerations corresponding to each frequency band established in Section 6.0; denote S_{aEHS}.

Compare S_{aEHS} to S_{amax}, if $S_{aEHS} < S_{amax}$ the equipment/component/piping is considered adequate insofar as the effect of EHS-augmented spectra is concerned, proceed to Section 8.0. If $S_{aEHS} > S_{amax}$, evaluate the analysis and design to establish whether the available seismic design margin is adequate to accommodate the higher seismic load indicated by S_{aEHS}. If the existing seismic qualification and/or design analysis for the equipment/component/piping does not permit the foregoing scrutiny, or if the results indicate inadequate margin or are inconclusive, refer the case to Civil/Structural Discipline for specific evaluation and disposition on the possible need for reanalysis.

7.0 Establish the method of testing used. If the test response spectra (TRS) method was used, proceed to Section 7.1. If the required input motion (RIM) test method, such as harmonic input (sine-beat) was used, proceed to Section 7.2.

7.1 Establish the TRS used. Compare the TRS to the corresponding EHS-augmented spectra from Reference (B). If the TRS envelopes the Reference (B) spectra, the equipment/component is considered adequate; proceed to Section 8.0.

If the Reference (B) spectra exceed the TRS, proceed to calculate the augmented spectra acceleration level, S_{aEHS}, as defined in Section 6.1. Establish the qualification acceleration level for the equipment/ component from the seismic report or from the TRS by performing the SRSS of the spectral accelerations corresponding to each natural frequency of horizontal modes; denote it is S_{aT}. Compare the S_{aEHS} to S_{aT}; if $S_{aEHS} < S_{aT}$ the equipment/component is considered adequate, proceed to Section 8.0. If $S_{aEHS} > S_{aT}$ refer the case to Civil/Structural Discipline for specific evaluation and disposition.

7.2 The equipment/component is not affected since the RIM represents the upper-bound acceleration response determined by dynamic analyses at the locations of line-mounted devices or components. However, verify in accordance with Section 4, if the EHS-augmented spectra have to be incorporated in the dynamic analysis of piping system, HVAC duct and cable tray support systems.

8.0 All of the seismic Category I equipment/component shall be documented with data sheet, (Form A) completed in accordance with notes (A) through (D) stated herein, if applicable, and/or the checklist (Form B) for equipment/component.

The disposition per column (E) of Form A or per Form B shall be completed in all cases and the following code for predefined dispositions may be used:

Code	Definition of Disposition
(1)	The spectra corresponding to the installed location of equipment/component/piping are not affected by the EHS-augmented spectra, as designated by the Case (1) spectra in Table 1. Form B can be used for disposition of equipment/component.
(2)	For the installed location of the equipment/component/ piping there was no specific previous design-basis spectra. The spectra used for the seismic qualification and/or design exceed the EHS-augmented spectra which have been incorporated as the design basis; therefore, the equipment/component/piping is adequate. Form B can be used for disposition of equipment/component.
(3)	The equipment/component/piping natural frequencies are over 4 Hz*, above which there is no effect due to EHS-augmented spectra.
(4)	The equipment/component/piping natural frequencies are over 8 Hz*, above which there is no effect due to EHS-augmented spectra.
(5)	The spectral responses specifically determined from the EHS-augmented spectra at the equipment/component/ piping frequencies in the low frequency range does not exceed the design basis spectral response.
(6)	The spectral response specifically determined from EHS-augmented spectra at the equipment/component/ piping frequencies in the low frequency range exceeds the design basis response, but there is adequate margin in the existing design.

* When scrutinizing seismic qualifications performed by a test utilizing the TRS method, these frequency limits should be adopted as 5 Hz instead of 4 Hz and as 10 Hz instead of 8 Hz. These broadenings allow increase of the cut-off frequencies by at least 1/3 octave.

Code	Definition of Disposition
(7)	The equipment/component was qualified by test utilizing a TRS that envelopes the EHS-augmented spectra. Form B can be used for disposition of equipment/component.
(8)	The equipment/component was qualified by test utilizing a TRS that does not envelop the EHS-augmented spectra. However, the spectral response specifically determined from the EHS-augmented spectra at the equipment/component frequencies in the low frequency range is below the qualification acceleration level of the TRS, therefore the equipment/component is adequate.
(9)	The equipment/component is adequate since single- frequency testing with RIM which envelopes the EHS acceleration response was used. Form B can be used for disposition of equipment/component.

Other, non-predefined dispositions must be specifically stated. The case referred to Civil/Structural Discipline for specific evaluation and disposition, as well as any cased dispositioned for re-analysis or retesting, must be specifically defined.

References

(A) Floor Seismic Acceleration Response Spectra Design Basis for STPEGS listed in Bechtel Drawing Nos. 4N16-9-S39150.

(B) Floor Seismic Acceleration Response Spectra augmented by EHS SSI Analysis for STPEGS C/S Calculation No. CC-9150, Sketches No. SK C-5 thru SK C-254.

(Sheet 1 of 2)

SEISMIC CATEGORY I
EQUIPMENT COMPONENT
DATA SHEET -

Equipment (A) or System	Method of (B) Seismic Qualification	Fundmental (C) Frequencies	Qualification (D) Acceleration Level	(for notes (A) through (D) see Sheet 2) Remarks/Disposition (E)

STPEGS UFSAR
FORM A
(Sheet 2 of 2)
Notes to Attachment 1

(A) Descriptive name of equipment or system. Include weight, size, capacity, etc. as applicable, and B&R or Bechtel Specification No. and Purchase Order No.

(B) Indicate if method is by Analysis or by test.

If by Analysis, define method such as: Modal Response Spectra or Equivalent Static

If by Test indicate: Test Response Spectra, or Required Input Motion

(C) Indicate source: Analysis or test. Give numerical values, include the lower 4 or 5 frequencies, and indicate if they correspond to lateral or vertical modes.

(D) Attach all the Floor Response Spectra used for the qualification, and define the governing cases if the information is available from qualification package.

Define acceleration value for Required Input Motion or Status methods. Attach the test response spectra, when used.

FORM B
(SHEET 1 of 2)

VERIFICATION OF SEISMIC QUALIFICATION OF EQUIPMENT TO THE FLOOR RESPONSE SPECTRA AUGMENTED BY ELASTIC-HALF-SPACE (EHS) SOIL-STRUCTURE INTERACTION (SSI) ANALYSIS

Equipment Name ______________________________

Base Report Log Number ______________________________
____

Is qualification of the equipment still valid using the EHS-augmented spectra?

[ ] YES [ ] NO

Verification:

1. Qualification Method:

[ ] Analysis [ ] Test [ ] Combination

2. Seismic Input:

[ ] RIM [ ] RRS

If seismic input is RIM, see Paragraph 4 below.

3. Required Response Spectra (RRS) specified for the qualification:

[ ] (1) The EHS-modified spectra are essentially enveloped by the design-basis spectra over the whole frequency range. The instances where the EHS-modified spectra exceed the design-basis spectra are restricted to the vertical response in the RCB, for which some spectral response peaks exceed the design-basis spectra by no more than 10% at isolated frequency points of less than 5 Hz.

[ ] (2) Design-basis spectra were not previously issued for the basement locations of the Reactor Containment Building (RCB), the Mechanical-Electrical Auxiliary Building (MEAB), and the Diesel Generator Building (DGB), as well as El. 83 feet of the RCB interior structure, the pressurizer support points in the RCB, and the enveloped spectra for the power block buildings. Therefore, the EHS-modified spectra are henceforth adopted as the design basis spectra for these locations.

[ ] (3) The EHS-augmented spectra exhibit a narrow frequency band where a distinct spectral response peak exceeds the design-basis spectra. The peak is confined to the low frequency range, and in all instances the EHS-augmented spectra exceed the design-basis spectra only at frequencies below 4 Hz.

FORM B
(SHEET 2 of 2)

[ ] (4) The EHS-augmented spectra exhibit a narrow frequency band where the spectral response exceeds the design-basis spectra defined by a "valley" between two peaks of the design-basis spectra. This trait is confined to the low frequency range, below 8 Hz, and is in addition to the Case (3) trait.

[ ] (5) The EHS-augmented spectra exceed the design spectra over the wide frequency range. This case is restricted to the basement locations of the Fuel Handling Building, where a very limited number of equpment/component are housed.

a. If RRS is either (1) or (2), see Paragraph 4, below.

b. If RRS is either (3) or (4), does TRS or the response spectra used for analysis envelop the EHS-augmented spectra? (attach TRS or response spectra for anlaysis)

[ ] YES [ ] NO

If yes, see Paragraph 4 below.

c. If RRS is (5), does TRS or the response spectra used for analysis envelop Design Basis Spectra (Drawing No. 4N16-9-S-39150)? (attach TRS or response spectra for analysis)

[ ] YES [ ] NO

If yes, see Paragraph 4 below.

4. <u>The qualification is not affected by EHS-augmented spectra</u>.

5. If the above comparison of seismic input does not resolve the effects of EHS-augmented spectra, the design criteria (TPNS No. 4A010SQ1004) is followed to determine the adequacy of the qualification. (Attach all data for the determination and conclusion.)

TABLE 1

LISTING OF DESIGN BASIS SPECTRA
(Including Designation of Case Number for the EHS SSI Effects)

Description		Drawing No.	ESH-Modified Spectra Case Number
Floor Design Response Spectra			
1. REACTOR CONTAINMENT BUILDING (RCB); CONTAINMENT STRUCTURE			
At El. (-)13.25 ft.	E-W Horizontal (OBE)	4N169S-39000	(2)
	N-S Horizontal (OBE)	-39001	(2)
	Vertical (OBE)	-39002	(2)
At El. 37.0 ft	E-W Horizontal (OBE)	-39003	(4)
	N-S Horizontal (OBE)	-39004	(4)
	Vertical (OBE)	-39005	(1)
	E-W Horizontal (SSE)-39006	(3)	
	N-S Horizontal (SSE)	-39007	(4)
	Vertical (SSE)	-39008	(1)
At El. 68.0 ft.	E-W Horizontal (OBE)	-39009	(4)
	N-S Horizontal (OBE)	-39010	(4)
	Vertical (OBE)	-39011	(1)
	E-W Horizontal (SSE)	-39012	(3)
	N-S Horizontal (SSE)	-39013	(4)
	Vertical (SSE)	-39014	(1)
At El. 108.0 ft.	E-W Horizontal (OBE)	-39015	(3)
	N-S Horizontal (OBE)	-39016	(3)
	Vertical (OBE)	-39017	(1)
	E-W Horizontal (SSE)	-39018	(3)
	N-S Horizontal (SSE)	-39019	
	Vertical (SSE)	-39020	(1)
At El. 153.0 ft.	E-W Horizontal (OBE)	4N169S-39021	(3)
	N-S Horizontal (OBE)	-39022	(3)
	Vertical (OBE)	-39023	(1)
	E-W Horizontal (SSE)	-39024	(3)
	N-S Horizontal (SSE)	-39025	(3)
	Vertical (SSE)	-39026	(1)
At El. 203.75 ft.	E-W Horizontal (OBE)	-39027	(3)
	N-S Horizontal (OBE)	-39028	(3)
	Vertical (OBE)	-39029	(1)
	E-W Horizontal (SSE)	-39030	(3)
	N-S Horizontal (SSE)	-39031	(3)
	Vertical (SSE)	-39032	(1)

TABLE 1 (Continued)

LISTING OF DESIGN BASIS SPECTRA
(Including Designation of Case Number for the EHS SSI Effects)

Description		Drawing No.	ESH-Modified Spectra Case Number
2. RCB; INTERNAL STRUCTURE			
At El. 19.0 ft.	E-W Horizontal (OBE)	-39033	(3)
	N-S Horizontal (OBE)	-39034	(3)
	Vertical (OBE)	-39035	(1)
	E-W Horizontal (SSE)	-39036	(3)
	N-S Horizontal (SSE)	-39037	(3)
	Vertical (SSE)	-39038	(1)
At El. 37.0 ft.	E-W Horizontal (OBE)	-39039	(3)
	N-S Horizontal (OBE)	-39040	(3)
	Vertical (OBE)	-39041	(1)
	E-W Horizontal (SSE)	-39042	(3)
	N-S Horizontal (SSE)	4N169S-39043	(3)
	Vertical (SSE)	-39044	(1)
At El. 52.0 ft.	E-W Horizontal (OBE)	-39045	(3)
	N-S Horizontal (OBE)	-39046	(3)
	Vertical (OBE)	-39047	(1)
	E-W Horizontal (SSE)	-39048	(3)
	N-S Horizontal (SSE)	-39049	(3)
	Vertical (SSE)	-39050	(1)
At El. 68.0 ft.	E-W Horizontal (OBE)	-39051	(3)
	N-S Horizontal (OBE)	-39052	(3)
	Vertical (OBE)	-39053	(1)
	E-W Horizontal (SSE)	-39054	(3)
	N-S Horizontal (SSE)	-39055	(3)
	Vertical (SSE)	-39056	(1)
At El. 83.0 ft.	Horizontal (OBE)	4N169S-39072	(2)
	Vertical (OBE)	-39073	(2)
	Horizontal (SSE)	-39074	(2)
	Vertical (SSE)	-39075	(2)
3. MECHANICAL-ELECTRICAL AUXILIARY BUILDING (MEAB)			
At All Elevations	Vertical (OBE)	4N169S-39081	(1)
	Vertical (SSE)	-39082	(1)
At El. 95.0 ft.	E-W Horizontal (OBE)	4N169S-39147	(1)
	N-S Horizontal (OBE)	-39148	(1)
	E-W Horizontal (SSE)	-39149	(1)
	N-S Horizontal (SSE)	-39151	(1)

TABLE 1 (Continued)

LISTING OF DESIGN BASIS SPECTRA
(Including Designation of Case Number for the EHS SSI Effects)

Description		Drawing No.	ESH-Modified Spectra Case Number
At El. 96.0 ft.	E-W Horizontal (OBE)	-39152	(1)
	N-S Horizontal (OBE)	-39153	(1)
	E-W Horizontal (SSE)	-39154	(1)
	N-S Horizontal (SSE)	-39155	(1)
At El. 85.0 ft.	E-W Horizontal (OBE)	-39083	(1)
	N-S Horizontal (OBE)	-39084	(1)
	E-W Horizontal (SSE)	-39085	(1)
	N-S Horizontal (SSE)	-39086	(1)
At El. 69.5 ft.	E-W Horizontal (OBE)	-39087	(1)
	N-S Horizontal (OBE)	-39088	(1)
	E-W Horizontal (SSE)	-39089	(1)
	N-S Horizontal (SSE)	-39090	(1)
At El. 51.0 ft.	E-W Horizontal (OBE)	-39091	(1)
	N-S Horizontal (OBE)	-39092	(1)
	E-W Horizontal (SSE)	-39093	(1)
	N-S Horizontal (SSE)	-39094	(1)
At El. 35.0 ft.	E-W Horizontal (OBE)	-39095	(1)
	N-S Horizontal (OBE)	-39096	(1)
	E-W Horizontal (SSE)	-39097	(1)
	N-S Horizontal (SSE)	-39098	(1)
At El. 21.0 ft.	E-W Horizontal (OBE)	-39099	(1)
	N-S Horizontal (OBE)	-39100	(1)
	E-W Horizontal (SSE)	-39101	(1)
	N-S Horizontal (SSE)	-39102	(1)
At El. 10.0 ft.	E-W Horizontal (OBE)	-39167	(2)
	N-S Horizontal (OBE)	-39168	(2)
4. FUEL HANDLING BUILDING (FHB)			
At All Elevations	Vertical (OBE)	4N169S-39103	(1)
	Vertical (SSE)	-39104	(1)
At El. 119.0 ft.	E-W Horizontal (OBE)	-39105	(1)
	N-S Horizontal (OBE)	-39106	(1)
	E-W Horizontal (SSE)	-39107	(1)
	N-S Horizontal (SSE)	-39108	(1)

TABLE 1 (Continued)

LISTING OF DESIGN BASIS SPECTRA
(Including Designation of Case Number for the EHS SSI Effects)

Description		Drawing No.	ESH-Modified Spectra Case Number
At El. 68.0 ft.	E-W Horizontal (OBE)	-39109	(1)
	N-S Horizontal (OBE)	-39110	(1)
	E-W Horizontal (SSE)	-39111	(1)
	N-S Horizontal (SSE)	-39112	(1)
At El. 48.0 ft.	E-W Horizontal (OBE)	-39113	(1)
	N-S Horizontal (OBE)	-39114	(1)
	E-W Horizontal (SSE)	-39115	(1)
	N-S Horizontal (SSE)	-39116	(1)
At El. 30.0 ft.	E-W Horizontal (OBE)	-39117	(1)
	N-S Horizontal (OBE)	-39118	(4)
	E-W Horizontal (SSE)	-39119	(1)
	N-S Horizontal (SSE)	-39120	(4)
At El. 4.0 ft.	E-W Horizontal (OBE)	-39121	(1)
	N-S Horizontal (OBE)	-39122	(5)
	E-W Horizontal (SSE)	-39123	(1)
	N-S Horizontal (SSE)	-39124	(5)
At El.-29.0 ft.	E-W Horizontal (OBE)	-39125	(1)
	N-S Horizontal (OBE)	-39126	(5)
	E-W Horizontal (SSE)	-39127	(1)
	N-S Horizontal (SSE)	-39128	(5)
5. DIESEL GENERATOR BUILDING (DGB)			
At El. 107.0 ft.	E-W Horizontal (OBE)	4N169S-39129	(3)
	N-S Horizontal (OBE)	-39130	(3)
	Vertical (OBE)	-39131	(1)
At El. 100.0 ft.	E-W Horizontal	(OBE)-39132	(3)
	N-S Horizontal (OBE)	-39133	(3)
	Vertical (OBE)	-39134	(1)
At El. 82.0 ft.	E-W Horizontal (OBE)	-39135	(3)
	N-S Horizontal (OBE)	-39136	(1)
	Vertical (OBE)	-39137	(1)
At El. 55.0 ft.	E-W Horizontal (OBE)	-39138	(3)
	N-S Horizontal (OBE)	-39139	(1)
	Vertical (OBE)	-39140	(1)

TABLE 1 (Continued)

LISTING OF DESIGN BASIS SPECTRA
(Including Designation of Case Number for the EHS SSI Effects)

Description		Drawing No.	ESH-Modified Spectra Case Number
At El. 25.0 ft.	E-W Horizontal (OBE)	-39169	(2)
	N-S Horizontal (OBE)	-39170	(2)
	Vertical (OBE)	-39171	(2)
6. ENVELOPED FLOOR DESIGN SPECTRA FOR ALL BUILDINGS			
At All Elevations	Horizontal (OBE)	4N169S-39176	(2)
	Vertical (OBE)	-39177	(2)
	Horizontal (SSE)	-39178	(2)
	Vertical (SSE)	-39179	(2)
7. ENVELOPED FLOOR DESIGN SPECTRA FOR THE RCB			
At El. up to 153 ft.	Horizontal (OBE)	4N169S-39180	(2)
	Vertical (OBE)	-39181	(2)
	Horizontal (SSE)	-39182	(2)
	Vertical (SSE)	-39183	(2)
8. ENVELOPED FLOOR DESIGN SPECTRA FOR THE MEAB			
At All Elevations	Horizontal (OBE)	4N169S-39184	(2)
	Vertical (OBE)	-39185	(2)
	Horizontal (SSE)	-39186	(2)
	Vertical (SSE)	-39187	(2)
9. ENVELOPED FLOOR DESIGN SPECTRA FOR THE FHB			
At El. up to 68 ft.	Horizontal (OBE)	4N169S-39188	(2)
	Vertical (OBE)	-39189	(2)
	Horizontal (SSE)	-39190	(2)
	Vertical (SSE)	-39191	(2)
10. ENVELOPED FLOOR DESIGN SPECTRA FOR THE DGB			
At All Elevations	Horizontal (OBE)	4N169S-39192	(2)
	Vertical (OBE)	-39193	(2)

Question 220.10N

Discuss and provide, for staff's review, the structural details of circulating water screen house, its model for seismic analysis, assumptions used in the model definition, procedures considered in the soil-structure interaction analysis, and the results of the analysis.

Response

The STPEGS design does not include a circulating water screen house but does include a circulating water intake structure. The circulating water intake structure is not a safety-related structure. A dynamic analysis to estimate seismic loads is, therefore, not required.

Question 220.11N

You have stated that the strain-compatible shear modulus and damping values are used for each element representing soil strata. Indicate, for each layer, what strain-levels these values correspond to. Also, give numerical values of the soil properties and corresponding strains for each layer of soil. Provide this information for both horizontal and vertical analysis. In the staff's opinion the soil properties used should be those corresponding to low strain levels which are consistent with the realistic soil strains developed during the earthquake. Use of high strain parameters needs to be adequately justified.

Response

The soil conditions at the STPEGS site consist of alternating layers of stiff to hard clays and dense silts and sands that extend to depths of several thousand feet (Section 6.1 of Ref. l). The soils in the upper approximately 330 ft have been categorized into thirteen general layers and five material types (Ref. 2). The dynamic shear moduli or shear wave velocities of the in situ soils, applicable to very low shear strain (approximately 10^{-4} percent), were determined from a detailed program of cross-hole shear wave measurement at the site utilizing a down-hole impact hammer (Ref. 2). The results are shown in Figure Q220.11N-l and Table Q220.11N-1. Figure Q220.11N-1 also presents the upper bound and lower bound values of shear wave velocity that were used in the SSI analysis. The upper bound soil properties were defined by increasing values of shear modulus at very low shear strains by 50 percent (equivalent to increasing values of shear wave velocity by 22 percent); the lower bound soil properties were defined by decreasing values of shear modulus at very low shear strains by 40 percent (equivalent to decreasing values of shear wave velocity by 23 percent).

The variations of shear modulus with shear strain were determined using the data from the shear wave measurements at very low strain levels and data from laboratory dynamic tests at higher strain levels, while the variations of damping ratios with strain were obtained from laboratory dynamic tests. The laboratory testing program, the test results and the development of the modulus reduction and damping curves are presented in Reference 2. Figures Q220.11N-2 through Figure Q220.11N-7 show the variations of shear modulus and damping ratio with shear strain for each material type.

The strain-compatible dynamic soil properties for cases involving the horizontal excitation were obtained by simulating the nonlinear behavior of soils by the equivalent linear method (Ref. 3). The equivalent linear method provides an approximate nonlinear solution when the modulus and damping values used in the analysis are compatible with the effective shear strain amplitudes (The effective shear strain amplitudes were defined as 0.65 times the peak shear strain in each element.) The results of a research study (Ref. 4) indicate that the use of average modulus and damping values based on average strains (i.e., equivalent linear technique) is sufficiently accurate for seismic analysis of nuclear power plant structures.

Response (Continued)

Values of the effective shear strain for each soil layer in the free-field shown in Figure Q220.11N-l are presented in Figures Q220.11N-8, -9 and -10

for cases of average, upper-bound, and lower-bound soil properties, respectively. The shear strains developed in these analyses were low, generally ranging from about 0.4 to 1 x $l0^{-2}$ percent for upper-bound properties to 1 to 2 x 10^{-2} percent for lower-bound properties. Values of strain-compatible shear wave velocity of a soil column in the free-field and below the Reactor Building and the Auxiliary Building for the cases of average, upper-bound, and lower-bound soil properties are shown in Figures Q220.11N-11, -l2 and -13, respectively (Ref. 1). It is noted that shear wave velocities of the cohesionless soil layers below the Reactor Building are higher than those in the free-field due to higher confining pressures and lower strain levels beneath the structure than in the free-field. The soil column beneath the Auxiliary Building shown in Figures Q220.11N-11 through Q220.11N-13 includes 22 ft of structural backfill. Thus, the shear wave velocities in the upper 22 ft correspond to those of the backfill. Comparisons of the shear wave velocities of the soil column beneath the Auxiliary Building with those of the soil layers in the free-field shown in Figures Q220.11N-11 through Q220.11N-13 indicate that the values of strain-compatible shear wave velocity of the backfill are equal to or higher than those in the free-field.

As shown in Figure Q220.11N-14, for upper-bound analyses, the strain compatible shear wave velocities are about equal to the very-low-strain (approximately 10^{-4} percent) shear wave velocities measured in the field. Therefore, the analyses for horizontal excitation have essentially included cases using very-low-strain soil properties.

Values of damping ratio for the cases of average, upper-bound, and lower-bound soil properties are presented in Figure Q220.11N-15, -16, and -17, respectively (Ref. 1). In all cases, damping ratios of the soil layers beneath the structures are lower than those in the free-field due to lower strain levels beneath the structures. Damping ratios are generally small, equal to or less than about 0.06 for cases of upper-bound soil properties.

For cases involving vertical excitation, the dynamic soil properties were selected such that they would be compatible with the measured compression wave velocities at the site (Ref. 1). The compression wave velocity between depths of approximately 5 to 80 ft was about 5,500 ft/sec. Between depths of approximately 80 to 400 ft, the compression wave velocity was about 6,000 ft/sec. In the upper 5 ft of the soil profile (above the water table), values of compression wave velocity for vertical excitation were selected using the strain-compatible moduli obtained from the analysis for horizontal excitation. The variation of the compression wave velocities with depth is shown in Figure Q220.11N-18 (Ref. 1). These compression wave velocities were used as a basis for assigning constant (strain-independent) moduli, since compression strains developed during vertical excitation were very small, indicating that there would be little tendency for reduction in modulus. Note that the strain-compatible damping ratios from the corresponding cases for horizontal excitation were used for the cases involving vertical excitation (Ref. 1).

REFERENCES to Q220.1lN

1. Woodward-Clyde Consultants (1976), "Soil-Structure Interaction Studies, STPEGS, Units 1 & 2", Report prepared for Brown & Root, Inc.

2. Woodward-Clyde Consultants (1975), "Basic Soil Data: STPEGS", Report prepared for Brown & Root, Inc.

3. Seed, H. B. and I. M. Idriss, "The Influence of Soil Conditions on Ground Motions During Earthquakes", Journal of Soil Mechanics and Foundation Division ASCE, Vol. 94, No. SM 1 (1969), pp. 99-139.

4. D'Appolonia Consulting Engineers, Inc. (1979), "Seismic Input and Soil-Structure Interaction", Report prepared for the U.S. Nuclear Regulatory Commission, NUREG/CR-0693.

TABLE Q220.11N-1

MATERIAL PROPERTIES OF IN SITU SOILS
HORIZONTAL ANALYSIS CASES FOR AVERAGE PROPERTIES***

Soil Layer ID	Sublayer Number	Depth Range (ft)	Material Type Number	Average Shear Wave Velocity Vs * (fps)	Maximum** Shear Modulus, G_{max} (ksf)	Modulus Reduction and Damping Curves (Figure Number)	Total Unit Weight, t (pcf)	Poisson's Ratio, 1
	1	0-6	1	610	1329	6	115	0.42
A	2	6-11	1	610	1444	6	125	0.42
	3	11-16	1	625	1516	6	125	0.42
	4	16-22	1	790	2423	6	125	0.42
	5	22-29.5	2	900	3144	7	125	0.42
B	6	29.5-36.5	2	910	3215	7	125	0.42
C	7	36.5-44	3	910	3215	8	125	0.35
	8	44-50	4	840	2761	9	126	0.42
D	9	50-59.5	4	1150	5175	9	126	0.42
	10	59.5-70.5	3	1150	5175	8	126	0.35
E	11	70.5-81.5	3	1160	5265	8	126	0.35
	12	81.5-91	4	1280	6564	9	129	0.42
F	13	91-100	4	1280	6564	9	129	0.42
	14	100-109	4	1220	5963	9	129	0.42
	15	109-119.5	4	1460	8540	9	129	0.42
H	16	119.5-132	3	1560	9674	8	128	0.35
	17	132-172	5	1229	5909	10	126	0.42
J	18	172-212	5	1173	5384	10	126	0.42
K	19	212-232	3	1541	9581	8	130	0.35

TABLE Q220.11N-1 (Continued)

MATERIAL PROPERTIES OF IN SITU SOILS
HORIZONTAL ANALYSIS CASES FOR AVERAGE PROPERTIES***

Soil Layer ID	Sublayer Number	Depth Range (ft)	Material Type Number	Average Shear Wave Velocity Vs * (fps)	Maximum** Shear Modulus, G_{max} (ksf)	Modulus Reduction and Damping Curves (Figure Number)	Total Unit Weight, t (pcf)	Poisson's Ratio, 1
L	20	232-281	5	1271	6431	10	128	0.42
M	21	281-291	3	1520	8969	8	125	0.35
N	22	291-331	5	1324	6915	10	127	0.42
--	23	331-346	3	1585	9758	8	125	0.35

* Refer to Figure Q220.11N-1 for plot of field shear wave velocity data obtained at Units 1 and 2.

** "Maximum" denotes shear modulus at very low shear strain levels (i.e. approx. 10^{-4} percent). The values of maximum shear modulus shown in the table correspond to the values of average shear wave velocity shown in the table.

*** From Table C.2-1 of Ref. 12

(G) Material type number is used to refer to a specific variation of modulus with strain (i.e. modulus reduction curves) and damping with strain shown in Figures Q220.11N-2 through Q220.11N-7.

Figure Q220.11N-1

Figure Q220.11N-2

Figure Q220.11N-3

Figure Q220.11N-4

Figure Q220.11N-5

Figure Q220.11N-6

Figure Q220.11N-7

Figure Q220.11N-8

Figure Q220.11N-9

Figure Q220.11N-10

Figure Q220.11N-11

Figure Q220.11N-12

Figure Q220.11N-13

Figure Q220.11N-14

Figure Q220.11N-15

Figure Q220.11N-16

Figure Q220.11N-17

Figure Q220.11N-18

Question 220.13N

To account for the effect of accidental torsion, NRC staff's position requires that an additional eccentricity of 5 percent of the maximum building dimension at the level under consideration shall be assumed over the actual geometrical eccentricity of Category I structures. Copy of revised SRP 3.7.2 (Attachment 2) is provided for your reference. Confirm that this staff position is fully complied with in your Category I structural design and analysis.

Response

The additional 5 percent eccentricity was not included in the initial design, only the actual geometric eccentricity between the center of mass and the center of rigidity was considered in the initial seismic analyses. Subsequent analyses for Category I structures have been performed to account for the effect of accidental torsion in accordance with the NRC position. The results of the confirmatory analyses summarized in Table 220.13N-1 indicate that the existing design of all Category I structures is adequate.

TABLE Q220.13N-1

RESULTS OF THE CONFIRMATORY ANALYSES -

Building/Structure Description of Key Shear Walls	Calculated Shear Force, k/ft., 5% Accidental Torsion: Excluded	Calculated Shear Force, k/ft., 5% Accidental Torsion: Included	Allowable, Shear Load, k/ft. Concrete Alone, No Reinforcing	Reinforcement For In-Plane Shear Sq.-in./ft. Required: Vertical	Reinforcement For In-Plane Shear Sq.-in./ft. Required: Horizontal	Reinforcement For In-Plane Shear Sq.-in./ft. Available: Vertical	Reinforcement For In-Plane Shear Sq.-in./ft. Available: Horizontal
Reactor Containment Building (RCB)							
Primary Shield Walls							
El. (-) 13'-3" to 12'-1"	128	130	290	None	None	-	-
12'-1" to 19'-0"	246	249	422	None	None	-	-
19'-0" to 38'-6 1/2"	332	334	390	None	None	-	-
Secondary Shield Walls							
Southwest, El. (-) 5'-3"	122	124	125	None	None	2.6	7.6
North, El. (-) 5'-3"	443	445	179	4.42	4.42	5.2	7.6
Containment Shell							
El. (-) 13'-3" (basement)	38	40	138	None	None	2.1	1.7
El. 38'-9"	31	33	0	None	0.84	2.8	0.90
El. 74'-9"	25	27	0	None	0.44	2.8	0.90
El. 133'-0" (Springline)	8.8	9.7	151	None	None	2.8	1.5

Building/Structure Description of Key Shear Walls	Calculated Shear Force, k/ft., 5% Accidental Torsion: Excluded	Calculated Shear Force, k/ft., 5% Accidental Torsion: Included	Allowable, Shear Load, k/ft. Concrete Alone, No Reinforcing	Reinforcement For In-Plane Shear Sq.-in./ft.: Required	Reinforcement For In-Plane Shear Sq.-in./ft.: Provided
Mechanical Electrical Auxiliary Building (MEAB)					
East Exterior Wall El. 10'-0"	72	78	86	1.03 (Min.)	1.60
North Exterior Wall El. 35'-0"	59	66	75	0.90 (Min.)	1.60
East Exterior Wall El. 60'-0"	22	24	75	0.90 (Min.)	1.60

TABLE Q220.13N-1 (Continued)

RESULTS OF THE CONFIRMATORY ANALYSES

Building/Structure Description of Key Shear Walls	Calculated Shear Force, k/ft., 5% Accidental Torsion		Allowable, Shear Load, k/ft. Concrete Alone, No Reinforcing	Reinforcement For In-Plane Shear Sq.-in./ft.	
	Excluded	Included		Required	Provided
East Exterior Wall El. 80'-0"	19	21	75	0.90 (Min.)	1.60
Fuel Handling Building (FHB)					
East Exterior Wall El. (-) 29'-0" to 4'-0"	135	153	85	1.30	2.40
North Exterior Wall El. (-) 29'-0" to 4'-0"	184	198	46	2.90	3.10
South Exterior Wall El. 21'-11" to 30'-0"	124	130	62	1.30	1.70
South Exterior Wall El. 4'-0" to 21'-11"	140	142	62	1.60	1.70
South Exterior Wall El. 68'-0" to 119'-0"	114	119	46	1.40	1.60
Diesel Generator Building (DGB)					
West Exterior Wall El. 25'-0" to 55'-0"	30	35	58	0.72 (Min)	1.60
South Exterior Wall El. 25'-0" to 55'-0"	80	81	55	0.72 (Min)	1.60
Essential Cooling Water Intake Structure (EWIS)					
East Exterior Wall El. 10'-0"	37	42	31	0.72 (Min)	1.20
West Exterior Wall El. 34'-0"	47	54	46	1.08 (Min)	1.20

TABLE Q220.13N-1 (Continued)

RESULTS OF THE CONFIRMATORY ANALYSES

Building/Structure Description of Key Shear Walls	Calculated Shear Force, k/ft., 5% Accidental Torsion		Allowable, Shear Load, k/ft. Concrete Alone, No Reinforcing	Reinforcement For In-Plane Shear Sq.-in./ft.	
	Excluded	Included		Required	Provided
North and South Exterior Wall El. 34'-0"	41	47	46	1.08 (Min)	1.20
Interior Wall East to West El. 10'-0"	32	33	31	1.08 (Min)	1.20

Question 220.15N

When seismic Category I piping is directly connected to the nonseismic Category I piping, confirm that the attached nonseismic Category I piping, up to the first anchor beyond the interface, are designed in a manner that earthquake of SSE intensity will not cause failure of seismic Category I piping.

Response

In the case described above, the nonseismic Category I piping up to the first anchor beyond the interface is seismically analyzed and designed with the seismic Category I piping to withstand an Safe Shutdown Earthquake (SSE) level earthquake.

Question 220.16N

The analysis procedures used for composite damping calculation seem not consistent with those of the SRP Section 3.7.2.II.15. Discuss the basis for your deviation and justify the adequacy of the method used.

Response

The approach described in UFSAR Section 3.7.3.15 is conservative, since the lowest element damping is arbitrarily assigned to all elements through the uniform damping assignment to all modes. The damping values based on testing programs were not used in the dynamic analysis of piping systems except in the case of the Reactor Coolant Loop.

Question 220.22N

Has buckling been considered in design of containment building? If yes, provide a discussion of the manner with which the adequacy of the building design is assured.

Response

Because of the massive dimensions of the containment shell (4-ft wall and 3-ft dome) and the relative magnitude of compressive stresses, buckling is not considered to be a possible mode of failure for the Reactor Containment Building.

Question 220.25N

State if the concrete is assumed to be cracked under any load combination involving axisymmetric and non-axisymmetric loadings. If so, by what method have you considered the cracking and the basis thereof?

Response

The structural analyses for the determination of design moments, forces, and shears under all loads are performed on the basis of linear elastic analysis. Nonlinear analyses involving iterative processes to account for concrete cracking are not used under any load combination involving axisymmetric or nonaxisymmetric loadings. The cracking of concrete is considered in the design of the individual concrete sections, for which the amount of reinforcing steel is provided without relying on the concrete to resist any tension. For the design of reinforced concrete sections under thermal loading, the state-of-stress under nonthermal loads is determined first, and if necessary, the reductions in thermal stresses are calculated based on concrete cracking, reinforcement yielding (within allowable limits), compatibility of state-of-stress and strain, and boundary conditions. The foregoing reductions of thermal stresses operate on the design loads calculated by linear elastic analyses, and do not represent nonlinear iterative analyses devised to account for concrete cracking.

Question 220.28N

In Section 3.8.1.5.1.1 of FSAR it is mentioned that allowable stresses may be increased by 33-1/3 percent when temperature effects are combined with other loads. SRP Section 3.8.1.II.5 requires that no 1/3 increase in allowable stresses is permitted for load combinations including OBE or wind loads. Please confirm that this position has been fully complied with or justify the deviation.

Response

The one-third allowable stress increase referred to in UFSAR Section 3.8.1.5.1.1 pertains exclusively to the case when the loading combination includes thermal loads. The design of the reinforcement for the STPEGS Reactor Containment Building could rely on the one-third allowable stress increase only when thermal loads are present in combination with Operating Basis Earthquake (OBE) and wind loads.

Question 220.29N

Confirm that the materials of construction are in accordance with Article CC-2000 of ASME-ACI 359 Code, augmented by Regulatory Guide 1.103, 1.107 and 1.136. If not, identify the deviations and justify same.

Response

The materials of construction for the containment are in accordance with Article CC-2000 of the ASME-ACI 359 Code. As stated in Section 3.12, STPEGS conforms with Regulatory Guide (RG) 1.103. RG 1.107 is not applicable to STPEGS since the Containment does not use grouted tendons. RG 1.136 is not applicable to STPEGS due to its implementation date.

Question 220.30N

The staff presently accepts the use of ACI-349 as augmented by Regulatory Guide 1.142 in the design of Category I concrete structures other than containment. FSAR Sections 3.8.3, 3.8.4, and 3.8.5 have mentioned the use of ACI-318 Code for Concrete Structure. Evaluate and assess the impact of using ACI-349 as augmented by Regulatory Guide 1.142. Identify specific deviations from the staff position and the areas where use of ACI-318 Code results in less conservative design. Also discuss specific means for disposition of these less conservative design areas or justify their design adequacy.

Response

The only significant difference between the ACI-318 and ACI-349 codes is in the load combination equations. The STPEGS load combinations comply with the Standard Review Plan (SRP) requirements, which are the same as the ACI-349 loading combinations as modified by RG 1.142. Therefore, the STPEGS structural design satisfies the current NRC acceptance criteria.

Other differences are:

1. Provisions regarding quality assurance (QA)

2. Provisions of Appendix A, B, and C of the ACI-349 Code (these appendices are not included in the ACI-318 Code).

With regard to Item 1, STPEGS criteria require compliance with the applicable QA requirements including 10CFR50 Appendix B which is referenced in ACI-349, and no discrepancy arises with respect to the ACI-349 Code.

With regard to item (2), the STPEGS criteria for thermal considerations and for impulsive and impactive effects are the same as, or more conservative than those prescribed in the Code in Appendix A and Appendix C, respectively.

With regard to Appendix B of the Code, the STPEGS design criteria differs from the Code provisions in the following respects:

a) For the welded anchor studs of standard embedded plates used for miscellaneous supports, and for ductile-type undercut expansion anchors (Drillco Maxibolts), the interaction equation prescribed by the STPEGS criteria for combined tension and shear is:

$$\frac{t}{T}^{5/3} = \frac{s}{S}^{5/3} \leq 1.0$$

Response (Continued)

instead of the linear equation implied by the Code (Subsection B.6.3.2):

$$\frac{t}{T} + \frac{s}{S} \leq 1.0$$

where:

t, s = design tension load and shear load, respectively
T, S = allowable tension load and shear load, respectively (allowable leads based on ultimate loads)

b. For grouted rock-bolts (Williams), the interaction equation prescribed by the STPEGS criteria for combined tension and shear is:

$$\left(\frac{t}{T}\right)^2 + \left(\frac{s}{S}\right)^2 \leq 1.0$$

instead of the linear equation implied by the Code.

c. Anchor bolts for certain applications are allowed to be provided with embedment lengths that result in ultimate load capacities that satisfy the required design load with the prescribed load factors, but do not necessarily satisfy the generic Code provision to develop the full tensile strength of the steel bolts, implied in Subsection B.4.2.

Discussion

Items a and b

The foregoing interaction equation (with 5/3 and 2.0 exponents) are allowed by the STPEGS criteria only for the cases where the tension and shear ultimate loads of the stud/bolts represent ductile behavior governed by the steel material strength. For the Maxibolts, the hole drilled into the concrete is undercut (conically enlarged in diameter at its base) in order to provide a positive mechanical anchorage for the expanded head of the bolt. This positive anchorage, plus the prescribed deep embedment and wide separation between bolts, preclude slippage and/or concrete cone failure so that the full strength of the steel bolt is invariably developed as demonstrated by tests. Similarly, for the rock-bolts, the combination of an effective head expanded by torquing upon initial installation, followed by grouting by injection of a high-strength non-shrink mix through an axial hole in the bolt, plus the prescribed deep embedment, assures the development of the full strength of the steel bolts. That means that the concrete ultimate load capacities, which are calculated in accordance with the ACI-349 code for the above bolts with a specific embedment and spacing, exceed and fully develop the steel material ultimate load of the bolts. Therefore, in these cases the relevant interaction mechanism is that

Response (Continued)

applicable to steel bolts as opposed to the interaction associated with concrete anchorage or cone failure represented by the linear interaction. For steel studs in concrete the ultimate load capacities and interaction behavior have been extensively evaluated by tests as reported in References (1) and (3), where the interaction equation with 5/3 exponents is recommended. For steel bolts the interaction behavior recognized by the AISC in Reference (2) is defined by an elliptical relationship which is equivalent to the interaction equation with an exponent of 2.0. It is noted that the interaction equation with exponents of 2.0 (AISC) is the upper bound analytical expression derived from tests, and it envelops the more conservative equation with 5/3 exponents.

The foregoing approach, whereby the implied linear interaction is recognized for the design of anchor studs/bolts which are proportioned to fully develop the steel material strength so that slippage and/or concrete cone failure do not govern, is also mentioned in Reference (3). In this reference paper the elliptical shear/tension interaction is recognized as valid, but it is conditionally recommended for the reassessment of existing designs rather than for generic use in new designs. This is actually the case for the STPEGS since the designs affected by the elliptical interactions equations are mostly the earlier designs based on the original STPEGS criteria established prior to the ACI-349 Code. The subsequent new designs for embedded plate anchors performed by Bechtel are in accordance with the Code.

For the cases of anchor studs/bolts where the concrete ultimate load capacity governs because of allowed reductions in embedment and/or spacing, the STPEGS criteria reverts to the linear interaction equation implied by the ACI-349 Code.

Therefore, based on the foregoing clarifications and on consideration of Reference (3), it is regarded that the interaction equations as prescribed by the STPEGS criteria are adequate to assure the structural integrity of the anchor studs/bolts under combined tension and shear, and are consistent with an interpretation of the Code supported by the ASCE paper of Reference (3).

References

1. Design Data 10 - Embedment properties of headed studs by TRW, Nelso Division, 1977. (Refer to section 1.0 and 6.0, and references cited therein).

2. Commentary on the specification for the design, fabrication and erection of structural steel for buildings, AISC, November 1, 1978. (Refer to subsection 1.6.3).

3. State-of-the-art report on steel embedments, by ASCE Nuclear Structures and Materials Committee, June 1984. (Refer to subsection 3.3.3.2 and 4.1.2.3).

Item c

In some instances, the anchor bolt size (diameter) provided for equipment mounting is based on the bolt hole size specified in the equipment manufacturer drawings. The resultant bolt size is verified by the STPEGS engineer to be adequate for the calculated design loads, and the bolt anchorage into the concrete (as governed by the bolt embedment, spacing and head or anchor plate at the end of the bolt) is designed to satisfy the calculated design loads. Often in these cases the bolt size as derived from the manufacturer's standardized drawing is actually oversized with respect to the calculated loads. Therefore, it is not necessary to extend the overdesign into the bolt anchorage by attempting to fully develop the ultimate tensile strength of bolts whose function does not demand loads close to the ultimate load range.

In these cases of oversized bolts, it is considered sufficient to design the bolt anchorage (using the ACI-349 Code formulations) to develop the calculated factored design load for the specific bolts rather than to develop the generic bolt ultimate load.

In view of the above discussion, the design procedures and construction practices used in the STPEGS ensure that the structures are adequate for the specified conditions prescribed by the current NRC criteria.

In accordance with the request made during the NRC structural audit, the impact of the NRC positions as stated in RG 1.142 has been evaluated. The following table compares the NRC and STPEGS positions on the twelve items included in RG 1.142.

TABLE Q220.30N-1

STPEGS POSITIONS ON REGULATORY GUIDE 1.142 "SAFETY-RELATED CONCRETE STRUCTURES FOR NUCLEAR POWER PLANTS (OTHER THAN REACTOR VESSELS AND CONTAINMENTS)" -

1. Structures required to withstand pressures and to maintain a certain degree of leak-tightness during operating and accident conditions will be reviewed in accordance with specific provisions of Standard Review Plan 3.8.3.	1. The requirements for leak-tightness specified to Standard Review Plan 3.8.3 are applicable to PWR ice-condenser containment internal structures and to BWR containment internal structures, and therefore are not applicable to STPEGS, which has PWR dry containment internal structures.
2. When concrete structures are used to provide radiation shielding, provisions of ANSI/ANS 6.4-1977 (see Appendix A) are applicable to the extent that they enhance the radiation shielding function of these structures. Reduction in shielding effectiveness due to embedment, penetrations, and openings should be fully evaluated.	2. Concrete structures which are used as radiation shields are analyzed for shielding effectiveness utilizing the methods addressed in Section 12.3. Reductions of shielding effectiveness such as shielding discontinuities, penetrations and opening (e.g., doors and access hatches), are reviewed for impact on radiation dose rate zoning. Additional shielding in the form of penetration seals or labyrinths is provided as necessary to ensure operating personnel exposures are maintained ALARA.
3. The Code lacks specific requirements to ensure the ductility of concrete moment frames. Adherence to the requirements of Appendix A to ANSI/ACI 318-77 is acceptance.	3. The STPEGS Category I structures do not utilize concrete moment frames, and therefore this position is not applicable to STPEGS design.
4. In addition to the requirements of Section 1.3.1 of the Code, the inspectors should have sufficient experience in reinforced and prestressed concrete practice as applied to the construction of nuclear power plants. The examiners/ inspectors qualified to Appendix VII of Section III, Division 2, of the ASME Boiler and Pressure Vessel Code (ACI 359) are acceptable as inspectors.	4. Inspectors involved with concrete related work on the STPEGS are qualified in accordance with ANSI N45.2.6, "Qualifications of Inspection, Examination and Testing personnel for Nuclear Power Plants," a widely accepted standard in nuclear construction.

TABLE Q220.30N-1 (Continued)

STPEGS POSITIONS ON REGULATORY GUIDE 1.142 "SAFETY-RELATED CONCRETE STRUCTURES FOR NUCLEAR POWER PLANTS (OTHER THAN REACTOR VESSELS AND CONTAINMENTS)"

5. In lieu of the frequency of compressive strength testing required by Section 4.3.1 of the Code or that required by ANSI N45.2.5 as endorsed by Regulatory Guide 1.94, the following is acceptable: Samples for strength tests of concrete should be taken at least once every shift for each class of concrete placed or at least once for each 100 cu yd of concrete placed. When the standard deviation for 30 consecutive tests of a given class is less than 600 psi, the amount of concrete placed between tests may be increased by 50 cu yd for each 100 psi the standard deviation is below 600 psi, except that the minimum testing rate should not be less than one test for each shift when concrete is placed on more than one shift per day or less than one test for each 200 cu yd of concrete placed. The test frequency should revert back to each 100 cu yd placed as soon as the test data of any 30 consecutive tests indicate a higher standard deviation than the value controlling the decreased test frequency.	5. Concrete for the STPEGS is tested every 100 cu yds (or at least once a day during production). This test frequency meets or exceed both ACI 318 and ANSI N45.2.5 requirements. The provisions to reduce testing frequencies outlined in this position have not be exercised.
6. The load factors used in Section 9.3.1 of the Code are acceptable to the staff except for the following: a. In load combination (9), (10), and (11), $1.3T_o$ should be used in place of $1.85T_o$.	6. The load combinations and the associated load factors used in the STPEGS design meet the minimum requirements specified in Standard Review Plan Sections 3.8.3 and 3.8.4 and therefore are consistent with the

TABLE Q220.30N-1 (Continued)

STPEGS POSITIONS ON REGULATORY GUIDE 1.142 "SAFETY-RELATED CONCRETE STRUCTURES FOR NUCLEAR POWER PLANTS (OTHER THAN REACTOR VESSELS AND CONTAINMENTS)"

b. In load combination (6), $1.5P_a$ should be used in place of $1.25P_a$.

c. In load combinations (7), $1.25P_a$ and $1.25E_o$ should be used in place of $1.15P_a$ and $1.15E_o$, respectively.

d. In load combination (2), and (10), $1.9E_o$ and $1.4E_o$ should be used in place of $1.7E_o$ and $1.3E_o$, respectively.

modifications to the load factors outlined in this position.

7. When the lateral and vertical pressures of liquids are due to the normal groundwater variation in the soil surrounding the structure, the load factors of H loading of Section 9.3.1 should be applied to these forces or their related internal moments and forces.

7. In the STPEGS design, the load factors used to computer the water pressure resulting from the groundwater table are, as a minimum, those applicable to the dead load of the structure. The design water table used to calculate hydraulic forces on structures which extend below the water table is based on a high water table elevation. Since the unit weight of water is well defined and the design is based on the high water table elevation corresponding to 1 foot below grade, the groundwater loads are actually defined with a high level of certainty and are not subject to adverse variation. Therefore the load factors applicable to well defined loads, such as dead load, are considered appropriate.

8. In Section 9.3.2 the effects of differential settlement should be included in load combinations (1) through (11).

8. In the STPEGS design, the effects of differential settlement would have been included, had significant differential settlement been anticipated. However, the natural soild and Category I backfill, which support all Category I structures, have been

TABLE Q220.30N-1 (Continued)

STPEGS POSITIONS ON REGULATORY GUIDE 1.142 "SAFETY-RELATED CONCRETE STRUCTURES FOR NUCLEAR POWER PLANTS (OTHER THAN REACTOR VESSELS AND CONTAINMENTS)"

	investigated and evaluated to ensure that differential settlements within structures will remain within tolerable limits. As part of an ongoing program, settlement in the structures is monitored to ensure that this is the case. Differential settlements within structures observed to date are considered negligible.
9. The consideration of loads due to pool dynamics for the concrete structures in pressure-suppression containments will be evaluated on a case-by-case basis.	9. Because STPEGS does not utilize pressure-suppression contain-ments, this position is not applicable to the STPEGS design.
10. The local exceedance of section strengths in accordance with Appendix C of the code is acceptable in analyses for impactive or impulsive effects of Y_r, Y_j, and Y_m in load combinations (7) and (8), and those of tornado-generated missiles in load combination (5) except for the following: a. The deformation and degradation of the structure resulting from such an analysis will not cause loss of function of any safety-related structures, systems, or components. b. The section strengths should be adequate to satisfy these load combinations without the impactive or impulsive.	10. The STPEGS design is in compliance with this position.

TABLE Q220.30N-1 (Continued)

STPEGS POSITIONS ON REGULATORY GUIDE 1.142 "SAFETY-RELATED CONCRETE STRUCTURES FOR NUCLEAR POWER PLANTS (OTHER THAN REACTOR VESSELS AND CONTAINMENTS)"

c. In Section C.3.4, the permissible ductility ratios (u) when concrete structure is subjected to a pressure pulse due to compartment pressurization or external explosion (blast) loading should be as follows: 1) For the structure as a whole u ≤1.0. 2) For a located area in the structure u ≤3.0.	
d. In Section C.3.7, where shear controls the design, the permissible ductility ratios should be as follows: 1) When shear is carried by concrete alone, u ≤1.0. 2) When shear is carried by combination of concrete and stirrups or bent bars, u ≤1.3.	
11. The local exceedance of section strengths in accordance with Appendix C of the Code is also acceptable under the impactive and impulsive loadings associated with aircraft impact, turbine missiles, and a localized pressure transient during an explosion, subject to the applicable exceptions of regulatory position C.10.	11. The STPEGS design is consistent with this position.
12. The generic criteria of Appendix A "Thermal Consideration", of the Code are acceptable for the analysis of structures under T_o and T_a.	12. The STPEGS design considers thermal effects for Category 1 reinforced concrete structures. In general, the OPTCON computer code is used for determining the thermal effects on the design of reinforced concrete sections.

TABLE Q220.30N-1 (Continued)

STPEGS POSITIONS ON REGULATORY GUIDE 1.142 "SAFETY-RELATED CONCRETE STRUCTURES FOR NUCLEAR POWER PLANTS (OTHER THAN REACTOR VESSELS AND CONTAINMENTS)"

	Even though the method outlined in Appendix A of the ACI 349 code has not been used, OPTCON reflects the state-of-the-art methodology in reinforced concrete design, incorporating an equally acceptable procedure for computing the thermal effects. OPTCON is one of the modules of the Bechtel Structural Analysis Program, Post Processor described in Appendix 3.8.A. (Refer to the response to Q220.25N for a more detailed discussion on the consideration of cracked sections in the STPEGS structural analysese.)

Question 220.32N

The Fuel-Handling Building contains a spent fuel pool. A copy of "Minimum Requirements for Design of Spent Fuel Racks" is enclosed (Attachment 3). Provide the information as required and discuss your compliance with this position.

Response

HL&P has evaluated the long term need for increased spent fuel storage at STPEGS through the use of higher density spent fuel racks and decided to purchase higher density racks, these new racks will comply with Appendix D to Standard Review Plan (SRP) 3.8.4.

The present racks will be used only for the initial fuel delivery, low-power testing and the early part of Cycle 1. The analysis of these 14-in. center-to-center spent fuel racks was performed using the load combinations and acceptance limits outlined in Table Q220.32N-1 (attached). These load combinations and acceptance limits are taken from the paper "OT Position for Review and Acceptance of Spent Fuel Storage and Handling Applications", dated April 14, 1978, with modifications dated January 18, 1979, and have been used consistently by Westinghouse for the evaluation and recent license amendments for spent fuel racks at other plants.

The load combinations and acceptance limits for the seismic and thermal loads are from the table on page IV-6 of the January 18, 1979 modifications. The load combinations for the stuck fuel incident and the fuel drop accident are taken from the text of the paper. Although these load combinations and acceptance limits are not exactly the same as those stated in Appendix D of SRP 3.8.4, the intent of Appendix D has been met.

TABLE Q220.32N-1

STORAGE RACK LOADS AND LOAD COMBINATIONS -

Load Combination	Acceptance Limit
D + L	Normal Limits of NF 3231.1a
D + L + P_f	Normal Limits of NF 3231.1a
D + L + E	Normal Limits of NF 3231.1a
D + L + T_o	Lesser of $2S_y$ or S_u stress range
D + L + T_o + E	Lesser of $2S_y$ or S_u stress range
D + L + T_a + E	Lesser of $2S_y$ or S_u stress range
D + L + T_o + P_f	Lessor of $2S_y$ or S_u stress range
D + L + T_a + E'	Faulted condition limits of NF 3231.1c (see Note 3)
D + L + F_d	The functional capability of the fuel racks shall be demonstrated

1. The abbreviations in the table above are those used in Standard Review Plan (SRP) Section 3.8.4 where each term is defined except for T_a, which is defined here as the highest temperature associated with the postulated abnormal design conditions. F_d is the force caused by the accidental drop of the heaviest load from the maximum possible height, and P_f is the upward force on the racks caused by a postulated stuck fuel assembly.

2. The provisions of NF-3231.1 of ASME Section III, Division I, shall be amended by the requirements of Paragraphs c.2, 3, and 4 of Regulatory Guide 1.124, entitled "Design Limits and Load Combinations for Class A Linear-Type Component Supports".

3. For the faulted load combination, thermal loads were neglected when they are secondary and self-limiting in nature and the material is ductile.

Question 220.33N

With regard to your submittal on masonry walls (Reference letter from G. W. Oprea to D. G. Eisenhut, dated September 4, l980) the following information is requested.

The staff has established a position on the evaluation of safety-related masonry walls. A copy of this position is attached herewith (Attachment 4) for your assessment of masonry wall design at South Texas Project. Compare the staff's criteria with the criteria which you used in the design of STPEGS masonry walls. Identify and provide justification for all deviations from the staff's criteria. The justification provided should be based on experimental tests and/or analytical considerations, as appropriate.

Specific questions on the submittal with the above reference are as follows:

(1) Provide detailed calculations for three representative masonry walls at least one wall being of multiwythe construction if any and one in the Reactor Building which experience all the loads identified in Attachment 2 and 3 of the enclosure to your letter of September 4, 1980. If there are walls which experience loads such as LOCA, and thermal, as indicated in the Attachment 2 and 3 referenced above, provide detailed calculations for one of these walls also. The calculations should identify all the load and load combinations. Provide response spectra and damping values used. Also provide details and the actual mechanism in the field.

(2) Submit the examples with discussion on:

   (a) The effects of three components of earthquake loading

   (b) The mechanism through which composite action of multiwythe walls (if any) is assumed to occur

   (c) Seismic drifts effects

   (d) Attachment of walls to the columns and floors to demonstrate the adequacy of the assumptions used in analysis

Response

Safety-related concrete masonry unit (CMU) walls are not planned to be used inside any of the seismic Category I structures. If safety-related CMU walls are determined to be necessary, the walls will be designed in conformance with the referenced evaluation criteria (Standard Review Plan [SRP] Section 3.8.4 Appendix A), refer to revised Section 3.8.4.4. Therefore, the requested information describing deviations from the staff's criteria and sample calculations are not considered necessary since presently on STPEGS there are no safety-related CMU walls.

Question 220.34N

Prepare for the structural design audit scheduled for the week of January 11, 1982 by completing the design audit forms (Attachment 5) before the audit date. The subject of structural design audit is discussed in Appendix B to SRP Section 3.8.4 (Attachment 6).

Response

The structural design audit forms were transmitted by letter to Mr. Thomas Novak on June 30, l983 (Correspondence serial number ST-HL-AE-967). A revision to the structural design audit forms were transmitted by letter to Mr. Thomas Novak on December 19, 1984 (Correspondence serial number ST-HL-AE-1162). The stresses at key sections of Containment shell and mat are given in Table 3.8.1-7. Governing stress ratios for principal steel members are given in Table 3.8.3-4.

Question 110.2

Subparagraph NCA-1130(b) of the ASME B&PV Code Section III requires non-code mechanical or electromechanical devices such as valve operators to be covered by the code when these devices act as component supports. Provide a commitment to insure that the design of devices which become attachment points for component supports, thus providing component support load path, will adequately consider these support loadings.

Response

The STPEGS does not currently use devices such as valve structures as supports, restraints, or attachment points for supports and restraints. However, should such devices be used in this manner, the design of these devices will adequately consider all support loadings.

Question 110.3

Describe the allowable buckling loads for Class 1, 2 and 3 component supports subjected to normal, upset, emergency, and faulted load combinations.

Response

For normal, upset, emergency, and faultd conditions, all Class 1, 2, and 3 component supports are designed in accordance with the criteria as specified in Subsection NF or ASME Section III.

Question 110.4

Provide the basis for selecting the location, required load capacity, and structural and mechanical performance parameters of safety-related hydraulic snubbers in order to achieve a high level of operability assurance, including:

1. A description of the analytical and design methodology utilized to develop the required snubber locations and characteristics.

2. A discussion of design specification requirements to assure that required structural and mechanical performance characteristics and product quality are achieved.

3. Procedures, controls to assure correct installation of snubbers and checking the hot and cold settings during plant start-up tests.

4. Provisions for accessibility for inspection, testing, and repair or replacement of snubbers.

Response

The only application of hydraulic snubbers is for the upper support structures for the steam generators. Appropriate preliminary design stiffnesses for these supports (as well as stiffnesses for all other Reactor Coolant System [RCS] supports) are included in the reactor coolant loop model so that loads can be generated at all support locations for all applicable loading conditions. Loads at the steam generator upper supports are then used to verify adequacy of the support structure, including snubbers.

The RCS snubbers provided for STPEGS Units 1 and 2 are the hydraulic shock arrestor type and are designed and manufactured in accordance with ASME Section III, Subsection NF. Additionally, all snubbers are subjected to a thorough testing program which verified their capability to function properly before, during, and after upset and faulted condition loadings. All aspects of design and manufacture are in accordance with accepted Westinghouse quality assurance procedures (Quality Control Standard 1, QCS-l; Ref: WCAP-8370 "NES Quality Assurance Program", approved by NRC 12/31/74). Instruction manuals are provided with the snubbers and contain detailed procedures for installation which assure proper installation and checkout during plant start-up testing. Also, precautions are taken to assure accessibility to the snubbers for purposes of inspection and testing. All snubbers have the capacity for in-place testing.

Question 110.14

Provide the following information regarding the stress limits to be used for bolting materials:

1. For ASME Class l components, provide stress limits to be used for bolting materials for faulted condition loading. Neither ASME Section III nor Appendix F to ASME Section III contains faulted stress (Level D Service Limit) limits for bolts.

2. For ASME Class l, 2, and 3 component supports, provide stress limits for bolting materials for both emergency and faulted condition loading. Neither Section III, Appendix XVII nor Appendix F contain emergency of faulted stress (Level C or D Service Limit) limits for component support bolts.

<u>Response</u>

1. Stress limits used for Class l component bolting for the faulted condition are as follows:

   Reactor Vessel Closure Studs

   $P_m \leq 2.4\ S_m$ or $0.7\ S_u$

   $P_m + P_b \leq 3.6\ S_m$ or $1.05\ S_u$ (whichever is lower)

   Reactor Coolant Pump Main Flange Bolting

   $P_m \leq 0.7\ S_u$

   $P_u + P_b \leq 1.05\ S_u$

   Steam Generator Manway Cover Bolting (loaded in tension only)

   $P_m \leq 2.0\ S_m$

2. Stress limits used for Class l, 2, and 3 component support bolting are those of ASME Section III Appendix XVII (XVII-2460) and/or ASME Code Case 1644, increased according to the provisions of ASME Section III (XVII-2110[a]) for emergency conditions and F-1370(a) of Appendix F for faulted conditions.

   NOTE: The Replacement Steam Generators were fabricated to the 1989 edition of the ASME code, which now addresses faulted stress limits for bolts. The code requirements were applied.

Question 110.18

For active pumps and valves, and for all other components (including piping and vessels) required for safe shutdown of the plant, provide assurance that the design criteria; i.e., stress limit, deformation limit, etc., which have been utilized to evaluate the acceptability of each such component under exposure to its worst case postulated loading environment, will provide for sufficient component dimensional stability to assure its system functional capability as has been assumed in the FSAR Chapter 15 analyses. Acceptable criteria for piping are provided in Attachment 110-1.

Response

Active pumps and valves are qualified for operability by test and/or analysis. This testing and/or analysis verifies that active pumps and valves will perform their safety function when subjected to the must severe loads which would be imposed by the SSE coincident with the maximum faulted plant condition nozzle loads. The maximum nozzle loads imposed by the piping systems and the seismic accelerations imposed due to building location and/or piping system design are confirmed to be less than the maximum nozzle loads and seismic loads used for component design. Thus, active pumps and valves are qualified for loads which are at least as severe as the maximum loads which are expected to occur as a result of faulted condition loadings.

The stress limits which are applied to active pumps (Tables 3.9-4A and 3.9-4B) are only nominally higher than Level B stress limits and less than Level C stress limits. This assures that the pumps will not experience permanent deformation or otherwise be damaged during the short duration of the faulted condition event. Likewise, stress limits for active valves are presented in Tables 3.9-5 and 3.9-5A (Class 1) and 3.9-6 and 3.9-6A (Class 2 and 3). In addition, the stress limits imposed on the non-ASME Code extended structures of active valves assure that the extended structures do not experience permanent deformation or damage and that the functional capability of the valves is not impaired.

The design procedures for Level C and D stress limits delineated in Section III of the ASME Code provide adequate assurance that structural discontinuities in piping, tanks, and vessels will retain their specified geometric configuration during the improbable emergency and faulted condition events. These procedures provide adequate margins to assure the primary pressure boundary of components and the function of component supports. Conservative stress indices and intensification factors based upon analytical and experimental results as specified in the Code are used for analysis in the area of structural discontinuity of piping, tanks, and vessels. The use of these proven procedures and conformance with ASME III requirements provide an acceptable basis to assure the functional capability of these components.

Question 110.19

Provide the following information with regard to buckling loads:

1. Provide the bases for the allowable buckling loads, including the buckling allowable stress limit, under faulted conditions for all NSSS and BOP ASME Class 1 component supports.

   Also describe the analytical techniques used in determining both the calculated buckling loads under faulted conditions and the critical buckling loads of the ASME Class 1 and 2 component supports.

2. In FSAR Section 3.9.1.4.7, you state that for all NSSS Class l component supports, loads shall not exceed 0.90 times the critical buckling strength. We require that Class l component supports meet the following criteria which are consistent with Regulatory Guides 1.124 and 1.130, and F-1370 of the ASME Code.

   Whenever the design of component supports permits loads in excess of 0.67 times the critical buckling strength, verification of the support functional adequacy shall be established by full scale experimental testing (II.1252(b)). The results of such tests shall be submitted for NRC review on an individual case basis. It is our understanding that the design criteria for component supports in Appendix F to ASME Section III is currently being reevaluated by the applicable code committee and that some changes to the existing criteria may be made. As an alternative to full scale testing, we will consider any revised criteria after approval by the ASME for inclusion in Appendix F. State your intent with regard to this position.

3. Provide the allowable buckling loads under faulted conditions for Class 2 and safety-related Class 3 component supports. Criteria consistent with the staff position for Class l supports in Item 2 above will be acceptable.

<u>Response</u>

1. For Class 1 supports within Westinghouse scope, member critical buckling loads (P_{CR}) are calculated in the following manner:

$$P_{CR} = \left(1 - \frac{(kl/r)^2}{2\,C_c^2}\right) S_y A$$

   where

$$C_c = \frac{2\pi^2 E}{S_y}$$

Response (Continued)

Member compressive axial loads are limited to 2/3 P_{CR}, in accordance with ASME Boiler & Pressure Vessel Code Section III, Appendix F. For BOP Class l Supports, the ASME Boiler and Pressure Vessel Code Section III is followed.

2. Item 3 of Section 3.9.1.4.7 has been deleted per response to NRC Question 110.1.

3. Allowable buckling loads under faulted conditions for safety-related Class 2 and Class 3 component supports are calculated in the same manner as for Class l supports as stated above, except where buckling loads are negligible due to the configuration of equipment such as pumps, etc.

Question 110.22

Criteria are provided in Section 3.9.3.3 of the FSAR for the design and installation for mounting of pressure relief devices. The information provided discusses compliance with Regulatory 1.67 and Code Case 1569. Also reference is made to ASME Class 2 and 3 safety valve installations. Section 5.2.2.5 of the FSAR references Section 3.9.3.3 as applicable for the design of the "mounting" of ASME Class l pressure relief devices. The information provided in Section 3.9.3.3 is not applicable for the design of closed discharge pressure relieving systems such as that used for the pressurizer safety and relief valves on the STPEGS units. Both the Regulatory Guide and the Code Case referenced, while providing acceptable criteria for the design of open discharge systems, do not contain criteria for the design of closed discharge systems. Provide a description of the methodology used for the design of ASME Class l, 2, and 3 closed discharge systems, specifically including a description of how valve discharge reaction forces for the pressurizer ASME Class 1 safety valves are determined and limited as necessary so as not to exceed the loads used by the NSSS supplier for the design of the safety valve mounting brackets on the pressurizer.

Response

A piping system analysis is performed which considers the effects of pressure, gravity, thermal expansion and anchor movement, seismic, seismic anchor movement, loss of coolant accident, design basis accident, thermal transient loadings, and shock loads caused by safety and relief valve actuation.

Shock loading of the pressurizer relief piping system of a PWR unit can be induced by the opening of any or all of two relief valves and three safety valves. The activation of these valves allows the discharge of high pressure fluid from the pressurizer into the discharge piping, causing pressure and momentum transients throughout the piping system. These transients create signficant time-varying unbalanced forces in each straight run of the piping until steady-state flow is achieved. The analysis to obtain the structural response of the system following the sudden opening of the valves consists of a thermal-hydraulic analysis to obtain the force histories acting on the piping system as a result of the high pressure fluid flow, and a dynamic structural analysis to determine the response of these transient forces. The method of analysis consists of the following steps:

1. Development of a thermal-hydraulic model of the system.

2. Performance of thermal-hyraulic analysis to determine transient state histories at discrete locations throughout the system.

3. Integration of transient state histories to develop force histories applicable to bends and straight sections of the piping system.

4. Development of a lumped mass structural model of the piping system.

5. Performance of structural dynamic analysis of the system with the forces developed in Step 3.

Response (Continued)

Subsequent to the performance of individual load case analyses, a code compliance analysis is performed. This analysis combines the results of all loads, including shock loads in accordance with code and design specification requirements. Resultant piping restraint design loads are used for the design of individual pipe supports. The support design scheme used for the STPEGS does not utilize the safety valve mounting brackets of the pressurizer.

Question 110.24

The exception taken to position C.2.a.(2) and C.2.a.(4) of Regulatory Guide 1.121 in Section 3.2.1 of the FSAR is unacceptable without further justification. The Regulatory Guide recommendation for a 300-percent margin against burst failure, based on normal operating pressure differential, should be satisfied for all types of defects. This margin of safety may be demonstrated either analytically or experimentally. Test data submitted by Westinghouse for certain types of through wall defects have indicated that additional margin remained in the tube beyond the point where bulging occurs. A lower margin of safety may be applicable to these test data, provided it is shown that the remaining strength beyond bulging to gross rupture provides an equivalent margin of safety as recommended in Regulatory Guide 1.121.

On this basis, provide additional information that substantiates the equivalency of the Westinghouse 200 percent margin, based on Westinghouse performed tests, to the 300 percent margin recommended by the Regulation Guide which is related to a somewhat less conservative definition of tube failure. This equivalency must be justified for all types of tube defects. It is our understanding that the STPEGS term "margin of safety" is to be considered equivalent to "factor of safety" used in Regulatory Guide 1.121.

<u>Response</u>

STPEGS will not be taking exception to positions C.2.a.(2) and C.2.a.(4) of Regulatory Guide 1.121. See UFSAR Section 3.12.1.

Question 110.31

Recent operating reactor experience indicates that vibratory loads associated with the operation of positive displacement pumps have contributed to high cycle fatigue pipe failure. Such failures are known to occur on both the suction and discharge sides of positive displacement pumps in PWR charging systems.

Describe the measures that are proposed to be taken at the STPEGS facility to absorb these vibratory loads originating from the positive displacement charging pumps. If pulsation dampers or other mechanical devices are to be used in the pumps' vicinity, furnish a description of such devices; i.e., manufacturer, type, size, location, and effectiveness of the device. In case pulsation dampers or other mechanical devices are not employed to dampen vibratory loads:

1. Describe the vibratory loads origination at the positive displacement pump and transmitted to the discharge and suction pipe and associated pipe supports.

2. Describe in some detail how the maximum vibratory loads were established for calculating the maximum alternating stress in the design of the pipe runs and associated supports. Also describe the analytical procedure to determine the fatigue stresses in the affected piping system.

3. Furnish an isometric sketch of the pipe-affected piping system showing the location of the pipe supports and the peak alternating stresses. Also indicate the locations which will be monitored for vibration during the preoperational piping vibration and dynamic effects test program.

Response

Pulsation dampeners provided at the positive displacement charging pump suction and discharge to minimize piping vibration. These pulsation dampers are described as follows:

Manufacturer: Associated Piping and Engineering Company

Model

- Suction: SOCN 3-10
- Discharge: PDSN 2-16T

Type

- Suction: Variable vapor volume
- Discharge: Fluid kinetic

Size

- Suction: 10-inch-diameter, 30-inch height

Response (Continued)

- Discharge: 16-inch-diameter sphere

Maximum operating pressure

- Suction: 15 psig
- Discharge: 2500 psig

Maximum pressure variation

- Suction: 4 psi
- Discharge: 50 psi

Refer to revised Section 3.9.2.1.2 for a description of the vibratory test program.

Question 210.38N

Justify not considering the following primary system transients for normal conditions listed in FSAR Section 3.9.1.1.6.

1. Reactor coolant pumps startup and shutdown

2. Reduced temperature return to power.

Response

The design transients for STPEGS are based on Westinghouse internal design criteria documents, Systems Standard Design Criteria 1.3, Rev. 2, and 1.3, Appendix A. These documents do not include reactor coolant pumps (RCPs) startup and shutdown or reduced temperature return to power transients. These two transients were not specifically considered for Westinghouse plants designed during the time frame for which these documents are in effect.

However, in the case of the first transient, i.e., RCPs startup and shutdown, W assumes that variations in Reactor Coolant System (RCS) primary side temperature and in pressurizer pressure and temperature are negligible and that the steam generator secondary side is completely unaffected. It is considered by Westinghouse that due to the overall number of transient events considered in the design of STPEGS, not including this transient in the design has a minimal effect.

Reduced temperature return to power is not considered in the RCS design basis for STPEGS, therefore that transient is prevented from occurring by operational limitations contained in the proposed technical specifications.

The NRC MEB has reviewed and approved similar plants (Comanche Peak and Byron) which do not consider these two transients.

Question 210.40N

Identify components for which inelastic analysis has been used. If any, provide details of methods used.

Response

Inelastic analysis has not been used to qualify any components including piping. Inelastic analysis is sometimes used to evaluate plant response due to pipe break as discussed in Section 3.6.

Question 210.46N

On page 3.7-21 of the FSAR, it is stated that in certain cases, such as with auxiliary piping connected to the reactor coolant loop, multiple spectra have been used to reduce the excessive conservatism in supplying enveloped spectra over the entire length of piping. Discuss how multiple spectra are used.

Response

1. NSSS Scope

   For piping and components supported at multiple elevations Westinghouse uses the most limiting spectra in performing seismic analysis.

   Multiple spectra are not used in Westinghouse scope analyses.

2. BOP Scope

   Multiple response spectra are used when use of an enveloped spectra results in an excessively conservative design. In such cases supports, anchors, and nozzles are excited by their corresponding response spectra. For example, a piping system connected to the reactor coolant loop (RCL) and supported by the internal structure will have two response spectra as the forcing functions. The RCL spectrum is applied at the RCL-auxiliary piping interface and the Reactor Containment Building internal structure spectrum is used at the support locations. The responses due to multiple spectra are combined by absolute summation followed by modal summation for each direction, then combination for directions. Modal and directional summation is in accordance with Regulatory Guide (RG) 1.92. Bechtel computer program ME101 "Linear Elastic Analysis of Piping Systems" is used for multiple response spectra analysis. This computer program is discussed further in Section 3.9.1.2.2.1.

Question 210.47N

SRP Section 3.9.2.III.2.a.(2)(c) states that to obtain an equivalent static load on equipment or component which can be represented by a simple mode, a factor of 1.5 is applied to the peak acceleration of the applicable floor response. FSAR Section 3.7.3B.1.7 does not comply with this guidance. Provide justification for not using a factor of 1.5.

Response

SRP Section 3.7.2 agrees with the above statement concerning a factor of 1.5 applied to the peak acceleration but also notes that a value less than 1.5 may be used if justified.

For rigid equipment, since there is no resonance or magnification of the floor response, no additional factors are applied to the high frequency acceleration levels of the applicable floor response when calculating the seismic acceleration coefficient.

Limited Flexible Equipment is defined as having only one (1) predominant mode in the frequency range subject to possible amplification (<33 Hz). In performing the static analysis as defined in Section 3.7.3B.1.7, the total weight of the equipment or component is multiplied by the amplified response at its calculated fundamental natural frequency. This provides a conservative equivalent static load for this equipment or component.

For flexible equipment and piping Westinghouse uses dynamic analyses.

Question 210.48N

Provide additional information to justify the use of a multiplication factor of 1.0 in the equivalent static load method for design of cable tray hangers and heating, ventilating, and air conditioning (HVAC) duct supports.

Response

As stated in Section 3.7.3A.1.2 dynamic analyses using the modal response spectrum method were performed for typical cable tray and HVAC support systems. The seismic force and moment response obtained from the dynamic analyses is established to be less than the corresponding response from the equivalent static method using a factor of 1.0 times the peak acceleration of the applicable floor response spectra. Therefore, use of the multiplication factor of 1.0 in analyses by equivalent static method is justified.

This approach was reviewed by the Structural Engineering Branch during the STPEGS audit during the week of January 7, 1985.

Question 210.49N

SRP 3.9.2.II.2.h specifies criteria for using constant vertical static factors. The use of constant vertical static factors is acceptable only if it can be justified that the structure is rigid in the vertical direction. Provide assurance that this guidance has been used.

Response

1. NSSS Scope

   Constant vertical static factors are not used by Westinghouse.

2. BOP Scope

   Constant vertical load factors are not used to obtain vertical response loads for the seismic design of Category I structures, systems, and components. Multimass dynamic analyses for both horizontal and vertical directions of excitation are performed to obtain the seismic responses and floor response spectra.

   For subsystems within structures, when the floor response spectra are used to define vertical input motion and/or loads for the Seismic Qualification and/or design of equipment and components, the rigidity of the structural subsystems is taken into consideration. Parametric analyses have been performed to determine the minimum subsystem frequencies required to assure effectively-rigid subsystems behavior that justifies use of the floor vertical response spectra directly without any additional amplification to account for subsystem flexibility. The established frequency limits are implemented in the Project as a specific requirement for the design of structural subsystems that support safety-related equipment. Subsystems identified to have low frequencies, if any, are stiffened to comply with the established frequency limits. Section 3.7.2.10 has been revised to reflect this response.

   This approach was reviewed by the Structural Engineering Branch during the STPEGS audit during the week of January 7, 1985.

Question 210.51N

Provide the basis used for the design of piping anchors which separate seismically designed piping and nonseismic Category I piping. Include in your discussion, the loads and load combinations used and how the local pipe wall stresses are considered.

Response

In the case where an anchor is used to separate seismic Category I piping systems from piping systems where seismic qualification is not required, the anchor is designed to meet seismic Category I requirements. This is in agreement with RG 1.29, paragraph C.3 which states, "seismic Category I design requirements should extend to the first seismic restraint beyond the defined boundaries. Those portions of structures, systems, or components that form interfaces between seismic Category I and nonseismic Category I features should be designed to seismic Category I requirements".

Loading conditions and load combinations for qualification of piping, components, and supports are specified in Table 3.9-2.4. In the case of an anchor, the piping analysis for the piping on each side of the anchor is performed independently using the appropriate loading conditions. Anchor loads are generated for both the upstream and downstream piping runs. Anchor loads for the nonseismic Category I side include either seismic loads due to Safe Shutdown Earthquake (SSE) or piping collapse loads. The loads from the two piping runs are then combined and used for the anchor design. Dynamic loads from the two sides are combined by square root of the sum of the squares (SRSS). Resultant static and dynamic loads are combined absolutely as required for the appropriate plant condition as defined in Table 3.9-2.4.

Local pipe wall stresses are considered in accordance with ASME Section III, subsection NC, ND, or ANSI B31.1 as appropriate. The applicable subsection is determined by the pipe class. No seismic boundary anchors are placed on ASME Class 1 piping.

Question 210.52N

FSAR Table 1.3-1, Comparison with Similar Facility Design, states that the new design of the reactor vessel head closure system and lower internals are different from the Comanche Peak plant. Provide additional information which describes the differences in lower internals design between STPEGS and Comanche Peak. Specifically, describe any changes in the reactor internals design which may have resulted from utilization of the rapid refueling concept at STPEGS. If such changes exist, discuss the effects of these changes on the response of the reactor internals to flow-induced excitation and provide the basis for meeting the guidelines of RG 1.20 and maintaining Indian Point, Unit 2 as the prototype plant for STPEGS.

Response

No changes were made to the STPEGS reactor internals resulting from the utilization of the rapid refueling concept that would impact the vibratory response of the internals. The utilization of lifting rods in the upper internals to facilitate the removal of the upper internals with the upper head has no impact on the internals vibratory response. In fact the vibration assessment, based on flow turbulence, is only concerned with the region below the upper support plate in the lower guide tube region, inlet nozzle, downcomer and outlet nozzle locations.

The STPEGS plant is based on the four loop Nuclear Steam Supply System (NSSS) design of Indian Point insofar as Regulatory Guide (RG) 1.20 is concerned. In addition, the STPEGS plant incorporates such design enchancements as have already been reviewed and approved by the NRC staff such as neutron pad versus thermal shield and the inverted top hat design. One additional modification concerns the change to the reactor internals to permit the use of a 14-ft core. To account for this the fuel no longer rests on a lower core plate but simply rests on the lower support plate. An analytical flow-induced vibration assessment has been performed and documented for the STPEGS plant. It has been concluded that the vibrational response of this plant obtained from scale model tests and instrumented plant tests, shows that the internals vibration levels are low and that the STPEGS reactor internals design is adequate to assure structural integrity against flow induced vibrations.

Question 210.53N

FSAR Section 5.3.1.7 describes the Roto-Lok reactor vessel head closure system which is used for the STPEGS Units 1 and 2 reactor vessel head. It also states that a prototype Roto-Lok closure system has been tested to verify this closure design. Results of these tests are presented in the WCAP-8447, December, 1974. However, Section 7 of WCAP-8447 states that, "Also, it should again be noted that the program described in this report was for development hardware and testing only. The final design and analysis for a particular vessel is performed by the vessel supplier when the Roto-Lok is actually applied by production vessels." The staff's review of the WCAP-8447 as provided in a letter from J.F. Stoltz to C. Eicheldinger dated September 2, 1977, determined that WCAP-8447 provides an acceptable basis for the preliminary design of the Roto-Lok closure system. Furthermore, in that evaluation, the staff required that for the first reactor vessel to use this closure system (STPEGS Plant) the results of final design and analysis of the closure system be provided in the FSAR. The applicant is requested to provided this information. Include in your discussion how the assumptions presented in WCAP-8447 are applicable to the STPEGS Units 1 and 2 plant specific reactor vessels.

Response

The STPEGS reactor vessel Roto-Lok closure system configuration is shown in Figure Q210.53N-1. This closure assembly used the sawtooth lug design discussed in Chapters 6 and 7 of WCAP-8447 (proprietary) with the following modifications:

1. Stud fillet radii at the top of the lug to shank junctures were increased from 0.187 in. to 0.250 in.,

2. Insert fillet radii at the bottom of the lug to cylindrical inside diameter junctures were reduced from 0.187 in. to 0.125 in.,

3. The length of each lug was increased from 1.975 in. to 2.095 in. at the shank on each stud, and

4. The lug length was increased the same amount at the cylindrical inside diameter of each insert.

The final Roto-Lok closure region design was analyzed by the STPEGS reactor vessel vendor (Combustion Engineering) using the ANSYS three-dimensional finite element computer program. The assumptions used in the proprietary WCAP-8447 (see pages 3-5 through 3-7 and 6-1) are still applicable to this analysis with the following revisions:

1. The specified stud preload is 110 percent of the design pressure blow-off load during normal operation or 110 percent of the hydrostatic blow-off load during the hydrotest versus the 120 percent factor used in the WCAP.

2. The full length of the closure stud was used in the analysis instead of just the portion in the vessel and closure flanges.

Response (Continued)

3. The crown portion of the closure head was modelled with two elements through the thickness in lieu of one layer.

4. The closure region was modelled as a 5 degree wedge with the width consisting of three elements. The effect of the stud holes in the circumferential direction was also handled in a more refined fashion than in the WCAP.

5. The reactor vessel's internal surfaces in contact with the primary coolant were assumed to have an infinite heat transfer coefficient instead of a finite film coefficient associated with turbulent flow.

6. Heat transfer by conduction, radiation, and convection in lieu of just convection was assumed to occur across the air gaps between the vessel components and the studs and nuts.

7. The strength reduction factor in the fatigue analysis was increased from 3.75 to 4.0.

The results of the vessel vendor's analysis of the Roto-Lok stud assembly are presented along with the corresponding ASME code allowables in the following table. This table shows the code allowable limits are met.

Category	Governing Value	ASME Code Allowable
Design Stud Membrane Stress Intensity	34.73 ksi	34.8 ksi
Maximum Average Stud Service Stress Intensity	54.3 ksi	84.0 ksi
Maximum Stud Service Stress Intensity	76.8 ksi	126.0 ksi
Usage Factor	0.502	1.0

Figure 210.53N-1

Question 210.54N

The staff finds that there is insufficient information describing the design of safety-related HVAC ductwork and supports. Provide the design basis used for qualifying the HVAC ductwork and support structural integrity.

Response

HVAC ducts are fabricated from sheet metal and/or steel plate. The duct supports are fabricated from rolled structural shapes. All ducts and supports are galvanized.

Safety-related ducts and duct supports are designed for combinations of gravity, pressure, and seismic loads utilizing allowable stresses that maintain the response within the elastic range. The seismic analysis of ducts and duct supports is based on the equivalent static method as stated in Section 3.7.3A.1.2 and 3.7.3A.3.3. Codirectional seismic responses due to longitudinal, transverse, and vertical earthquakes are combined by the SRSS method or the component factor method. The component factor method is equivalent to the SRSS method, and in certain types of analyses is more practical than the SRSS method for combining codirectional responses from the three components of earthquakes. The component factor method is widely used in the industry for the design of structures, systems, and components of nuclear power plants. The maximum error possible by the use of the component factor method is less than one percent with respect to the SRSS method.

The rationale for the use of the component factor method is attached. Section 3.7.3A.6 has been revised to identify the use of the component factor method as an acceptable option in addition to the SRSS method with the exception that the component factor method is not used for piping analysis.

Tables Q210.54N-1 and Q210.54N-2 give the load combinations and allowable stresses used in the design of duct and duct supports.

Expansion anchors (Hilti Kwik-bolts) are used occasionally in supports for safety-related HVAC ducts. As explained in response to Q210.62N, the design allowable loads are based on tested ultimate load capacities with an applied factor of safety of four or higher. Design allowable loads are not increased for faulted or abnormal/extreme environmental loading combinations. The integrity of the expansion anchors is not compromised by normal operational vibratory motion due to the low amplitude nature of the vibration.

In specific isolated instances, as determined from pipe break analyses and/or tornado depressurization analyses, the loads due to compartment pressurization/depressurization and/or jet impingement are included in the design of safety-related ducts. The loads due to pipe break are considered as additive to the loads of combinations (2) and (3) of the above tables.

Response (Continued)

Safety-related HVAC ducts are designed using analytical guidelines established from testing results. Following are the principal codes and standards used in the design:

1. AISC - "Specification for the Design Fabrication and Erection of Structural Steel for Buildings", 1969, including Supplements 1 and 2.

2. AISC - "Code of Standard Practice for Steel Building and Bridges", 1976.

3. AISI - "Specification for the Design of Cold-Formed Steel Structural Members", 1968 and AISI - "Supplementary Information on the 1968 Edition of the Design of Cold-Formed Steel Structural Members", 1971.

   Exception: Section 2.3.4 of AISI 1968 states that the ratio h/t of the webs of flexural members shall not exceed 500. Actual tests performed on HVAC ducts substantiate the use of w/t and h/t ratios of up to 1500 for ducts. The STPEGS approach allows these ratios to exceed 500, but restricts these values to less than 1500.

4. AWS - Structural welding code AWS D1.1, 1977 and code for welding zinc-coated steel AWS 19.0.

5. OSHA - Department of Labor, Volume 37, Number 202, Part II - Applicable sections on platforms, handrails and ladders.

6. SMACNA - Sheet metal and air conditioning contractor's national association high pressure duct construction standards and low-pressure duct construction standards.

Supports for safety-related HVAC ducts are designed by the working stress method using the AISC specification, 1969 edition.

TABLE Q210.54N-1

LOAD COMBINATIONS FOR HVAC DUCTS -

Load Case	Loading Combination	Allowable Stress
(1)	D + P	0.6 Fy
(2)	D + P + E	0.6 Fy
(3)	D + P + E_s	0.9 Fy
(4)	D + P + W_{tp}	0.9 Fy

Symbols used in load combinations:

D - Dead weight of duct
P - Maximum operating pressure inside duct
E - Operating basis earthquake load
E_s - Safe shutdown earthquake load
Fy - Minimum specified yield strength of duct material
W_{tp} - Tornado differential pressure

TABLE Q210.54N-2

LOAD COMBINATIONS FOR HVAC DUCTS -

Load Case	Loading Combination	Allowable Stress
(1)	D	F_s
(2)	D + E	F_s
(3)	D + E_s	1.5 F_s or 0.9 Fy, whichever is smaller

Symbols used in load combinations:

D - Dead load
E - Operating basis earthquake load
E_s - Safe shutdown earthquake load
F_s - Allowable stress for support material governed by AISC or AISI as applicable
Fy - Minimum specified yield strength of support material

VALIDITY OF THE COMPONENT FACTOR METHOD

In the component factor method, the following equation is used to determine the total seismic load:

$$R_{total} = R_i + 0.4R_j + 0.4R_k \qquad (1)$$

In the following, adequacy of the above equation is demonstrated. First, consider a combined response, R' defined as follows:

$$R' = R_i + 0.414R_j + 0.318R_k \qquad (2)$$

In which

$$R_i \geq R_j \geq R_k \geq O \qquad (3)$$

Let

$$R_j = R_j + R_k \quad (R_j = O \text{ if } R_j + R_k)$$

$$R_i = R_i + R_j = R_i + R_j + R_k \quad (R_i = O \text{ if } R_i = R_j) \qquad (4)$$

The SRSS method gives:

$$R = \{(R_i + R_j + R_k)^2 + (R_j + R_k)^2 + R_k^2\}^{1/2}$$

$$= \{3R_k^2 + 2R_j^2 + R_i^2 + 2R_i(R_j + R_k) + 4R_jR_k\}^{1/2} \qquad (5)$$

According to Eq. (2)

$$R' = (R_i + R_j + R_k) + 0.414(R_j + R_k) + 0.318R_k$$

$$R' = 1.732R_k + 1.414R_j + R_i = \{[1.732R_k + 1.414R_j + R_i]^2\}^{1/2}$$

$$R' = \{3R_k^2 + 2R_j^2 + R_i^2 + 2R_i(1.414R_j + 1.732R_k) + 4.9R_jR_k\}^{1/2} \qquad (6)$$

Comparing Eqs. (5) and (6), it is obvious that the combined response calculated according to Eq. (2) is always more conservative than the combined response by the SRSS method. In the special case that $R_i = R_j = R_{k'}$ they become identical to each other, i.e., R = R' = 3R_k.

For convenience of engineering applications, Eq. (2) can be simplified by replacing the factors 0.414 and 0.318 by common factor of 0.4. This reduces Eq. (2) to Eq. (1). By inspection, the maximum probable error of Eq. (1) with respect to the SRSS method is less than 1 percent. This maximum error occurs when $R_k = 0$ and $R_i = R_j$. In this special case, the SRSS method gives R = 1.41R_i and Eq. (1) gives R = 1.4R_i.

VALIDITY OF THE COMPONENT FACTOR METHOD

In implementing Eq. (1), permutations of the component factors (1.0, 0.4, 0.4) and, positive and negative values of the seismic stresses are taken into account. The resulting 24 sub-combinations will contain the most critical case (i.e., the maximum absolute value of the total seismic response) and will be combined with stresses due to other loads using proper sign. The most critical case, thus identified, forms the basis of the final design.

Question 210.55N

Provide the basis for assuring the ASME Code Class 1, 2, and 3 piping systems are capable of performing their safety function under all plant conditions. Describe the methodology used to assure the functional capability of essential piping system when service limits C or D are specified.

Response

Loading combinations for the various plant conditions (i.e., normal, upset, emergency, faulted) and the corresponding stress limits for ASME Code Class 1, 2, and 3 piping and pipe supports are given in the Section 3.9. These stress limits are in compliance with the code requirements and form the basis for assuring that the piping systems are capable of performing their safety functions under specified plant conditions.

NSSS Scope

For essential piping systems, functional capability has been satisfied by analysis using the following method:

Component	Limit	Calc Method
Straight pipe, welds, reducers	1.8 Sy	NB-3650, Eq. (9)
Branches, tees	2.0 Sy	NB-3650, Eq. (9)
Elbows, 5D bends	1.8 Sy	NB-3650, Eq. (9)*

* B_1 and B_2 indices are replaced as follows:

$$0 \leq B_1 = -0.1 + 0.4h \leq 0.5$$

and $B_1 = 0.5$ for $B_2 = 1.0$

$$B_2 = \begin{cases} \dfrac{1.3}{h^{2/3}} & , \text{for } \propto_o > 90^o \\ \dfrac{0.895}{h^{0.9122}} & , \text{for } \propto_o = 90^o \\ 1.0 & , \text{for } \propto_o = 0^o \end{cases} \quad \text{and } B_2 \geq 1.0$$

Linear interpolation for $0 < \propto_o < 90^o$

Where:

$$h = \frac{tR}{r_m^2}$$

R	=	bend radius
r_m	=	mean pipe radius
t	=	nominal wall thickness

Response (Continued)

The applicable loading cases for the Class 1 piping components to meet the functional capability limits for reactor coolant loop and the pressurizer safety and relief system are:

P_o + DWT + SSE

Where:

P_o = design pressure

DWT = deadweight

SSE = safe shutdown earthquake

To assure the functional capability of a Class 1 system not larger than 1-in. diameter which is analyzed to ASME Code Class 2 rules, the following stress limits have been used to supplement the level D requirements for ASME Class 2 stainless steel elbows.

$$B_1 \frac{PD}{2t} + B_2 \frac{Mj}{Z} \leq 1.8\ Sy$$

Where: $B_1 = (-0.1 + 0.4h)$ and $0 \leq B_1 \leq 0.5$

and $B_1 = 0.5$ for $B_2 = 1.0$

$$B_2 = \begin{pmatrix} 1.3/(h^{2/3}) \text{ for } \propto_o > 90^o \\ 0.895/(h^{0.9122}) \text{ for } \propto_o = 90^o \\ 1.0 \text{ linear for } \propto_o = 0 \end{pmatrix} \quad \text{and } B_2 \geq 1.0$$

Linear interpolation for $0 < \propto_o < 90^o$

Where: $h = \frac{tR}{r^2_m}$ and $\propto_o$ is the angle of the bend in degrees.

Other terms are as defined in NC-3600 of Section III of the ASME Code. There are no Class 2 stainless steel elbows or bends with Do/t > 50.

The loading combination for the reactor vessel head vent system is:

P_o + DWT + SSE

BOP Scope

For essential piping systems, the functional capability has been satisfied by analysis using methods given in GE Topical Report, Functional Capability Criteria for Essential Mark II Piping, NEDO-21985, September 1978, or an equivalent analysis.

Question 210.56N

The staff review of FSAR Section 3.9.3.3 finds that the design and installation details for mounting of pressure-relief devices require further clarification. Provide the following information for our review:

1. Clarify whether it is the intention of Section 3.9.3.3.2 to address BOP supplied components.

2. Clarify whether all the NSSS scope safety and relief valves transients are evaluated using detailed dynamic analysis techniques. Provide assurance that the most severe potential sequence of discharges, i.e., the maximum values of forces and moments are considered for multiple-valve discharges.

3. Provide a discussion of the basis for assuring that the valve end loads are acceptable. Specifically, address how the applicable design loads will be correctly reflected in the valve design specification.

Response

A. NSSS SCOPE

A description of the pressurizer safety and relief valve system is given in Section 3.9.3.3.1.1. This section also describes the analytical model of the system, the determination of forces, and method of analysis. The programs used in the dynamic analysis of the system are also provided in Section 3.9.3.3.1.1. All relevant valve discharge cases are evaluated using detailed dynamic analysis techniques. Discharge of the safety valves is the limiting design case for the downstream piping of all cases considered. The three safety valves are identical and have the same set pressure (± 1 percent). It was assumed that all three safety valves open simultaneously. The simultaneous opening of the safety valves results in peak loads in the common circular header. No appreciable impact in the tailpipe region, due to safety valve discharge, will occur if the valve sequencing is adjusted. The detailed design analyses performed for this discharge case illustrates a safety factor of 2 between the calculated stresses in the tailpipe and the allowable stresses.

The valve end loads are verified to be acceptable by ensuring that all calculated values are below conservative values specified in the piping design specification which has been approved by the valve engineer. Specific values are reconciled to the valve specification or vendor reports if any values exceed those specified in the piping design specification.

B. BOP Scope

1. Section 3.9.3.3.2 is intended to address the BOP supplied components. Section 3.9.3.3.2 has been revised to clarify applicability to BOP components.

Response (Continued)

2. BOP multiple valve discharge is applicable only to the main steam safety relief valves. The main steam safety relief discharge piping is designed so that the thrust force is transferred to the support structure, thus eliminating concern regarding force transfer to the piping system.

3. Consideration of active valve end loads is discussed in Sections 3.9.3.2.1.2 and 3.9.3.2.3. Calculated valve end loads are compared for compliance with the allowable loads identified in the valve specifications or in the vendor documentation.

Question 210.57N

The staff review of FSAR Section 3.9.3.4 finds that there is insufficient information regarding the design of ASME Class 1, 2, and 3 equipment and component supports. Per SRP Section 3.9.3, our review includes an assessment of design and structural integrity of the supports. The review addresses three types of supports: (1) plate and shell, (2) linear, and (3) component standard types. For each of the above three types of supports, excluding pipe supports, provide the following information (as applicable) for our review:

(a) Describe (for typical support details) which part of the support is designed and constructed as component supports and which part is designed and constructed as building steel (NF vs. AISC jurisdictional boundaries).

(b) Provide the complete basis used for the design and construction of both the component support and the building steel up to the building structure. Include the applicable codes and standards used in the design, procurement, installation, examination, and inspection.

(c) Provide the loads, load combinations, and stress limits used for the component support up to the building structure.

(d) Provide the deformation limits used for the component support.

(e) Describe the buckling criteria used for the design of component supports. Specifically, describe how the "A" term used in the response to NRC Question 110.19 was defined.

<u>Response</u>

A. NSSS SCOPE:

1. <u>Class 2 and 3 component supports</u>

(a) The supports are linear type or plate and shell type, and are part of the equipment. A typical support is welded to the equipment directly to the pressure boundary or wear plate, and is required to be rigidly attached to a foundation. The equipment designed to Code editions prior to the inclusion of Subsection NF into the ASME Code have the supports designed in accordance with the requirements of the AISC manual; equipment designed to the Code editions after the inclusion of Subsection NF are designed in accordance with ASME Code Subsection NF.

Response (Continued)

(b) The design, construction, examination, and inspection of the auxiliary equipment supports are in accordance with the requirements of ASME Subsection NF or AISC, depending on the procurement date of the equipment as discussed in the Part (a) response. In accordance with Westinghouse auxiliary equipment specifications, the equipment is required to be rigidly mounted.

(c) The loads and the loading combinations for the supports of the auxiliary equipment supplied by Westinghouse are the same as those of the supported component. These loads and combinations are given in Section 3.9.3.

The stress limits are in accordance with the ASME Code Subsection NF or AISC, depending on the procurement date of equipment as discussed in the response of Part (a).

(d) For passive auxiliary components, only the structural integrity of the pressure boundary and supports is required to be assured. Since passive components perform no safety function other than retaining structural integrity, there are no deformation limits specified for the supports or for the passive auxiliary components.

Deformation of supports for active pumps is limited so that certain critical clearances are maintained and the pump remains operable. These critical clearances are specified in the pump specifications.

(e) Buckling is prevented by limiting compressive stresses for linear-type auxiliary equipment supports under loadings from all service conditions to the limits of AISC Section 1.5 or ASME Appendix XVII-2210. These limits are based on the Column Research Council (CRC) buckling curve for centrally-loaded columns. Critical buckling loads are limited to two-thirds of the CRC curve.

Plate and shell type supports for Class 2 and 3 auxiliary equipment are evaluated for buckling and instability through selective use of the criteria of Appendix XVII, Subarticle XVII-200 and Subsection NC, Subparagraph NC-3133.6 of Section III of ASME Code. Subparagraph NC-3133.6 gives methods for calculating the maximum allowable compressive stress in cylindrical shells subjected to axial loadings that provide longitudinal compression stresses in the shell. Subarticle XVII-200 gives requirements for structural steel members including allowable

Response (Continued)

compressive loads based on slenderness ratios and interaction equations for combined stresses.

Uses of the above requirements in the design of linear or plate and shell type supports for Westinghouse-supplied auxiliary equipment ensures the dimensional stability of the support throughout the range of applied loadings.

2. Primary Equipment Supports

The following is a listing of support versus category for the RCS equipment supports.

Reactor Vessel Support Box	Plate and Shell
Steam Generator Columns	Linear
Steam Generator Lower Lateral Support	Linear
Steam Generator Upper Lateral Support	Linear
Reactor Coolant Pump Columns	Linear
Reactor Coolant Pump Tie Rods	Linear
Pressurizer Lateral Supports	Linear
Reactor Vessel Support Shoe/Pins	Linear

(a) Figures Q210.57N-1 and Q210.57N-2 show for a typical configuration the NF boundary between component support and building structure.

(b) All parts and components of the Class 1 primary equipment supports are designed and fabricated in accordance with Subsection NF of the ASME Code. The design and construction of the primary equipment support is based on a general design specification which is amended by a plant specific specification. The specifications address the design, procurement, installation, examination and inspection of the components which make up the primary equipment supports.

(c) Design loads, load combinations, and stress limits are contained in Tables 3.9-2.1 and 3.9-2.1A.

Final qualification of the RCS equipment supports is based upon loads and stresses resulting from a plant specific reactor coolant loop analysis. The results are summarized in a final as-built (P.E. stamped) design report.

(d) No deformation limits are used in the design and analysis of the primary equipment supports. The structural members are designed to the stress limits of the ASME Code, Section III, Subsection NF so that all members remain elastic. The elastic behavior of

Response (Continued)

the members is then considered in the reactor coolant system loop analysis.

(e) The buckling criteria used for the design of the primary equipment supports is based on the slenderness ratio. The allowable compressive stresses are limited to the requirements of the ASME Code, Section III, Articles XVII-2110b and XVII-2213. Critical buckling is based upon CRC curves where $kl/r < C_c$ (that is, for most RCS equipment support members) and the Euler curve where $kl/r > C_c$.

C_c is the slenderness ratio corresponding to the upper limit of elastic buckling failure.

The "A" term used in response to NRC Q110.19 is the cross sectional area of the member.

B. BOP SCOPE (excluding pipe supports):

1. The jurisdictional boundary between the pressure-retaining component and the component support is established in accordance with subsection NF of the ASME III Code.

The jurisdictional boundary for ASME Section III, Division 1, Subsection NF component supports, is the baseplate or building structure to which the component support is attached.

The typical support configurations shown Figures Q210.57N-3 and Q210.57N-4 are samples and are only intended to show NF jurisdictional boundaries.

2. Component supports and any supporting structure between the component and the building structure, are designed, constructed, and inspected in accordance with applicable ASME requirements. Baseplates which are supplied by the equipment vendor or owner in order to facilitate attachment to the building structure are designed and procure in accordance with AISC requirements. Welds between an NF item and non-NF item are designed, performed and inspected in accordance with the appropriate sections of ASME Section III, V, and IX. The baseplate is attached to the building structure by either welding or bolting. The welds to the building structure are considered to be AISC and as such are performed and inspected identically with the requirements delineated in the letter from M. Wisenburg to H. Thompson dated February 25, 1985 (ST-HL-AE-1185).

Refer to the response to item Q210.62N for the design of anchor bolts for component supports.

Response (Continued)

3. The loads and load combinations for component supports are presented in Table 3.9-2.4.

   The allowable stress limits are presented in Tables 3.9-7b and 3.9-7c.

4. Deformation limits for component supports are specified by the suppliers for strain sensitive equipment. The limits insure that clearance and alignment requirements are met.

   There are no deformation limits specified for tanks, vessels, or exchanger component supports.

5. For component supports, the designs are in accordance with the buckling criteria given in ASME III Subsection NF.

Figures Q210.57N-1

Figures Q210.57N-2

Figures Q210.57N-3

Figures Q210.57N-4

Question 210.58N

Valve discs are considered part of the pressure boundary and as such should have allowable stress limits. Provide these limits for our review.

Response

1. NSSS Scope

The valve discs for Class 1 valves greater than 4-in. size are analyzed using the following allowables for acceptance criteria.

Primary Membrane, $P_m \leq 1.0\ S_m$

Primary Membrane + Bending, $P_m + P_b \leq 1.5\ S_m$

For Class 2 and 3 valves where analysis is required per the specification, the following acceptance criteria are used.

Primary Membrane, $P_m \leq 1.0\ S$

Primary Membrane + Bending, $P_m + P_b \leq 1.5\ S$

2. BOP Scope

A. ASME III, Class 1 Valves

No large bore (>4-inch-diameter) valves are in the BOP scope. For 4-in. and smaller valves structural integrity is demonstrated by a differential pressure test across the disc and not by analysis. NB-3530 contains requirements for hydrostatic tests for the shell and disc. The hydrostatic test report for the valve includes details to show that the requirements of NB-3530 are met.

B. ASME III, Class 2 and 3 Valves

For Code Class 2 and 3 valve discs no design requirements are described in NC or ND-3500. However, tests for structural and pressure integrity for valve disc or plugs are described in NC/ND-3514(b). A disc hydrostatic test is required with the disc or plug in the fully closed position with a test pressure across the disc or plug equal to the pressure rating of the valve at 100°F. The ASME III design specifications may be used to stipulate a higher or lower test pressure and do require specific limiting seat leakage.

Design requirements for valve discs and plugs are determined by the manufacturer, since items such as disc geometry, method of seating, materials, etc., are controlled by the manufacturer and subject only to review and acceptance by the owner, or his designee, as permitted in the ASME code.

Question 210.60N

Does the design criteria for component supports in systems categorize the stresses produced by seismic anchor point motion of piping and the thermal expansion of piping as primary or secondary? It is the staff's position that for the design of component supports, and stresses produced by seismic anchor point motion of piping and the thermal expansion of piping should be categorized as primary stresses. The application of this position is most critical for those supports which would be subjected to large deformations.

Response

The stresses produced by seismic anchor point motion of piping and thermal expansion of piping are considered as primary stresses in the design of component supports. Nuclear Steam Supply System (NSSS) component supports which have been designed in accordance with ASME III Subsection NF have been evaluated for compliance with this position and are acceptable.

Question 210.61N

Describe what actions have been taken to address the staff concerns regarding stiff pipe clamps as described in IE Information Notice 83-80.

Response

The applications of stiff pipe clamps on STPEGS have been reviewed based on IE Information Notice 83-80. Section III of the ASME B&PV Code does not provide rules for evaluating stresses due to loadings from nonintegral attachments such as clamps; however, clamp-induced stresses have been evaluated by methods consistent with the intent of the Section III of the ASME B&PV Code. The procedure includes the following:

1. Identification of the locations of "stiff" clamps installed on ASME Section III Nuclear Class 1 piping systems.

2. Identification of the types of clamps, the loads acting on the clamps, and the bolt pre-load values used in their installation. In piping, stresses due to all loading conditions at the locations of stiff clamps have also been identified and reviewed.

3. Addition of the primary membrane and primary bending stresses caused by the load being transmitted to the pipe through the clamp to the stresses caused by internal pressure and bending computed by equation 9 of NB-3652. Clamp-induced stresses caused by the constraint of the expansion of the pipe due to the internal pressure were added to other secondary stresses in evaluating equation 10. Clamp induced stresses due to differential-temperature and differential-thermal-expansion coefficients were calculated and added to other operating secondary and peak stresses. The fatigue usage factor at the clamp location was computed taking into consideration clamp induced stresses from pressure, temperature, and support loadings. The clamp induced stresses were added to the stresses in the pipe including secondary and peak stresses computed for each load set pair.

Although bolt preloads are not addressed under the ASME B&PV Code rules for piping, bolt preloads could result in damage to pipe if a clamp was improperly designed. Calculations were made to ensure that bolt preloads could not result in plastic deformation of the pipe walls.

A brief summary of the criteria used and the results of the analysis has been submitted under seperate cover letter (see ST-HL-AE-1468, dated October 30, 1985).

Stiff clamps were not used on STPEGS to meet stiffness criteria. They were designed to meet the requirements for strength and load distribution using a minimum of space. The STPEGS position is to minimize the use of stiff clamps.

The clamp design utilizes a double nut arrangement to prevent the nuts from backing off. The low temperature (650̃F) and stresses in the bolt from preloads will not cause a relaxation of the material. Consequently, no lift-off from the piping will occur.

Question 210.62N

The staff's review of your component support design finds the additional information is required regarding the design basis used for bolts.

(a) Describe the allowable stress limits used for bolts in equipment anchorage, component supports, and flanged connections.

(b) Provide discussion of the design methods used for expansion anchor bolts used in component supports.

Response

NSSS Scope

For primary equipment supports the bolt design, including anchor bolts, is in accordance with the Subsection NF (NF-3280). Allowable stresses are per Appendix XVII-2460 and/or those of Code Case 1644. The stress allowable may be increased according to the provisions of XVII-2110(a) and F-1370(a) for emergency and faulted conditions, respectively.

For tanks and heat exchangers supplied by Westinghouse, the only bolting for supports provided by Westinghouse is on the regenerative heat exchanger. These bolts meet the requirements of Subsection NF and Code Case 1644.

Bolting on supports for Westinghouse supplied Class 2 and 3 pumps meets the requirements of ASME B&PV Code Subsection NF and Code (i.e., Section III or Section VIII).

For flanged connections on tanks and heat exchangers the allowable stress limits are per the applicable section of the ASME Code (i.e., Section III or Section VIII).

For all bolts in the Westinghouse scope of design, an allowable stress equal to or less than the yield strength of the material at temperature is used for all loading conditions for component supports.

BOP Scope:

a. The bolts used in equipment anchorage and component supports including NSSS components, are classified as part of the building structures (i.e., non-ASME) and their embedment lengths are calculated using ACI-318. Allowable stresses for anchor bolts are in accordance with the AISC specification, except for safety-related NSSS component anchor bolts which are in accordance with the ASME Code.

For bolts used in flanged connections on tanks and heat exchangers the allowable stress limits are per the applicable section of the ASME Code (i.e., Section III or Section VIII).

For all bolts in the BOP scope, an allowable stress equal to or less than the yield strength of the material at temperature is used for all loading conditions for component supports.

Response (Continued)

b. In the STPEGS two types of expansion anchor bolts are used for permanent plant installations: the wedge-type (Hilti Kwik-bolt) and the ductile-type (Maxibolts) manufactured, respectively, by Hilti Fastening Systems, Inc. and by Drillco Devices Ltd.

For Hilti Kwik-bolts the allowable design loads in shear and tension are based on tested ultimate load capacities with an applied factor of safety of 4.0 or higher. These allowable loads are for all loading combinations, and specifically, are not increased for faulted or abnormal/extreme environmental loading combinations.

For Maxibolts the allowable design loads prescribed for tension are based on 0.33 times the specified ultimate tensile strength of the bolt steel material (F_u = 125 ksi), and for shear are based on 0.17 times F_u. Comprehensive tests performed on Maxibolts demonstrate that this type of expansion anchors, which is positively anchored into an undercut hole, develops the full ductility and tensile strength of the bolt material without any concrete failure. Therefore, the ultimate load capacity is governed by the steel bolt, and accordingly, the above provisions for allowable loads in accordance with the AISC Specification are appropriate and applicable. In the case of "Abnormal/Extreme Environmental" and "Faulted" loading conditions, the allowable loads are increased by a factor of 1.5.

For evaluation of simultaneous tension and shear loads, the design loads are combined by the following interaction formulas:

$$\left(\frac{t}{T}\right)+\left(\frac{s}{S}\right)\leq 1.0$$ (For Hilti Kwik-bolts)

$$\left(\frac{t}{T}\right)^{5/3}+\left(\frac{s}{S}\right)^{5/3}\leq 1.0$$ (For Maxibolts, whose load capacity is governed by steel material. Accordingly, this interaction formula with 5/3 exponents, which is enveloped by the AISC formula with 2.0 exponents, is used).

Where:

(t, s) = design tension and shear loads, respectively

(T, S) = specified allowable tension and shear loads, respectively

The design tension in expansion anchor bolts is calculated in the component support design process utilizing either a manual calculation or a computer analysis. The baseplate flexibility and prying action effects on the bolt tension are taken into account as described in the STPEGS responses to NRC Bulletin 79-02 (Ref. letter ST-HL-AE-1073 dated 07/30/84).

Question 032.3

We require that the environmental qualification program be provided for at least one item in each of the following groups of Class lE equipment (both NSSS supplied and B.0.P equipment).

1. Switchgear
2. Motor control centers
3. Valve operators (in-Containment)
4. Motors
5. Logic equipment
6. Cables
7. Diesel generator control equipment
8. Sensors
9. Limit switches
10. Heaters
11. Fans
12. Control boards
13. Instrument racks and panels
14. Connectors
15. Penetrations - Including design provisions for the overcurrent protection circuits
16. Splices
17. Terminal blocks and
18. Terminal cabinets

The qualification program should include:

1. Identification of equipment including,
    a. Manufacturer
    b. Manufacturer's type number
    c. Manufacturer's model number

Question 032.3 (Continued)

2. Equipment design specification requirements, including,

   a. The system function requirements

   b. An environmental envelope which includes all extreme parameters, both maximum and minimum values, expected to occur during plant shutdown, normal operation, abnormal operation and any design basis event

   c. Time required to fulfill its function when subjected to any of the extremes of the environmental envelope specified above

   d. The location of the equipment

3. Test plan

4. Test set-up

5. Test procedures

6. Acceptability goals and requirements

7. Test results

8. Identification of the documents which include and describe the above items

9. Justification must be provided when analyses is used to qualify equipment.

In accordance with the requirements of Appendix B of 10CFR50 the Staff requires a statement verifying: (1) that all remaining Class lE equipment will be qualified to the program described above and (2) that the qualification information will be available for an NRC audit.

Provide the information requested above.

Response

Most of the information requested concerning the environmental qualification program for the Class 1E equipment has been submitted to the NRC in Supplement l in WCAP-8587, Revision l (Reference 3.11-1).

The applicant believes further details of sample equipment qualification programs are not necessary for the FSAR. All results and test programs will be available for audit and all Class 1E equipment vendors have Quality Assurance programs in accordance with Appendix B of lOCFR50.

Question 040.8

Potential problem with containment electrical penetration assemblies: Recent operating experience at Millstone Unit No. 2 has shown that the deterioration of the epoxy insulation between splices has caused electrical shorts between conductors within a containment electrical penetration assembly. Indicate what tests and/or analysis that have been performed to demonstrate the acceptability of the design in this regard. Provide whatever information is required to perform an independent evaluation of this aspect of the electrical penetration design.

<u>Response</u>

1. The Millstone No. 2 Electrical Penetration Assemblies were manufactured and supplied by General Electric Company.

   The Electrical Penetrations used for the STPEGS Units 1 and 2 are of Westinghouse design and are not similar to G.E. Series 100 assemblies. A special epoxy compound, developed by Westinghouse, is used to seal the conductors and header. The epoxy compound consists of elastomer materials (1) silicone rubber for long life and high temperature performance, and (2) ethylene propylene rubber for long life and normal temperature performance. There are no internal bare contacts nor cable splices within the penetration assemblies. Additionally, the penetrations do not require any nitrogen gas pressure to function. Nitrogen pressurization is required only as a media for monitoring leakage from the assemblies.

   The electrical penetrations to be utilized at the STPEGS are Westinghouse modular type with a flange bolted bulkhead interface to the primary containment penetration nozzles. Feed-through modules are fully inserted and rest against the header plate. Three clamps keep the module in place by bearing against the shoulder of the module.

2. Westinghouse Creep Tests of the epoxy used in the Containment electrical penetration demonstrated the acceptability of the epoxy in that it did not soften after long-term exposure at 125°C temperatures.

   Westinghouse prototype tests have confirmed that electrical penetrations of the type to be utilized at the STPEGS meet the requirements of IEEE 317-1976 and IEEE 323-1974.

Question 321.4

Provide an analysis with respect to each position in the Regulatory Guide 1.140 (March 1978), "Design, Testing and Maintenance Criteria for Normal Ventilation Exhaust System Air Filtration and Adsorption Units of Light Water-Cooled Nuclear Power Plants," for each atmosphere cleanup system designed to collect airborne radioactive materials during normal plant operation including anticipated operational occurrences. Only the items of noncompliance need be listed with the justification for noncompliance.

Response

The design of STPEGS Normal Ventilation Exhaust Systems' Air Filtration and Adsorption Units complies with Regulatory Guide 1.140 (March 1978) except as noted in Table Q321.4-1 and in Table 3.12-1, Note 80 and as described below.

There are two locations in each unit where HEPA filters were installed in non-nuclear applications: RCB Supplemental Purge Exhaust and Radioactive Vent Header. These installations were to limit migration of particulate to the unit vent and are not required for any safety related function; nor was the application required to credit dose calculations. RG 1.140 and N509/N510 do not apply.

TABLE Q321.4-1

REGULATORY GUIDE 1.140 (MARCH 1978)
NONCOMPLIANCE ITEMS -

Regulatory Position	RCB Containment Carbon Subsystem	MAB	TSC
C.1.a	Complies except radiation levels. The two components that could be jeopardized by radiation exposure are the filter unit's Fire Protection Control Panel and the fan motors. The Fire Protection Control Panel is located outside the Containment in a low radiation zone and the fan motor is capable of performing its function at the radiation level of its location.	Complies except radiation levels. Normal radiation levels are insignificant for the type of equipment involved.	Same as MAB.
C.2.c	Complies except flow rate is not monitored or alarmed. This system does not operate continuously during normal plant operation only for pre-containment access such as refueling. In addition, the system utilizes a 100 percent recirculation mode in lieu of an exhaust air system.	MAB Charcoal Filter Units are equipped with a high filter differential pressure switch. When the filter load increases, causing a subsequent reduction in air flow, an alarm is annunciated in the Main Control Room.	Complies.
C.3.f	Complies, except duct system air flows are less than (-)10 percent of design, for 1.25 times the design dirty filter condition (Ref. ANSI 509-1980 Section 5.10.9 and ANSI 510-1980 Section 8.3.1). A high filter differential pressure switch alarm for changing dirty filters will preclude operation at 1.25 times the design dirty filter condition. See item C.2.c above for further justification.	Complies, except duct system air flows are within ±15 percent of design, for different filter conditions (clean, 1.25 times dirty, and 0.5 times 1.25 dirty). The reduction in filter efficiency due to higher flows is negligible, and it does not effect plant operation and safety since no credit has been taken for these filters in determining the offsite dose release.	Complies.
C.5.d	Complies except allowable bypass leakage is 0.1 percent.	Same as RCB.	Same as RCB.