ENCLOSURE 1

SAFETY EVALUATION REPORT
RELATED TO AMENDMENT NOS. 54 THROUGH 64 FOR
SECTIONS 3.7.1 AND 3.7.2
OF FINAL SAFETY ANALYSIS REPORT
OF WATTS BAR NUCLEAR PLANT, UNITS 1 AND 2
DOCKET NOS. 50-390 AND 50-391
TENNESSEE VALLEY AUTHORITY

INTRODUCTION

In June 1982, the staff approved the last revision of the Final Safety Analysis Report (FSAR) for the Watts Bar Nuclear Plant (WBN), Units 1 and 2, including amendments through No. 53 (Ref. 1). Subsequently, the Tennessee Valley Authority (TVA) revised and submitted FSAR Amendment Nos. 54 through 64. Most of these revisions are technical in nature while others are editorial. This technical evaluation report provides a technical evaluation of the adequacy of all technical amendments in FSAR Sections 3.7.1 and 3.7.2. The evaluations are discussed in the following sections.

EVALUATION

3.7 Seismic Design

This section was added to the FSAR to describe Set A, Set B, and Set C seismic analyses.

The original analyses of seismic Category I structures were performed in accordance with "Set A criteria." Set A criteria are the original design-basis criteria for WBN.

As a result of various issues identified between 1987 and 1989, seismic reanalyses of certain structures were performed. Evaluations of the existing structures used the site-specific response spectra (SSRS) developed for WBN and in conformance with the current standard review plan (SRP, NUREG-0800) criteria. The criteria used for this evaluation are called Set B criteria. SRP 1981 Revision 1, as updated according to the provisions of SRP 1989 Revision 2, formed the basis of the Set B analysis. Specific evaluations for soil-supported structures were performed for (1) the requirement of varying the soil shear modulus by +100 percent and -50 percent from the best estimate and (2) the limiting of the hysteretic soil damping ratio to a maximum value of 15 percent. Although the above requirements have not been incorporated in amendment 64 of the FSAR, TVA submitted the marked -up copy of the related pages of the FSAR changes (Ref. 2, Item No. CAS001). The seismic responses including the amplified response spectra obtained from the Set B analysis are only to be used for evaluation of existing seismic Category I structures, systems and components, and validating the existing design calculations.

To develop seismic loads for new designs and modifications, the Category I structures evaluated to Set B criteria were reananlyzed using the original criteria with new seismic models, including soil-structure interaction. This analysis is called "Set C analysis." As discussed in Reference 4, Set C analysis does not stand by itself. The purposes of this analysis are to calculate structural responses, which represent the results based on the original design basis with the structural model upgrading, and to combine set C analysis results with the Set B results.

The envelope of the seismic responses from the Set B and Set C analyses are to be used in all new designs and modifications to Category I structures.

For certain structures, TVA identified no seismic issues during 1987-1989. Therefore, TVA did not perform Set B and Set C analyses for these structures. However, TVA stated that if these structures need to be evaluated in the future, such evaluations will use Set B criteria. According to TVA, the underground electrical concrete conduit banks were being evaluated to the Set B criteria. However, Amendment 64 states that Set B and Set C analyses were not performed for the underground electrical concrete conduit banks. TVA committed to revise the FSAR to be consistent with the design calculations completed for Watts Bar plant (Ref. 2, Item No. CAS002).

The addition of this section is consistent with the applicant's commitments made in the WBN seismic corrective action program (CAP) plan, Revision 2, (Ref. 4) which the staff approved in Inspection Reports (IRs) 50-390/89-21; 50-391/89-21 (Ref. 3) and, therefore, is acceptable.

3.7.1.1 Ground Response Spectra

FSAR Section 3.7.1.1 specifies the ground response spectra for use as the seismic input motions for the original design (Set A), re-evaluation (Set B), and new design or modification (Sets B+C) seismic analyses of the WBN Category I structures, components, and systems. Ground response spectra for the Set A analysis are the Modified Newmark Response Spectra specified in the previous FSAR. In Section 3.7.1.1.1 of the revised FSAR, the Modified Newmark Response Spectra are redesignated as the "original site response spectra" and are shown in Figures 3.7-1 through 3.7-4 for damping ratios of 0.5 percent, 1 percent, 2 percent, and 5 percent respectively. The corresponding peaks of the ground acceleration (or zero period accelerations) for the operating basis earthquake (OBE) are 0.09g and 0.06g horizontal and vertical motions respectively. Section 3.7.1.1.1 of the revised FSAR specifies that the same original site response spectra be the seismic input motion for the Set C analysis. This criterion is consistent with the one specified in the WBN Seismic Corrective Action Program (CAP) plan, Revision 2, (Ref. 4), which the staff approved in Reference 3, and in conformance with the Standard review plan (SRP) requirements. Therefore, the changes made in this subsection are acceptable.

Section 3.7.1.1.2 specifies the site-specific response spectra that are to be the seismic input criteria for the Set B analysis. The staff accepted the site specific response spectra in its June 1982 safety evaluation report (SER) (Ref. 1). The associated peaks of the ground acceleration for the horizontal and vertical components of the site-specific SSE are 0.215g and 0.18g, respectively, and the corresponding peaks of the ground acceleration for the site-specific OBE are 0.09g and 0.06g. Using the site-specific response spectra as input motion for the Set B analysis is acceptable because it is consistent with the criterion specified in the seismic CAP, Revision 2 (Ref. 4).

On the basis of the evaluation discussed above, the staff concludes that Section 3.7.1.1 of the FSAR as supplemented by the revisions committed to in Reference 2 by TVA is acceptable.

3.7.1.2 Design Time Histories

FSAR section 3.7.1.2 specifies the artificial ground motion (acceleration) time histories that are compatible with the ground response spectra described in Section 3.7.1.1 of the revised FSAR. In its 1982 SER, the staff accepted the four artificial acceleration time histories developed for the original site response spectra. Figures 3.7-1 through 3.7-4 compare the averaged OBE response spectra obtained from the four artificial acceleration time histories for 0.5 percent, 1 percent, 2 percent and 5 percent damping, respectively, with the original site ground response spectra.

These four spectrum plots duplicate the ones contained in the previous FSAR, and they start at the period of 0.05 second. However, this starting period for spectrum plots is different from the 0.03-second starting period listed in Table 3.7-1 of the revised FSAR. In addition, as shown in Figures 1 through 4 of TVA Design Criteria Document WB-DC-20-24, Revision 5, (Ref. 5) other than the ratio of 2 between the SSE and OBE, the OBE averaged spectra in the FSAR differ in shape from the SSE averaged spectra at both short- and long-period ends of the spectra. In Reference 2, the applicant stated that the SSE averaged spectra in WB-DC-20-24, Revision 5, contain some plotting errors, and these errors will be corrected. In Reference 2, TVA also committed to replace FSAR Figures 3.7-1 through 3.7-4 with the corrected spectrum plots. Because the SSE averaged spectra in WB-DC-20-24 start at a period of 0.03 second, this TVA commitment will simultaneously resolve the discrepancies in (1) the starting period between FSAR Table 3.7-1 and FSAR Figures 3.7-1 through 3.7-4, and (2) the shape of the averaged spectra between the revised FSAR and WB-DC-20-24.

The applicant developed three components for the artificial ground motion (acceleration) time history for the SSE site-specific response spectra, as specified in Section 3.7.1.2.2 of the revised FSAR. Two of these histories represent the horizontal components and one represents the vertical component of the ground motion. The SRP requires that the three components of the artificial time history be statistically independent of each other and that their response spectra envelope the site-specific response spectra for all damping ratios to be used in the seismic analyses (analyses of structures, systems and components). In addition, because only a single set of time history components was developed, the SRP requires that the power spectrum density function (PSDF) of each time history component envelopes the 80-percent level of target PSDF within the frequency range of interest. The FSAR states that all three components of the artificial time history satisfy the statistical independence and response spectrum enveloping requirements of the SRP, and that FSAR Figures 3.7-4a through 3.7-4c show a comparison of the 7-percent damaging response spectrum of each time history to the site-specific response spectrum. FSAR Figures 3.7-4d through 3.7-4f also show a comparison of the PSDF of each time-history component with the corresponding 80-percent level of target PSDF. The PSDF of the time history components envelopes the 80-percent level of target PSDF throughout the frequency range of 0.3 to 33 Hz except for a slight local dip at low frequencies of from 0.5 to 0.7 Hz for the second horizontal component (H2) and from 0.40 to 0.42 Hz and from 1.2 to 1.6 Hz for the vertical component. In accordance with IR 50-390/89-21; 50-391/89-21, the staff previously reviewed TVA calculation B26 890427 012 and concluded that the three time-history components satisfy the SRP requirements of statistical independency and spectrum enveloping for the damping ratios of 1 percent, 2 percent, 3 percent, 4 percent, 5 percent and 7 percent. Figures 3.7-4a through 3.74c of the revised FSAR are adopted from this TVA calculation. The deficiency in the FSAR is that it does not present the results of spectrum comparison for damping ratios other than 7 percent. To resolve this deficiency, the applicant committed to include in the next FSAR revision the spectrum comparison results from TVA calculation B26 890427 012 for the damping ratios of 1 percent, 2 percent, 3 percent, 4 percent, 5 percent and 7 percent (Ref. 2). The staff found the TVA commitment to be an adequate resolution. FSAR Figures 3.7-4d through 3.7-4f, which show the PSDF comparison, are adopted from TVA calculation B26 890929 100. The staff previously reviewed this TVA calculation and considered the slight local dip on the PSDF of the H2 and vertical time-history components at certain low frequencies to be inconsequential because the response spectra still envelope the target spectra at these frequencies and because such low frequencies are outside the general frequency range of interest. Thus, based on the discussion in IR 50-390/89-21; 50-391/89-21, the staff concluded that the three components of the site-specific artificial time history also satisfy the SRP requirement for PSDF matching.

Based on the evaluation discussed previously, the staff concludes that FSAR Section 3.7.1.2, as supplemented by the revisions that the applicant committed to in Reference 2, is acceptable.

3.7.1.3 Critical Damping Values

FSAR Tables 3.7-2, 3.7-2A, and 3.7-2B present the damping values used for seismic analyses of Category I structures, systems and components. Although these tables include damping values for soil, structures, systems, and components, this section only covers the technical evaluation of damping values used in structures. For damping values used in soil, this report provides technical evaluations in the appropriate sections relating to the seismic analysis of soil-supported structures. Similarly, the damping values used for systems and components are covered in sections relating to those items.

Tables 3.7-2A and 3.7-2B were included in FSAR amendment 64 inadvertently. The applicant has committed to delete these two tables from this amendment (Ref. 2, Item No. CAS009). Also, the applicant has committed to revise the text of FSAR amendment 64 to eliminate any references to these two tables (Ref. 2, Item No. CAS009).

FSAR Table 3.7-2 shows that the damping values for structures used for the Set C analysis are the same as those used for the Set A analysis. Because Set A criteria represent the original design criteria and has already been approved by the NRC, the staff accepts the damping values used for structures in Set C analyses. In Table 3.7-2, the applicant also proposed to use the damping values specified in Regulatory Guide (R.G.) 1.61 for Set B analyses. As discussed in Reference 3, the use of R.G. damping values is acceptable to the staff for Set B analyses.

For the additional diesel generator building (ADGB), because the design was completed after the issuance of the safety evaluation report (Ref. 1), the Set A analysis had never been performed for this building. Although the applicant performed a Set B analysis, the damping values used, which are consistent with the R.G. 1.61 requirements, are not shown on Table 3.7-2. The applicant committed to revise Table 3.7-2 to include the damping values used (4% for OBE and 7% for SSE) for the ADGB Set B analysis (Ref. 2, Item No. CAS009). For the Set C analysis, 5-percent damping was used for both OBE and SSE, which is the same damping value as specified for "other concrete structures" in the previous FSAR. This damping value is also acceptable to the staff because this damping value is consistent with R.G 1.61 criteria for SSE and for OBE. This damping is a slightly higher value but the enveloping requirement for loads derived from Set B and Set C calculations should compensate for the effect of the damping value.

3.7.1.4 Supporting Media for Seismic Category I Structures

The values of shear wave velocity used in the structural seismic response calculations for either soil or rock foundation materials are presented in a revised Table 3.7-3 for the Set A calculations. These values correspond to the values previously accepted as appropriate for the wave speeds of these foundation materials (Ref. 1). For the Set B and Set C calculations, values of shear wave velocity were generated from soil column analyses (SHAKE-type computations) for the specific foundation configurations under each structure as well as for the input ground motions specified at the top of bedrock in these analyses. The use of SHAKE computer code to calculate the strain dependent soil properties is acceptable to the staff, because this computer code has been used to license other nuclear plants. A range of values of shear moduli was computed for each soil type in the soil column to account for the variation in properties (upper bound, best estimate, and lower bound). These analyses considered initial low strain values and degradation with strain level appropriate for these soil types which accounted for depth in the soil column and the results of field and laboratory data. These approaches are considered acceptable for the Set B and Set C calculations because they agree with the requirements of the SRP.

3.7.2 Seismic System Analysis

3.7.2.1 Seismic Analysis Methods

3.7.2.1.1 Category I Rock-Supported Structures--Original Analyses (Set A)

A number of modifications have been made to the general description of this FSAR section. They are all relatively minor changes in wording. These changes are considered acceptable because they do not alter the content of the paragraph but only serve to clarify the text.

Shield Building

This subsection presents a discussion of the original (Set A) seismic analysis of the shield building. The analysis proposed by the applicant did not involve a technical amendment to the FSAR.

Interior Concrete Structure

This section of the FSAR discussing the Set A seismic analysis of the interior concrete structure does not require technical amendment. However, the elastic modulus of concrete as shown in Table 3.7-6 is in error because it is different from the value specified in Table 3 of the applicant's seismic design criterion WB-DC-20-24, Revision 5 (Ref. 5). The applicant has agreed to correct the elastic modulus of concrete shown in FSAR Table 3.7-6 to be consistent with WB-DC-20-24, Revision 5 (Ref. 5). The staff reviewed the applicant's commitment and found it acceptable.

Steel Containment Vessel

This section of the FSAR discusses the Set A seismic analysis of the steel containment vessel. Because the FSAR has been reorganized, the text, Tables 3.7-5A and 3.7-5B, and Figures 3.7-7B and 3.7-7C simply duplicate the corresponding information in Section 3.8.2.4 of the previous FSAR. Therefore, this topic does not require technical amendment in the revised FSAR. However, it is not clear to the staff how the two different sets of mass eccentricities listed in Table 3.7-5B were utilized in the Set A seismic analysis. The applicant confirmed that the first set of mass eccentricities was used in the production analysis, and that the second set of mass eccentricities (shown in the last column of Table 3.7-5B) was utilized to study the sensitivity of the response of containment to the accidental torsion resulting from an assumed mass eccentricity equal to approximately 5 percent of the diameter of the containment. This accidental eccentricity was also considered in the final design calculations. For the purpose of clarification and consistency, the applicant committed in Reference 2 to delete the second set of mass eccentricities from Table 3.7-5B. The staff found this corrective action acceptable.

North Steam Valve Room

This section discusses the Set A seismic analysis of the north steam valve room. It duplicates the previous FSAR wording except for the deletion of the text referencing another section of FSAR regarding the soil spring calculation procedure which was used in Set A calculations to account the soil-structure interaction effects. Since there is no justification for such deletion, the applicant agreed in Reference 2 to revise the FSAR by cross-referencing Section 3.7.2.1.3 for the soil spring calculation procedure for the north steam valve room. The staff found the corrective action taken by the applicant acceptable.

3.7.2.1.2 Category I Rock-Supported Structures--Evaluation and New Design or Modification Analyses (Set B and Set B+C)

This section was added to the FSAR to describe the Set B and Set B+C seismic analysis performed for the Category I rock-supported structures. SRP Revision 1 (1981), updated to the provisions of SRP, Revision 2 (1989), formed the basis for the Set B and Set B+C criteria. Specific evaluations were performed for: (a) the requirement of varying the soil shear modulus by +100 percent and -50 percent from the best estimate, and (b) limiting the hysteretic soil damping ratio to a maximum value of 15 percent. Although this statement was not included in Amendment 64 to the FSAR, TVA committed to include it in the next revision of the FSAR (Ref. 2, Item No. CAS001).

In the fifth paragraph on p. 3.7-7a, Amendment 64 made reference to Table 3.7-2B for the structure damping values in Set B and Set C analyses. As previously discussed in Section 3.7.1.3, the applicant committed in Reference 2 to delete both Tables 3.7-2A and 3.7-2B and to update Table 3.7-2. To be consistent with this corrective action, the applicant also committed in Reference 2 to replace any reference in the FSAR to Table 3.7-2B by Table 3.7-2. This commitment is acceptable to the staff. Staff review of the applicant's Set B and Set B+C analyses for each individual rock-supported Category I structures are discussed in the material that follows.

Reactor Building (Including Shield Building, Interior Concrete, and Steel Containment Vessel)

For the reactor building, rock-structure interaction was included in the seismic analysis using the SASSI computer code. The use of SASSI computer code is acceptable to the staff (Ref. 17). Tables and figures illustrating the properties and configurations of the individual structure models are:

- Shield Building - Table 3.7-4A; Figure 3.7-5A
- Interior Concrete - Tables 3.7-6A and 3.7-6B; Figures 3.7-8A and 3.7-8B
- Steel Containment - Table 3.7-5C; Figure 3.7-7A

Except for the vertical modeling of the dome, the structural models for the both the shield building and steel containment vessel are essentially the same as those in the Set A analysis. A completely new three-dimensional model was developed for the interior concrete. The structural modeling technique as described in the FSAR and the tables/figures listed above are consistent with those contained in the TVA calculations which have previously been reviewed and accepted by the staff in IR 50-390/89-21; 50-391/89-21 (Ref. 3). Staff review of the FSAR identified two concerns, however. The first concern is the statement in the FSAR that, for the shield building, the beam element properties for the Set B/Set C structure model are the same as those used in the Set A analysis. This contradicts Table 3 of TVA seismic design criteria document WB-DC-20-24, Revision 5 (Ref. 5), which shows that the concrete modulus in the Set A analysis differs from that used in Set B/Set C analyses. Because the Set B and Set C calculations were based on WB-DC-20-24, in Reference 2, the applicant committed to revise the FSAR statement to be consistent with WB-DC-20-24, Revision 5. The staff found the applicant's corrective action sufficient to resolve the first concern. The second concern is the FSAR statement that except for the single-degree-of-freedom vertical dome model, the model configuration, lumped masses, and elastic beam element properties for the steel containment vessel are the same as those used in the Set A analysis. The Set A analysis model as shown in Table 3.7-5B includes mass eccentricities although, as discussed previously, the applicant committed in Reference 2 to delete the last column in Table 3.7-5B for the purpose of clarification. However, this change appears to contradict the statement in the FSAR that "The dynamic model for the SCV Set B and Set C analyses is represented by a 3-D lumped mass, concentric single stick model..." which implies that mass eccentricities were excluded from the Set B and Set C analysis model. Table 3.7-5C, in which the mass and member properties of the model are shown, does not show any mass eccentricities either. The applicant should verify whether or not mass eccentricities were actually included in the Set B and Set C analysis model for the steel containment. Therefore, the second staff concern remains open.

Auxiliary Control Building

For the Set B and Set C analyses, the auxiliary control building (ACB) was represented by a three-dimensional lumped mass model with a fixed base as depicted in FSAR Figure 3.7-9A. The stiffness and mass properties were unchanged from the original Set A analysis except for the concrete shear modulus. These properties are listed in FSAR Tables 3.7-9 and 3.7-10. To account for torsional effects, the eccentricities of the center of mass and center of rigidity were included in the model. The centers of mass and rigidity are as shown in FSAR Table 3.7-9A. An additional eccentricity equal to 5 percent of the maximum building plan dimension was used to calculate the torsional moments that result from accidental eccentricity. The staff confirmed that the information contained in the figures and tables mentioned in this paragraph were the same as shown in the TVA document with RIMS No. B26 89-0427-033. The staff reviewed this document during inspection (Ref. 3) and found that the consideration of the torsional effects including the accidental eccentricity is consistent with the SRP requirements.

The time-history analyses for Set B criteria were based on a structural damping values for concrete structures of 4 percent for OBE and 7 percent for SSE. The statistically independent North-South and East-West components of ground-motion time history were applied simultaneously to the horizontal model. Similarly, vertical time-history analysis was performed on the vertical model. Structural responses and amplified response spectra (ARS) were computed by combining the horizontal and vertical directions using the square-root-of-the-sum-of-the-squares (SRSS) method. ARS were obtained for both OBE and SSE since the structural damping values were different.

The time-history analyses for Set C criteria were based on Set A structural damping of 5 percent for both OBE and SSE. The structural responses and ARS for OBE were computed by combining the two horizontal and vertical responses using the SRSS method. The responses for the SSE were obtained by multiplying the OBE results by a factor of two. This is acceptable since the damping value is the same in this case.

The changes in analysis criteria stated in this section are in accordance with the Seismic Analysis Corrective Action Program (Ref. 4) and TVA Design Criteria WB-DC-20-24 (Ref. 5), which were both accepted by the staff (Ref. 3). Therefore, the FSAR revision discussed in this section is acceptable to the staff.

Essential Raw Cooling Water Intake Pumping Station

For Set B and Set C analyses, the lumped-mass model of the intake pumping station (IPS) was revised from the original Set A analysis. To account for torsional effects, eccentricities between the centers of mass and rigidity were included in the Set B and Set C analyses. Since the IPS is supported on rock, the lumped-mass model was fixed at the base. Horizontal soil springs to account the embedments were not included in these analyses since the addition of such springs were found to have a negligible effect on the natural frequency on the IPS. Also, the highest water level in the IPS was considered in the analyses, since the difference in the fundamental horizontal and vertical frequencies resulting from variations in the water level were insignificant.

The time-history analyses and the generation of ARS for Set B and Set C were performed in accordance with the method described for the auxiliary control building.

The criteria changes stated in this section are in accordance with the seismic CAP (Ref. 4) and TVA Design Criteria WB-DC-20-24 (Ref. 5), which were both reviewed and accepted by the staff (Ref. 3). Therefore, the criteria changes for the seismic analyses of the IPS are acceptable.

North Steam Valve Room

A new structural model was developed for the Set B and Set C analyses, and rock-structure interaction effects were accounted for using the SASSI computer code. The analysis method and model properties as given in Tables 3.7-13A and 3.7-13B, and model configuration as shown in Figures 3.7-10A and 3.7-10B are based on TVA calculations that were previously reviewed and accepted by the staff in IR 50-390/89-21; 50-391/89-21 (Ref. 3). This revised section of the FSAR is therefore acceptable.

Based on the evaluations discussed previously, Section 3.7.2.1.2 of the FSAR as supplemented by the FSAR revisions committed to in Reference 2 by the applicant is acceptable.

3.7.2.1.3 Category I Soil-Supported Structures--Original Analyses (Set A)

In the introductory paragraph to this section of the FSAR, only several editorial changes have been made which clarify the text without changing the intent of the descriptions. They are considered acceptable since they are editorial in nature only. The description of other changes made in this section of the FSAR are summarized below.

Diesel Generator Building:

The changes presented in the description of the soil foundation under the diesel generator building serve to make it conform to the actual conditions existing under the structure. The remainder of the modifications to this paragraph are editorial in nature. These are all considered acceptable since they clarify the description.

Waste Packaging Area:

The modifications made in the descriptions of the waste packaging area and refueling water tank and emergency raw cooling water (ERCW) pipe tunnels are again considered acceptable since they are only editorial in nature and serve to clarify the descriptions of the analysis performed under the original Set A evaluations.

Underground Electrical Conduit Banks:

The modifications to the FSAR presented in this section primarily are concerned with describing two separate aspects of the evaluation of these facilities. The first primary modification contains a detailed description of the analyses performed to estimate bending and shear stresses induced in flexible buried systems due to wave passage effects and is extracted directly from Section 5.2.4 of Design Document WB-DC-20-26 (Ref. 6). The modification serves to make the notation of this section compatible with the descriptions provided in Reference 6 but, in fact, does not significantly differ from the original description contained in the previously accepted FSAR. The only change lies in the notation to determine the peak acceleration of the surface ground motion, given the basement bedrock acceleration. During the inspection (Ref. 3), the soil amplication through the soil layer was reviewed and accepted by the staff. Therefore, this modification is considered acceptable, since it clarifies the analysis used for calculating the stresses in the conduit.

The second major modification made to this section is a detailed presentation of the analyses performed to estimate maximum values of axial stresses induced in buried systems due to the passage of surface seismic waves. These descriptions are also contained in Design Documents WB-DC-20-26 (Ref. 6) and WB-DC-40-31.5 (Ref. 7). These presentations are, in turn, based on the evaluations which have been presented in the open literatures (Refs. 8 through 16). These references have been reviewed and evaluated and are considered to present descriptions of procedures which lead to conservative estimates of the maximum axial loads applied to the systems. On the basis of the review of the design calculations during inspection (Ref. 3) and the review of the open literature the analysis methods contained in the design documents (Refs. 6 and 7) are considered acceptable, and the modifications to the FSAR appropriate.

Class 1E Electrical Systems Manholes and Handholes:

The modification in this paragraph is editorial in nature and is considered acceptable.

Miscellaneous Yard Structures:

The modification in this paragraph is a minor change which has been made to clarify the description of the structures of interest. This modification is editorial in nature and is acceptable.

Structure Interaction Analysis--Waste Package Area (WPA), Condensate Demineralizer Waste Evaporator (CDWE) Building, and Auxiliary Control Building (ACB):

This paragraph has been added to the description of the Set A calculations to summarize the results of the evaluation of the adequacy of seismic gaps between structures. The results of the evaluations of these structures indicate that the gaps provided are adequate to eliminate concern for this issue. On the basis of previous evaluations of the seismic calculations performed during site audit (Ref. 19), the conclusions presented are reasonable. This addition to the FSAR revision is, therefore, considered acceptable.

3.7.2.1.4 Category I Soil-Supported Structures-Evaluation and New Design/ Modification Analysis (Set B and Set B+C)

This new section has been added to the FSAR to describe those analyses performed for the Set B and Set C analyses for soil-supported structures. The analyses performed made use of the SHAKE and SASSI computer programs to determine structural response, including the effects of soil-structure interaction. In this approach, the ground motions for each case considered were specified at the level of the top of bedrock and were transmitted through the soil column to account for soil amplification effects on the free-field motions. The effects of strain dependent shear modulus degradation and equivalent soil damping were suitably accounted for in these calculations using appropriate properties for the particular materials in the overburden. In conformity with the requirements of Standard Review Plan (SRP, NUREG-0800), calculations were performed for upper-bound, best-estimate, and lower-bound soil properties to include the effects of potential soil variability in the analyses, with enveloping of calculated responses used to arrive at design acceleration response spectra for each input control motion.

In the calculations reviewed during various audits conducted at the site (Ref. 19), it was noted that the range of variability included in the analyses was from 1/2 to 3/2 of the best-estimate, low-strain shear moduli, which is less than the SPR required range of 1/2 to twice the best-estimate properties. However, the procedure used to broaden the computed amplified response spectra by ± 15 percent in addition to the variability in soil properties considered was shown for this particular site to conservatively envelope the effect of variation of properties normally considered.

In addition, some calculations using the lower bound soil properties led to effective soil hysteretic damping ratios which exceeded the limits of the current version of the SRP. Additional computations were performed which for this site indicate that these exceedances do not lead to significant changes to the computed structural responses (axial forces, shear and bending moments) and amplified response spectra. The descriptions provided in the FSAR adequately describe the calculations conducted for these soil-supported structures.

On the basis of the detailed audits conducted, the descriptions provided in this section are considered acceptable.

3.7.2.1.5 Category I Pile-Supported Structures

This section was not changed since it refers to the calculations conducted for the Set A criteria including ground motions. Since the following section presents the results of additional computations conducted for the Set B and Set C calculations, the applicant committed to fix the title of this section to indicate that it refers to the original Set A calculations.

3.7.2.1.6 Category I Pile-Supported Structures-Evaluation and New Design/ Modification Analyses (Set B and Set B+C)

The primary addition to this section concerns the description of the evaluation of the additional diesel generator building (ADGB) performed for the Set B and Set C criteria. The ADGB was designed following the design of the other Category I structures and added to the FSAR by amendment 57. The reanalyses performed for this structure made use of the SHAKE and SASSI computer codes as described above, but incorporated the effects of the pile foundations into the structural model. On the basis of staff's previous review (Ref. 17) and the discussion in Section 3.7.2.1.4 above, the application of SASSI and SHAKE computer codes for WBN soil-structure interaction calculation is acceptable to the staff. The seismic response analysis was performed with the CLASSI computer program for the upper-bound, best-estimate, and lower-bound soil columns. The use of CLASSI computer code, which has been widely used to license many other nuclear power plants, is acceptable to the staff. Similar departures from the SRP, as described above for the other soil-supported structures, were noted in other licensee calculations, and the rationale for staff acceptance of the results of these calculations are also applicable for this structure. The description of the analyses presented in this section is considered adequate based on the detailed audits of the seismic calculations performed during the various site visits (Ref. 19).

3.7.2.2 Natural Frequencies and Response Loads for the Nuclear Steam Supply System

The previous FSAR included tables and figures to explicitly show information on natural frequencies, mode shapes, and response loads from the Set A analysis of the nuclear steam supply system (NSSS). Amendment 64 deleted such information and made reference to a Westinghouse report instead (Ref. 18). The staff questioned the basis for this deletion. To resolve the staff concern, the applicant committed in Reference 2 to reinstate the applicable portion from the previous FSAR Section 3.7.2.2 and replace the amendment. This commitment by the applicant resolved the staff concern.

3.7.2.3 Techniques Used for Modeling

3.7.2.3.1 Other Than NSSS

This section addresses the criterion for determining whether or not a sub-system may be decoupled from the structure when developing the structural model. The criterion in the previous FSAR has been amended. The amended criterion is a function of the ratio in mass and frequency between the subsystem and the structure. The staff found that the amended criterion is consistent with the one specified in TVA Seismic Design Criteria WB-DC-20-24, Revision 5, (Ref. 5) which, in general, conform with the SRP requirements and concludes that Section 3.7.2.3.1 is acceptable.

3.7.2.3.2 For NSSS Analysis

The previous FSAR addressed the seismic analysis model of the reactor coolant system and included figures showing the configurations of the models for both the reactor coolant system and reactor pressure vessel. Amendment 64 deleted the description of the NSSS model. Instead, it made reference to Section 5.2.1.10.3 of the FSAR for the description of the NSSS analysis model and to the Westinghouse report (Ref. 18) for Westinghouse-supplied model of the reactor coolant loop system. The staff questioned the basis for this deletion. To resolve the staff concern, the applicant committed in Reference 2 to reinstate the previous FSAR Section 3.7.2.3.2 to replace the amendment. This commitment resolved the staff concern, and the reinstated Subsection 3.7.2.3.2 is acceptable.

3.7.2.4 Soil-Structure Interaction

The primary modification in the description provided in the FSAR concerns descriptions of the procedures associated with the evaluation, new design and modification analyses performed for the Set B and Set C analyses. The procedures and computer analyses used in these analyses are described in Sections 3.7.2.1.3 and 3.7.2.1.4 above. The added paragraphs are consistent with the previous descriptions provided and, based upon the previous reviews (Ref. 3), are considered acceptable.

3.7.2.5 Development of Floor Response Spectra

3.7.2.5.2 Evaluation and New Design or Modification Analysis

Except for Set C analysis of the auxiliary control building, the amplified response spectra (ARS) for both Set B and Set C analyses were generated at the 75 frequency points specified in the revised FSAR Table 3.7-1 and at the natural frequencies of the foundation-structure system. These 75 frequency points are the same as those specified in SRP Table 3.7.1-1. For Set C analysis of the auxiliary control building, the ARS were generated at the 55 period points as specified in the updated FSAR Table 3.7-1, and at the natural periods of the building. These 55 period points are the same as used for Set A ARS generation. The frequencies or periods specified in the updated FSAR Table 3.7-1 for Set B and Set C ARS generation are identical to those specified in Table 5 of WB-DC-20-24, R5, which the staff previously accepted in IR 50-390/89-21 and IR 50-391/89-21 (Ref. 3). The staff, however, had a concern that FSAR Amendment 64 did not specify the time interval for Set B and Set C structural response analyses which generated the floor response time histories, and the time interval for generating ARS. In Reference 2, the applicant agreed to include the following time interval information for Set B and Sec C analyses in the next amendment of the FSAR:

Structure Response Analysis Method	Time Interval for Structure Response Analysis	Time Interval for ARS Generation
Time Domain Method	0.005 sec.	0.005 and 0.0025 sec.
Frequency Domain Method	0.01 sec.	0.010 to 0.0025 sec.

The time interval for structural response analysis is consistent with the specification of TVA Seismic CAP, Revision 2, which has been accepted by the staff (Ref. 3). The time interval, DT, for ARS generation varies with the frequency, f, such that 1/(f*DT) equals or exceeds 10. It is a common industry practice and acceptable to NRC. The applicant's commitment in Reference 2 thus resolved the previous staff concern.

Effect of the three earthquake components on ARS generation due to structural coupling was accounted for in the Set B analysis with either one of the two following methods. With the first method, the three components of earthquake ground motion were input simultaneously to the structural response analysis, so that the floor response time history and the ARS generated thereof automatically included the structural coupling effect, if any. With the second method, one component of earthquake ground motion was input to the structure analysis at a time and the ARS was generated; co-directional ARS due to structural coupling were then combined by the square-root-sum-of-squares (SRSS) rule. In Set C analysis, only the second method was used to account for the effect of three earthquake components on ARS due to structural coupling. The methods discussed previously are consistent with those specified in Tables 4 and 5 of TVA seismic CAP, R2, for Set B and Set C analysis, respectively.

ARS were generated for a constant damping value of 1, 2, 4, 5 and 7 percent for the OBE condition, and 2, 3, 5 and 7 percent for the SSE condition. In addition, ARS for the ASME Code Case N411 variable damping were generated for both the OBE and SSE conditions. To account for the uncertainty in structural modeling, the frequency shift due to the soil property variation, and analysis technique, the peaks of the final Set B and Set C ARS were broadened by a ±15 percent and ±10 percent of the corresponding structural frequencies, respectively, for all Category I structures except the ERCW pipe tunnels. The final Set B+C ARS for use in the new design or modification were then obtained from enveloping the final Set B and Set C ARS.

The spectral damping values and the procedure for generating the final Set B and Set B+C ARS are consistent with the corresponding criteria specified in WB-DC-20-24, R5, and are hence acceptable to the staff.

3.7.2.6 Components of Earthquake Motion

3.7.2.6.1 Original Analysis (Set A)

There is no technical amendment to this section.

3.7.2.6.2 Evaluation and New Design/Modification Analyses (Set B and Set C)

This new section addresses the technique for spatial combination of effects from the three earthquake components in the Set B and Set C analyses of structures:

(1) When response spectrum method of structure analysis is used, co-directional maximum responses from the three earthquake components are combined with the square-root-of-the-sum-of-the-squares (SRSS) technique.

(2) When time-history method of structure analysis is used, either combine the co-directional maximum responses with the SRSS technique or, as an option in the Set B structure analysis, algebraically combine the co-directional concurrent responses at each time step to produce a time history of the combined response.

The spatial combination techniques described above for structural analyses were found to be consistent, in general, with the SRP requirements and the staff concludes that Section 3.7.2.6.2 is acceptable.

3.7.2.7 Combination of Modal Responses

3.7.2.7.1 Other Than NSSS

3.7.2.7.1.1 Original Analysis (Set A)

There is no technical amendment to this section.

3.7.2.7.1.2 Evaluation and New Design or Modification Analyses

This new section addresses the technique for combining modal responses for Set B and Set C analyses of structures, systems, and components other than the NSSS. For response spectrum method of analysis, modal responses are combined in accordance with NRC Regulatory Guide 1.92, Revision 1. For time-history method of analysis, modal responses at each time step are combined algebraically. This is consistent with the criterion specified in TVA Seismic CAP, Revision 2, and the staff concludes that Section 3.7.2.7.1 is acceptable.

3.7.2.7.2 NSSS System

There is no technical amendment to this section.

3.7.2.8 Interaction of Non-Category I Structures With Seismic Category I Structures

There is no amendment to this section of FSAR.

3.7.2.9 Effects of Parameter Variations on Floor Spectra

In this section, the applicant proposed to broaden the spectral peaks of the ARS by ±10 percent based on the corresponding frequencies to account for the uncertainties owing to variations in material properties of the structure and soil foundation, and owing to approximations in structural modeling technique. The ±10 percent peak broadening deviates from the percentage actually applied in the WBN seismic analysis of Category I structures for generating the ARS. As was found during site audit (Ref. 19), the computed floor response spectra were smoothed and peaks associated with the structural frequencies were broadened ±10 percent for Set A and Set C analyses. For Set B analysis the peaks were broadened ±15 percent. The ±10 percent peak broadening is consistent with the criteria specified in TVA seismic CAP. The ±15 percent broadening of the peaks for a Set B analysis is in accordance with Regulatory Guide 1.122. The applicant committed to revise the FSAR to state that the ±10 percent broadening is for Set A and Set C analyses (Ref. 2, Item No. CAS038). As for the Set B analyses, the rule of ±15 percent will be applied. Therefore, the technique used for peak broadening of the floor response spectra is acceptable.

The FSAR also states that: "As an option, response spectra peak shifting as defined in ASME Code Case N-397 was used in some cases." Because this code case has never been used for accounting for the structural parameter variation, the applicant committed (Ref. 2, Item No. CAS039) to remove this statement from the FSAR.

3.7.2.10 Use of Constant Vertical Load Factors

3.7.2.10.1 Other Than NSSS

3.7.2.10.1.1 Original Analysis (Set A)

There are no technical amendments to these subsections.

3.7.2.10.1.2 Evaluation and New Design or Modification Analyses

This new section is unspecific about whether or not constant vertical load factors were used in Set B and Set C analyses. The applicant agreed in Reference 2 to add a statement to the FSAR that "Constant vertical load factors were not used for either Set B or Set C analysis." In addition, because this section is applicable to structures only and not for systems and components, the applicant agreed to delete the words "system and components" from the text. The staff found the applicant's corrective actions acceptable.

3.7.2.10.2 For NSSS

This section was not changed.

On the basis of the findings discussed previously, the staff concludes that Section 3.7.2.10 as supplemented by the FSAR revision committed to by the applicant in Reference 2 is acceptable.

3.7.2.11 Methods Used to Account for Torsional Effects

The only technical change made to this section is the statement that: "For Set B and Set C analyses, modeling of torsional effects was refined by three-dimensional modeling." The seismic models used for Set B and Set C analyses were reviewed and found that the torsional effects were properly included and the accidental eccentricity equal to 5 percent of the maximum structural dimension was considered (Ref. 3). Therefore, the staff finds the change to the FSAR acceptable.

3.7.2.12 Comparison of Responses--Set A versus Set B

This section is new and discusses the comparison of the responses from Set A and Set B analyses. The purposes of making these comparisons were to validate the original (Set A) design calculations based on the Set B analysis results on the existing plant structures, and to identify any features that required detailed reevaluation or upgrading. Currently, these comparisons and evaluations are being performed on a building-by-building basis. As committed to by the applicant, this section of the FSAR will be revised once these evaluations are completed (Ref. 2, Item No. CAS041). The current editorial revisions in this section are acceptable to the staff; however, staff acceptance of this subsection is open until the final review of the results of these comparisons.

3.7.2.14 Determination of Category I Structure Overturning Moments

3.7.2.14.2 Evaluation and New Design or Modification Analysis

This section was added to the FSAR to state that moments, shears, and vertical forces for Set B and Set C analyses were determined by the time-history modal analysis method. This statement is acceptable to the staff since both Set B and Set C seismic analyses were reviewed and found to be acceptable by the staff as documented in NRC Inspection Report 50-390/89-21; 50-391/89-21 (Ref. 3).

3.7.2.15 Analysis Procedure for Damping

There are two technical amendments to this section of the FSAR regarding the method for determining the modal damping value when elements with different damping ratios are considered in one structural model. The first amendment is the deletion of the technique for Set A analysis. According to the previous FSAR, the lowest element-associated damping value was taken to be the modal damping for the original analysis. The second technical amendment specifies the use of strain energy method for determining the composite modal damping for Set B and Set C analyses. The staff questioned the basis for the first amendment, and the applicant agreed in Reference 2 to reinstate the method for original analysis as specified in the previous FSAR. Regarding the method for Set B and Set C analyses, the staff found that the new FSAR contradicts TVA Seismic Design Criteria WB-DC-20-24, Revision 5, which states that "element associated damping shall be accounted for either directly or by the strain energy or composite modal damping approach." The applicant agreed in Reference 2 to revise the FSAR to be consistent with the statement in WB-DC-20-24, Revision 5. The technique, documented in WB-DC-20-24, for determining the composite modal damping is, in general, consistent with the SRP. The staff found both applicant's commitments to be sufficient resolution and concludes that Section 3.7.2.15 is acceptable.

<u>Reference</u>

1. NRC NUREG-0847, "Safety Evaluation Report Related to the Operation of Watts Bar Nuclear Plant, Units 1 and 2, Docket Nos. 50-390 and 50-391, Tennessee Valley Authority," Date June 1982.

2. Letter from E. Wallace (TVA) to NRC, "Watts Bar Units 1 and 2 - Documentation of Resolution to NRC Open issues - Watts Bar FSAR Amendment 64," dated December 18, 1990.

3. NRC Inspection Report Nos. 50-390/89-21; 50-391/89-21, dated May 10, 1990.

4. Letter from E.G. Wallace (TVA) to NRC, "Watts Bar Nuclear Plant (WBN) - Revision to Corrective Action Program (CAP) Plan for Seismic Analysis," dated May 9, 1990.

5. TVA Design Criteria No. WB-DC-20-24, Revision 5, "Dynamic Earthquake Analysis of Category I Structures and Embedments," RIM No. B26-90-0321-076.

6. "Concrete Yard Structures for Class 1E Electrical Systems," Design Criteria Document WB-DC-20-26, Rev. 6, TVA Division of Nuclear Engineering, 7/25/88, RIMS B26-88-0726-009.

7. "Analysis of Safety Related Buried Piping Systems," General Design Criteria Document WB-DC-40-31.5, Rev. 3, TVA Division of Nuclear Engineering, 2/28/90, RIMS B26-90-0305-077.

8. N.M. Newmark, "Problems in Wave Progation in Soil and Rock," Proceedings of the International Symposium on Wave Propagation and Dynamic Properties of Earth Materials, Albuquerque, New Mexico, Aug. 1968.

9. N.M. Newmark, "Earthquake Response Analysis of Reactor Structures," Nuclear Engineering & Design, vol. 20, 1972.

10. G.C.K. Yeh, "Seismic Analysis of Slender Buried Beams," Bulletin of the Seismological Society of America, vol. 64, no. 5, Oct. 1974.

11. H.H. Shah, S.L. Chu, "Seismic Analysis of Underground Structural Elements," ASCE, Journal of the Power Division, vol. 100, no. P01, July 1974.

12. E.C. Goodling, "Flexibility Analysis of Buried Piping," Joint ASME/CSME Pressure Vessels and Piping Conference, Montreal, June, 1978.

13. E.C. Gooding, "Buried Piping - An Analysis Procedure Update," International Symposium on Lifeline Earthquake Engineering, Fourth U.S. National Conference on Pressure Vessels and Piping Technology, ASME, Portland OR, 1983.

14. E.C. Goodling, "Seismic Stresses in Buried Elbows," ASCE National Convention, Boston, 1979.

15. "Seismic Response of Buried Pipes and Structural Components," ASCE Structural Division Committee on Nuclear Structures and Materials, ASCE New York, 1983.

16. M.A. Iqbal, E.C. Goodling, "Seismic Design of Buried Piping," Second ASCE Specialty Conference on Structural Design of Nuclear Plant Facilities, New Orleans, 1975.

17. Letter from S. Black (NRC) to O.D. Kingsley, Jr. (TVA), "Watts Bar Nuclear Plant, Unit 1 - Validation of SASSI Computer Code for Soil-Structure Interaction Analysis," dated October 31, 1989.

18. Westinghouse Report, "Lumped Mass & Stiffness Matrix Mathematical Model Generation for the Reactor Coolant Loop System of the Watts Bar Nuclear Plant, Unit 2," dated January 1985.

19. Memorandum from Peter Tam (NRC) to NRC Document Control Desk, dated October 19, 1990.

Open Items

The applicant should provide additional information to resolve the following open items:

(1) verification of whether or not mass eccentricities were actually included in the Set B and Sect C analysis model for the steel containment.

(2) Comparison of Set A responses with Set B responses - This subsection remains open until the staff final review of these results.

TVA Commitments

To resolve the staff concerns raised during the November, 1990 site audit (Ref. 1), through a letter dated December 18, 1990 (Ref. 2), the applicant made the following commitments:

(1) to revise the FSAR to be consistent with the design calculations completed for Watts Bar plant (Item No. CAS002)*.

(2) to correct the plotting errors contained in the SSE averaged response spectra shown in Design Criteria WB-DC-20-24 and to replace FSAR Figures 3.7-1 through 3.7-4 with the corrected spectrum plots (Item No. GAS005).

(3) to include, in the next FSAR revision, the spectrum comparison results from TVA calculation B26 890427 012 for the damping ratios of 1 percent, 2 percent, 3 percent, 4 percent, 5 percent and 7 percent (Item No. CAS003).

(4) to delete FSAR Tables 3.7-2A and 3.7-2B from Amendment 64 and to revise the text of this amendment to eliminate any references to these two tables (Item No. CAS009).

(5) to revise FSAR Table 3.7-2 to include the damping values (4% for OBE and 7% for SSE) used for the additional diesel generator building Set B analysis (Item No. CAS009).

(6) to correct the elastic modulus of concrete shown in FSAR Table 3.7-6 to be consistent with Design Criteria WB-DC-20-24, Revision 5 (Item No. CAS 014).

(7) to delete the second set of mass eccentricities from FSAR Table 3.7-5B (Item No. CAS016).

* The item numbers in the parenthesis denote the applicant's commitment item numbers shown in Reference 2.

(8) to revise the FSAR by cross-referencing Section 3.7.2.1.3 for the soil spring calculation procedure for the north steam value room (Item No. CAS018).

(9) to include the requirement of varying the soil shear modulus by +100%, -50% from the mean (best-estimate), and the best estimate shear modulus, and limiting the soil hysteretic damping ratio to the maximum of 15% (Item No. CAS001).

(10) to fix the title of Section 3.7.2.1.5 to indicate that it refers to the original Set A calculations.

(11) to reinstate the tables and figures to explicitly show information on natural frequencies, mode shapes, and response loads from the Set A analysis of the nuclear steam supply system from the previous FSAR Section 3.7.2.2 and to replace the amendment (Item No. CAS031).

(12) to include the time interval information for Set B and Set C analyses in the next amendment of the FSAR (Item No. CAS037).

(13) to revise the FSAR to state that the ±10 percent peak broadening is for Set A and Set C analyses (Item No. CAS038).

(14) to remove the statement "As an option, response spectra peak shifting as defined in ASME Code Case N-397 was used in some cases "from the FSAR (Item No. CAS 039).

(15) to delete the words "systems and components" from the text (Item No. CAS040).

(16) to revise FSAR Section 3.7.2.12 when the comparison of the Set A and Set B responses is complete (Item No. CAS041).

(17) to revise the modal damping calculation procedure in the FSAR to be consistent with the statement made in Design Criteria WB-DC-20-24, Revision 5 (Item No. 043).

References

(1) Memorandum from Peter Tam (NRC) to NRC Document Control Desk, dated October 19, 1990.

(2) Letter from E. Wallace (TVA) to NRC, "Watts Bar Units 1 and 2 - Documentation of Resolution to NRC Open Issues - Watts Bar Amendment 64," dated December 18, 1990.

Principal Contributor

T. Cheng

Dated: December 31, 1990

MECHANICAL ENGINEERING BRANCH INPUT TO WATTS BAR NUCLEAR PLANT SUPPLEMENT TO THE SER

3.2 CLASSIFICATION OF STRUCTURES, SYSTEMS AND COMPONENTS

3.2.1 Seismic Classification

The staff identified an issue regarding the seismic classification of structures, systems, and components at Watts Bar (WBN). In Amendment 50, the applicant incorrectly applied Position 3 of Regulatory Guide 1.29 (Reference A) by seismically qualifying mechanical systems comprised of portions which are Category I and portions not seismically qualified through the second change of direction beyond the defined boundary (such as a valve). Regulatory Guide 1.29, Position 3, states that the 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. Subsequently, in Amendment 64, the applicant revised the seismic classification to agree with Position 3. Therefore, this revision is acceptable to the staff.

The staff has also identified an issue regarding the seismic classification of the safety-related conduits and cable trays at Watts Bar (WBN). The cable trays and conduit are designated by TVA as "Seismic Category I (L)" (limited structural integrity) and are only designed and constructed to preclude failure which could reduce the ability of Category I structures, systems, or components to perform their intended function. There are no Seismic Category I cable trays and conduit at WBN. However, the supports for safety-related cable trays and conduit in Category I structures are designated as Seismic Category I, which is acceptable to the staff.

The staff does not accept TVA's safety classification and seismic qualification of cable trays and conduit at WBN. Regulatory Guide 1.29, Position C.1.q clearly states that Class 1E electrical systems are to be designated as Seismic Category I. "Systems" include the cable trays, conduit, supports, and switchgear; not just the cable. Furthermore, the NRC Standard Review Plan (NUREG-0800 dated July 1981) Section 3.7.2 states that non-Category I structures are to be analyzed and designed to prevent their failure under SSE conditions in a manner such that the margin of safety of these structures is equivalent to that of Category I structures. TVA's approach to classify its cable trays and conduit as Seismic Category I (L) is considered an open item.*.

3.2.2 System Quality Group Classification

3.2.2.1 Class A

Class A quality standards that are required for pressure-containing components of the reactor coolant pressure boundary are defined by the applicant as reactor coolant pressure boundary components whose failure could cause a loss of reactor coolant which would not permit an orderly reactor shutdown and cooldown assuming that makeup is only provided by the normal makeup system. Branch piping 3/8 inch inside diameter and smaller, or protected by a 3/8 inch diameter or smaller orifice, is exempted from Class A. The applicant has also stated that branch piping for the pressurizer steam space instrumentation nozzles (0.83 inch ID) is also exempted from Class A.

The staff reviewed the applicant's basis for the premise that a break in the steam space can be made up with normal charging. As part of an audit held at the WBN site on November 5-9, 1990, the staff reviewed a Westinghouse letter to TVA, "Pressurizer Class Breaks," WAT-D-6345, TVA Calculation No. NEB 850118604, dated January 18, 1985, which determined the maximum steam leakage from the pressurizer at 2250 psi to the containment through a 0.83 inch I.D. instrumentation nozzle. The results of the calculation indicated that the normal makeup system can provide an equivalent makeup flow rate and that a flow restrictor is not required in the pressurizer steam space instrumentation nozzle. On the basis of its review, the staff concludes that the calculation in the Westinghouse letter provides adequate justification for exempting the pressurizer steam

*See letter, P. S. Tam to O. D. Kingsley, November 29, 1990.

space instrumentation nozzles from the Class A quality group, and the Quality Group classification of the pressurizer steam space instrumentation nozzles is acceptable.

3.2.2.5 Relationship of Applicable Codes to Safety Classification for Mechanical Components

The applicant has provided a description of the use of paragraphs from Editions and Addenda of Section III of the ASME Boiler and Pressure Vessel Code (ASME Code) that are later than the Code of Record for the application. In Amendment 64, the FSAR was revised to describe the controls TVA places on the use of later Editions and Addenda of the ASME Code as it relates to the design of components for which TVA is the designer. The applicant's controls ensure that later Editions and Addenda have been incorporated by reference into 10 CFR 50.55a and that all related requirements necessary to support use of specific paragraphs in later Editions and Addenda are met in accordance with NA-1140. The use of later provisions of the ASME Code is permitted by paragraph NA-1140 of the 1971 Edition with Addenda through Summer 1973 (Code of Record). On this basis, the staff finds that the applicant's use of later Code paragraphs is acceptable.

The use of ASME Code Cases for the design or evaluation of plant components are required to be approved by the staff on a case-by-case basis. Any additional requirements or limitations shall be satisfied in accordance with Regulatory Guide 1.84 (Reference D) or Regulatory Guide 1.85.

3.6 PROTECTION AGAINST DYNAMIC EFFECTS ASSOCIATED WITH THE POSTULATED RUPTURE OF PIPING

In Amendment 64, FSAR Section 3.6A.2.1.2 was revised such that circumferential ruptures and longitudinal splits are no longer postulated by the applicant to satisfy a minimum number of intermediate breaks in high energy Class 1, 2, and 3 piping and piping containing high/moderate energy interfaces. The applicant proposes to eliminate from design considerations those breaks generally referred to as "arbitrary intermediate breaks" which are defined as those break locations which, based on piping stress and analysis results, are below the stress and fatigue limits specified in BTP MEB 3-1 (Revision 1) but are selected to provide a minimum of two postulated breaks between the terminal ends of a piping system. The FSAR change is consistent with Revision 2 to the Branch Technical Position MEB 3-1 of Standard Review Plan Section 3.6.2 in accordance with Generic Letter 87-11 "Relaxation in Arbitrary Intermediate Pipe Rupture Requirements" dated June 19, 1987 and is thus acceptable to the staff.

The staff has identified an issue regarding the determination of intermediate break locations based on high stress limits. In FSAR Section 3.6A.2.1.2 (Item 1 A), the licensee has established a pipe stress limit of 3.0 Sm for the stress intensity range (Sn) as a criterion for postulating intermediate break locations for high energy Class 1 piping runs. This limit is consistent with the 1971 edition of the ASME Boiler and Pressure Vessel Code Section III Subparagraph NB-3653.1 in which Sn is calculated according to equation 10 which sums stresses due to pressure, thermal and earthquake cyclic moments, gross structural or material discontinuity, and a linear thermal gradient (delta T1). Because the applicant's equation does not include a factor for delta T1, a pipe rupture limit of 2.4 Sm should be followed to account for the lower Sn value consistent with SRP, Revision 1, dated July 1989. In a letter dated December 18, 1990 (Reference E), TVA agreed to either include the delta T1 term in equation 10 or reduce the break postulation limit to 2.4 Sm. The staff finds that TVA's commitment adequately resolves this issue consistent with the guidelines of the SRP and is thus acceptable.

The applicant has provided information regarding the analysis of jet impingment loads from postulated breaks. In FSAR Section 3.6A.1.1.2, test data and analysis developed in NUREG/CR-2913 "Two Phase Jet Loads" dated January 1983 are used to establish the criteria that unprotected components located at a distance greater than 10 diameters from a pipe break are assumed undamaged by a jet of steam or subcooled liquid that flashes at the break without further analysis. The staff has previously reviewed the methodology used in NUREG/CR-2913 for determining the effects of such a jet on components at a distance greater than 10 diameters and has found it acceptable. Similar application of this criteria has been approved for other plants and is therefore acceptable for Watts Bar.

3.7 SEISMIC DESIGN

3.7.3 Seismic Subsystem Analysis

The staff has identified an issue regarding the number of earthquake stress cycles considered in the design of seismic subsystems. The applicant has stated that the number of equivalent peak stress cycles considered for the OBE and SSE are 20 cycles and 10 cycles respectively. Previously, the total number of cycles considered for OBE and SSE were 600 and 300 respectively, which was acceptable to the staff. As stated in the applicant's December 18, 1990 letter (Reference E) the reduced number of cycles specified applies to non-NSSS Category I subsystem components and ASME Section III Class piping and component fatigue analysis, and for the seismic testing of equipment. This criteria is not used in the qualification of cable tray, conduit, and HVAC systems. The number of equivalent peak stress cycles is based on the occurrence of two OBE's and one SSE during the design life of the plant (40 years). For each event ten cycles of maximum stress are considered based on the SRP (Reference F) and IEEE 344-1975 (Reference G).

For equipment and piping systems, the use of ten peak stress cycles for SSE is consistent with Sections 3.7.3 and 3.9.2 of the SRP and IEEE 344-1975 requirements and is, thus, acceptable to the staff. For the OBE case, the use of five OBE events for the entire design life of the plant is a guideline specified in Sections 3.7.3 and 3.9.2 of the SRP and IEEE 344-1975. The number of peak stress cycles for each OBE may be obtained from the actual time history or a minimum of 10 peak stress cycles can be assumed. If 10 peak stress cycles are used for each OBE then a total of 50 peak stress cycles for the entire design life of the plant would be required. Because the number of OBE events specified by the applicant does not meet the guidelines of the SRP and IEEE 344-1975, this issue remains open and will be addressed in a future supplement to the SER.

FSAR Section 3.7.3.3.1.1 was modified and a new FSAR Section 3.7.3.3.1.3 was added to describe the mass modeling of piping, HVAC, conduit, and cable tray subsystems for seismic evaluation. The applicant stated that continuous or discrete mass models are developed for manual or computer analyses. The adequacy in selecting and locating lumped masses and the consideration of all significant modes of vibration were reviewed. As described in the applicant's December 18, 1990 letter to the NRC (Reference E), in addition to the continuous mass, additional lumped masses are located at significant concentrated weights such as heavy fittings or other in-line or attached commodities. A sufficient number of masses are included such that additional masses (or degrees-of-freedom) would not increase the predicted response by more than 10%. Alternatively, the number of masses are modeled to be at least twice as many as the number of modes with frequencies less than 33 Hz. For piping, the spacing is based on 33 Hz frequency for spans between mass points with at least three mass points between supports in the same direction. The modeling methods described above are consistent with Section 3.7.2 of the SRP criteria (Reference F) for modeling of subsystems and, therefore, are acceptable.

FSAR Section 3.7.3.4.1 was revised to include the commitment that the frequencies of the subsystems are selected such that all significant modes of vibration are included in the analysis. Frequencies of simplified analysis models are determined by solutions of closed-form expressions. Frequencies of detailed analysis models are determined by computerized solutions. For HVAC, conduit, and cable tray systems the applicant's letter (Reference E) states that the FSAR will be revised to indicate that the number of modes included in the calculations are selected such that the inclusion of additional modes do not result in more than a 10% increase in responses. Alternatively, the dynamic analysis considers all modes up to 33 Hz and includes an additional check for any missing mass participation factors. These criteria are consistent with the guidelines stated in Section 3.7.2 of the SRP (Reference F) and are acceptable.

As stated in the applicant's December 18, 1990 letter (Reference E), for piping systems, Section 3.4.5 of the Watts Bar piping design criteria requires that all modes below 33 Hz be included in the piping analysis. Also, the contribution of higher modes (usually calculated by missing mass method) are combined with those of lower modes by the square-root-of-the-sum-of-squares (SRSS). The staff's review of the applicant's letter and design criteria finds that the applicant's methodology is consistent with the guidelines of Section 3.9.2 of the SRP (Reference F) for selecting significant frequencies for simplified and computerized piping analyses and is, thus, acceptable.

In FSAR Section 3.7.3.5.1, the applicant revised its description of the equivalent static load method and states that a multi-mode factor of 1.2 will be used for analysis of HVAC, conduit, and cable tray subsystems in lieu of the 1.5 factor previously used. A 1.5 multi-mode factor is in accordance with the guidelines of the SRP and was previously accepted by the staff in Section 3.7.3 of the Watts Bar SER. The justification for a 1.2 multi-mode factor was reviewed by the staff in an audit held on November 5-9, 1990 and is contained in Sargent & Lundy Calculation WCG-1-397 entitled "Two Degree of Freedom Comparison to a Couple System Response," dated February 21, 1990. The calculation uses the Complete Quadratic Combination (CQC) method to combine the modal responses in the response spectrum analyses which yields varying results to the methods recommended in Regulatory Guide 1.92 (Reference K). Also, the staff found that the selected configurations in the study might not bound all of the installed configurations at WBN. The applicant, in a letter to the NRC (Reference E), stated that additional calculations are currently being performed in order to address the concerns regarding bounding configurations and they will be submitted for the staff's review when complete. Therefore, this item remains open and will be addressed in a future supplement to this SER.

FSAR Section 3.7.3.6 was revised to describe the method used for the combination of the three components of earthquake motion for equipment, HVAC, conduit, and cable tray subsystems. Seismic input in each major horizontal direction is applied separately with the vertical input. Horizontal and vertical responses are combined by absolute summation and the larger of the two will be used for evaluation and design of the commodities. This method was utilized for all three seismic inputs Set A, Set B, and Set (B+C). The staff's evaluation of the development of Set A, B, and B+C seismic loads for original analysis/qualification, evaluation, and new design/modification is described in Section 3.7.2 of this supplement. The applicant's procedure for combining spatial components (one horizontal and vertical components) by the absolute sum method has been previously approved in Section 3.7.3 of the Watts Bar SER (Reference C) and, therefore, is acceptable.

A new FSAR Section 3.7.3.6.1 was added in Amendment 64 to provide specific requirements for piping subsystems with regard to the combination of the maximum directional responses caused by each of the three components of earthquake motion by SRSS. The applicant's procedures for combining spatial components of piping subsystem responses by the SRSS method are in accordance with the guidelines of Section 3.9.2 of the SRP (Reference F) and are, thus, acceptable.

In Amendment 64, FSAR Section 3.7.3.8.1 was revised to provide a more detailed description of the Codes used for piping analysis. The staff raised an issue regarding the analysis of some classes of pipe using ANSI B31.1. The applicant has stated in a letter dated December 18, 1990 (Reference E) that for piping analysis, the use of ANSI B31.1 applies to nonnuclear safety piping only which is acceptable to the staff.

In Amendment 64 to the FSAR, the applicant provided a listing of specific ASME Code Cases it proposes to use in the design of piping systems. The Code Cases are:

1. N-313, Alternate Rules for Half Coupling Branch Connections, Section III, Division 1, Class 2.

2. N-397, Alternative Rules to the Spectral Broadening Procedures of N-1226.3 for Class 1, 2, and 3 Piping.

3. N-411, Alternate Damping Values for Seismic Analysis of Classes 1, 2, and 3 Piping Systems, Section III, Division 1.

4. 1606, Stress Criteria for Section III, Class 2 and 3 Piping Subjected to Upset, Emergency, and Faulted Operating Conditions.

5. N-319, Alternate Procedure for Evaluation of Stresses in Butt Weld Elbows in Class 1 Piping, Section III, Division 1.

6. N-463, Evaluation Procedures and Acceptance Criteria for Flaws in Class 1 Ferritic Piping That Exceed the Acceptance Standards of IWB-3514.2.

7. N-122, Stress Indices for Integral Structural Attachments, Section III, Division 1, Class 1.

8. N-318, Procedure for Evaluation of the Design of Rectangular Cross Section Attachments on Class 2 or 3 Piping, Section III, Division 1.

9. N-391, Procedure for Evaluation of the Design of Hollow Circular Cross Section Welded Attachments on Class 1 Piping, Section III, Division 1.

10. N-392, Procedure for Evaluation of the Design of Hollow Circular Cross Section Welded Attachments on Class 2 or 3 Piping, Section III, Division 1.

The staff requested that the applicant specify the particular revision and date of the Code Cases it intends to use in its piping analyses. The applicant committed to use those Code Cases that are endorsed by RG 1.84 (Reference D) and will revise its FSAR to include the specific revisions of the Code Cases. Upon submittal of this information to the staff, the staff will complete its review and evaluation of the acceptability of each Code Case. The staff's evaluation of Code Case N-411 is provided in Section 3.7.3 of this supplement. The staff's evaluation of the remaining Code Cases will be included in a future supplement to this SER.

The staff identified an issue regarding the applicant's simplified seismic analysis of equipment. The applicant stated that for equipment qualification the peak acceleration of the applicable floor response spectra is multiplied by a factor of 1.5 if natural frequencies are not determined. Lower load factors (between 1.0 and 1.5) are only used when justified by frequency analysis. Previously, a factor of 1.5 was used regardless of frequency. As stated in Section 3.7.3 of the WBN SER (Reference C), it was understood that for balance-of-plant (BOP) equipment, the peak acceleration value of the applicable response spectrum was increased by a factor of 1.5 and applied as an equivalent static load factor to the entire mass of the equipment being evaluated.

The applicant's letter dated December 18, 1990 (Reference E) stated that when the equipment's natural frequency is determined and there is only one mode below 33 Hz (as determined by test or analysis) the equivalent static loads can be determined by using a minimum factor of 1.0. The peak acceleration of the floor spectra is used (without any load factor) provided any one of three listed criteria is met. One of these criterion is if the fundamental frequency of the equipment is lower than the rigid frequency but its other frequencies are higher than the rigid frequency. Under this condition, the response would be indicative of a one degree-of-freedom system for which a load factor of 1.0 would be appropriate. In addition, the staff finds the use of the peak acceleration from the floor response spectrum curve is conservative. Thus, the staff concludes that the use of a 1.0 load factor coupled with the peak acceleration from the floor response spectrum curve, when there is only one mode below 33 Hz, is acceptable.

The staff reviewed the applicant's criteria for consideration of torsional effects of eccentric masses in piping analysis. In Amendment 64, the applicant included member stiffnesses in the analysis to simulate the flexibility of cantilevers. Previously, the cantilever members were assumed to be infinitely stiff. This revision is consistent with the guidelines of Section 3.9.2 of the SRP (Reference F) and is, thus, acceptable.

FSAR Section 3.7.3.15 refers to Tables 3.7-2 and 3.7-24 for specific values to be used for the critical damping of structures, systems, and components. In Amendment 64, Table 3.7-2 has been revised to include damping values specifically for cable tray, conduit, HVAC, and equipment subjected to Set A, B, and B+C input loads. Previously, there were no damping values specifically given for these subsystems and components.

For conduit systems subjected to Set A loads, FSAR Table 3.7-2 duplicates the damping value of 2% for the SSE from the previous FSAR. No value is presented for the OBE case because the design is based on SSE only. For Sets B and B+C, damping values of 4% and 7% are used for the OBE and SSE respectively. During an audit held on November 5-9, 1990, the staff reviewed the justification for these damping values. The basis for the damping values for Set B and Set B+C are documented in a report of conduit tests performed by TVA "Summary Test Report on Damping in Electrical Conduit," CEB-BN-1028, dated June 1987, as well as in test reports by ANCO Engineers," Cable Tray and Conduit Raceway Seismic Test Program," Report No. 1053-21.1-4 (Volumes I-VI) and by Wyle Laboratories, "Seismic Qualification/Verification of Various Aluminum Electrical Conduit Configurations," Report No. 17743-1 (CEB-BN-1002), Volumes I and II, dated May 9, 1986.

For comparison purposes, NRC Regulatory Guide 1.61 (Reference P) recommends for welded steel structures, damping values of 2% and 4% for OBE and SSE, respectively. For bolted steel structures, damping values of 4% and 7% for OBE and SSE, respectively, are recommended. Conduit systems at WBN are primarily constructed of welded steel members (support frames) with some bolting-type connections. Typically, the bolting-type connections are the conduit clamp attachment to the support frame, concrete anchors when used, and the threaded fittings.

The staff review of the test reports concluded that the results of the Wyle tests are of limited value since they were performed only on aluminum conduit, whereas, most conduit at WBN are made of steel. For the ANCO tests which were performed at high acceleration levels (comparable to the SSE) much of the data suggests the use of approximately 4-5% damping based on a mean-value-minus-one standard deviation. The applicant had proposed the use of 7% damping for the SSE based on the TVA tests using the average value of damping times 0.85 to account for variation in the cable fill.

The staff has identified an issue regarding the use of 4% and 7% damping values for conduit systems. The staff determined there is insufficient basis for using average values of the damping test values particularly since the scatter of test data ranged from 3% to 22%. A second concern is whether the use of the limited TVA test data sufficiently covers the variation in configurations and design parameters such as cable fill, span lengths, diameters, and supporting conditions. The applicant provided some additional information in a letter dated December 18, 1990 (Reference E) which will require additional review. In its December 18, 1990 letter, (Reference E), the applicant also stated that the use of 4% and 7% damping values for OBE and SSE has precedence at some other nuclear power facilities, such as Vogtle (4% OBE/7% SSE), Byron and Braidwood (4% OBE/7% SSE), Diablo Canyon (7%), and Grand Gulf (7% OBE/7% SSE). However, it is not clear to the staff whether the bases to justify the use of higher damping values for these plants are applicable to WBN. Therefore, based on the above two concerns, this issue remains open.

For the HVAC subsystems, the staff also identified an issue regarding the proposed damping ratios in Table 3.2-7. As a result, TVA agreed to apply the R.G. 1.61 (Reference P) damping values for bolted structures to companion angle ducts, and the R.G. 1.61 values for welded structures to welded ducts. The damping values for pocket-lock construction are the same as those previously accepted by the staff for the Sequoyah Nuclear Plant (Reference R). In the applicant's December 18, 1990 letter to the NRC (Reference E), the applicant agreed to revise the HVAC damping ratios in FSAR Table 3.2-7 as follows:

	Set B		Set (B+C)	
	OBE	SSE	OBE	SSE
Companion Angle	4%	7%	4%	7%
Pocket Lock	7%	7%	7%	7%
Welded Duct	2%	4%	2%	4%

The staff finds the above values to be acceptable.

For cable tray systems, the damping ratios presented in FSAR Table 3.7-2 for the OBE and SSE, respectively, are 4% and 5% for Set A and 4% and 7% for Sets B and B+C. As justification for these values, the applicant stated that the values are consistent with the recommended values in NRC Regulatory Guide 1.61 (Reference P) for bolted structures and with the results of tests conducted by ANCO as documented in, "Cable Tray and Conduit Raceway Seismic Test Program," Report No. 1053-21.1-4 (Volumes I-VI). The cable tray systems, as installed at WBN, consist of cable tray assemblies bolted to each other and bolted to welded support frames which in turn are typically fixed with a bolted anchorage. The tray assemblies themselves have bolted support attachments, splice plates and in some cases bolted cover plates. As such, the systems can reasonably be expected to exhibit the characteristics of bolted structures for which damping ratios of 4% and 7% for the OBE and SSE, respectively, are recommended in R.G. 1.61. Further, in the ANCO tests, with cable tray assemblies bolted directly to a relatively rigid shake table frame, the minimum observed damping ratio was 7.5% for coated cables and 20% for uncoated cables, for 100% loaded trays at acceleration levels comparable to the OBE. These test conditions correspond with the actual cable system installations and the test results should be indicative of the results to be expected in the field. Based on these observations, the staff finds the applicant's damping ratios assigned to cable tray systems acceptable.

For equipment/components, the FSAR specifies damping values of 2% and 3% for the OBE and SSE, respectively. These damping values are applied to all three sets of seismic loads, Set A, B, and B+C. For Seismic Category I piping analysis, the applicant specifies damping values of 2% and 3% for OBE and SSE, respectively, for piping 12" diameter and larger and 1% OBE and 2% SSE for piping less than 12" diameter. These damping values are applied to seismic load Sets B and B+C. The damping values for Set A are unchanged from the previous FSAR. Because these damping values for equipment and piping are in agreement with Regulatory Guide 1.61 (Reference P), these damping values are acceptable to the staff.

The applicant has also proposed to use damping values from ASME Code Case N-411 as an alternative for piping systems. ASME Code Case N-411 has been found acceptable to the staff subject to certain limitations as specified in Regulatory Guide 1.84. In order to satisfy one of the limitations, the staff requires that the ASME Code Case N-411 damping values only be used in piping system response spectrum analyses where the Watts Bar seismic load set B+C is used. Subject to the above limitations, the staff finds the use of ASME Code Case N-411 for Watts Bar is consistent with Regulatory Guide 1.84 and is thus acceptable.

The staff reviewed the analysis of mounting for equipment and components. The applicant's criteria considers the flexibility of non-rigid supports to floor or wall-mounted equipment and components. For non-rigid supports, a coupled analysis of the equipment and/or component assembly and its support and/or anchorage is performed. For line-mounted equipment/components and their mountings, the subsystem response (e.g. piping response) at the equipment/component location is kept below the device qualification level. These methods adequately account for the potential amplification due to support flexibilities of equipment and components and are, thus, acceptable. To address the potential effects due to wall and floor flexibility on the amplified floor response spectra for the subsystem evaluations, a separate study was performed by TVA. The study has been previously reviewed by the staff as documented in NRC Inspection Reports 89-21 dated May 10, 1990 (Reference S) and in an audit report dated October 10, 1990 (Reference T), and has been found acceptable.

The staff reviewed the loads and load combinations used in the design of HVAC ducts and duct supports. The staff identified two concerns regarding the loads: (1) LOCA and high energy line break (HELB) pressure loads were not considered in the design of HVAC ducts inside containment and (2) the definition of fluid-induced loads did not include loads due to sudden damper closure.

The applicant agreed in a December 18, 1990 letter to the NRC (Reference E) to address the first concern by including a load in all the applicable duct load combinations which include accident pressure exterior to the duct due to jet impingement or compartmentalization pressure. Where possible, the duct will be protected from these effects. Otherwise, the duct shall be designed as necessary to withstand the forces from these effects consistent with allowable stress criteria.

The applicant responded to the second concern by stating that loads due to sudden damper closure are not considered because system operation precludes these loads. Fire dampers can only close when the fans are stopped and forced air flow is discontinued. Therefore, no pressure transients are expected to occur. In addition, other dampers, which close in response to an initiating accident event, have closure times ranging from approximately 4 to 16 seconds. These relatively slow closure rates preclude any significant loads due to pressure transients. The staff's review of the applicant's response finds the system operation adequately precludes the sudden damper closure load.

Therefore, the staff finds the applicant's methods for applying loads and load combinations to HVAC systems acceptable.

Since the original design of the structures, systems, and components at Watts Bar, a number of issues were raised by various sources. These sources include NRC inspection reports, Watts Bar reports (NRCs, CAQRs, PIRs, and SCRs), employee concerns, and internal and external reviews. Problems were identified in the area of design, construction, and inspection/quality assurance of the plant features.

To resolve these issues, a Corrective Action Program is being conducted by the applicant which will assure that WBN plant features meet upgraded design criteria and licensing commitments. One phase of this validation program consists of an engineering evaluation to validate the adequacy of the existing designs. The approach taken by the applicant in the Corrective Action Program is to validate the existing commodities by grouping the components having similar configurations and then evaluating the "worst case" or "critical case" and performing "bounding calculations."

The "worst case" approach involves identifying from actual installed configurations the most severe example of a given population. The worst case approach is being used to validate items such as platforms, pipe whip restraints, concrete and masonry walls.

The "critical case" approach uses actual or hypothetical configurations that combine attributes that have the greatest effect on the ability of the plant system or component in meeting allowable stresses. The critical cases combine the attributes from the various actual configurations in a given population. The critical case approach is being used to validate conduit systems, cable tray systems, and HVAC systems.

Bounding calculations envelop the effects of varying parameters on a representative population. Initially the features are grouped and the enveloping attributes are identified. Then, the bounding calculation determines the maximum stress for an actual or hypothetical condition. Bounding calculations may be performed to evaluate worst cases or critical cases. Presently bounding calculations are used for the evaluation of small bore pipe support variances, equipment seismic qualification, certain cable tray configurations, and other components.

The above descriptions are based on the definition of the worst case, critical case, and bounding calculation as provided by the applicant in Reference "AE" and as presented by the applicant during the site audit. Since all three approaches rely on either the actual configuration and attributes or the hypothetical combination of attributes, which are more severe, the use of the worst case, critical case, and bounding calculation approach is considered acceptable by the staff. The procedures used to perform the walkthrough as well as the basis for grouping the configurations and identifying critical attributes have not yet been reviewed. Thus, the implementation of these three methods will be reviewed and discussed in a future supplement to the SSER or in an NRC inspection report.

3.9 MECHANICAL SYSTEMS AND COMPONENTS

3.9.1 Special Topics for Mechanical Components

The applicant performed a non-linear elastic-plastic analysis of the feedwater system inside the containment. This analysis was used to evaluate the pressure boundary integrity of the feedwater piping for the feedwater water hammer that would occur due to the check valve slamming shut following a postulated rupture at the main header in the Turbine building. The applicant has proposed to use the rules in Appendix F of the ASME Code to develop acceptance criteria for the piping. However, as part of the piping evaluation the applicant has also proposed assuming that certain supports fail when the loads exceed their calculated capacities. The staff considers this criteria and the applicants proposed method of analysis an open issue requiring further staff review.

3.9.3 ASME Code Class 1, 2 and 3 Components, Component Supports and Core Support Structures

The staff identified an issue regarding the use of experience data as a method of seismic qualification of Category I (L) piping. Presently, the staff does not permit the use of experience data to qualify safety-related piping systems for the plant design loading conditions. Category I (L) systems are systems whose failure could affect the functioning of a safety-related system. The applicant, in FSAR Section 3.2, stated that Category I (L) systems are seismically qualified to meet the intent of position 2 of Regulatory Guide 1.29. The applicant provided information regarding the proposed methodology to use experience data. The staff is continuing its review of this item and the resolution will be addressed in a future supplement to the SER.

3.9.3.3 Design and Installation of Pressure Relief Devices

The staff also reviewed the design and installation of pressure relief devices. The applicant has provided revised set pressures, accumulation pressures, and blowdown pressures for the WBN main steam safety valves. The staff is continuing its review of these valve operating characteristics. Therefore, this issue is a confirmatory item and will be addressed in a future supplement to the SER.

3.9.3.4 Component Supports

The applicant proposed new criteria for service load combinations and associated stress limits for ASME Code Class 1, 2, and 3 piping supports in FSAR Section 3.9.3.4.2. For linear supports, the applicant had previously proposed load combinations and stress limits that were based on SRP Section 3.8.3 (NUREG-0800). The applicant's new criteria for load combinations and associated stress limits is based on AISC stress allowable criteria using the service level A, B and C stress limit factors currently specified in Subsection NF of the ASME Code. The applicant has placed an additional restrictions on the stress limits that, for all loading combinations, the tensile stresses shall not exceed 0.9 times the material yield stress and the buckling loads shall not exceed two thirds critical buckling. For component standard supports, the applicant proposed load combinations and associated stress limits which are either based on criteria in Subsection NF of the ASME Code or, for those standard component supports not originally designed to Subsection NF of the ASME Code, on criteria in Manufacturers Standard Specification (MSS) SP-58. The staff finds that the specified service load combinations and associated stress limits for piping supports in systems classified as Seismic Category I provide a conservative basis for the design of pipe support components to withstand the most adverse combination of loading events without loss of structural integrity.

The applicant proposed new support stiffness and deflection limits for seismic Category I piping supports in FSAR Section 3.9.3.4.2. The staff has requested that the applicant provide additional information in support of this change in criteria. Upon completion of its review of the additional information supplied by the applicant, the staff will report its findings in a supplement to the SER.

In Section 3.9.3.4 of the Watts Bar SER dated June 1982 (Reference C), the staff stated that the applicant had responded to IE Bulletin 79-02 (Reference AA) for the Watts Bar facility in a letter dated July 7, 1980. At that time, the staff reviewed the applicant's response with respect to pipe support baseplate flexibility and its effect on anchor bolt loads and determined that the staff needed additional information prior to the staff's acceptance of TVA's justification of the use of rigid baseplate criteria. The staff sent a letter dated June 28, 1985 (Reference AB) to TVA requesting additional information concerning flexibility requirements in pipe support baseplate design using concrete expansion anchors. TVA responded in a letter dated August 22, 1985 (Reference AC). At a recent audit at Watts Bar held November 5-9, 1990, the staff found that the TVA letter response of August 1985 (Reference AC) has been superseded as a result of the corrective action programs now being implemented at Watts Bar. The applicant committed to provide a revised TVA response to NRC IE Bulletin 79-02. Pending review and receipt of the applicant's revised response, the staff considers this item still open.

3.10 SEISMIC AND DYNAMIC QUALIFICATION OF SEISMIC CATEGORY I MECHANICAL AND ELECTRICAL EQUIPMENT

For equipment seismic and dynamic qualification, the applicant refers to Regulatory Guide 1.48 (Reference V) and to IEEE Standard 344-1971 (Reference W) or IEEE Standard 344-1975 (Reference G), depending on the date of procurement. The applicant's December 18, 1990 letter (Reference E) states that the qualification of Category I, Class IE equipment is performed in accordance with IEEE 344-1975 for equipment procured after September 1, 1974. For equipment procured prior to September 1, 1974, seismic qualification was performed in accordance with the requirements of IEEE 344-1971.

Although the SRP does not recommend adherence to IEEE 344-1975 for plants with Construction Permit applications docketed before October 27, 1972, the SRP does specify certain additional guidelines. These additional guidelines include describing the extent to which the seismic and dynamic qualification of mechanical and electrical equipment and their supports meet IEEE 344-1975, Regulatory Guide 1.100, and the criteria listed in the SRP Section 3.10. II.1. In addition, the SRP states that it should be demonstrated that all equipment has adequate margin to perform their intended design functions during seismic and dynamic events when considering the effects of possible multi-mode response and simultaneous vertical and horizontal excitations on equipment operability. The applicant has not yet demonstrated that it satisfies these SRP guidelines for equipment qualified. The applicant has committed only to IEEE 344-1971. Therefore, this issue remains open.

The staff identified an issue regarding the seismic design of cable trays and conduit at Watts Bar. FSAR section 3.10.3.2.1 states that all cable trays and conduit are designated as "Seismic Category I (L)" (limited structural integrity). The staff's evaluation of the applicant's seismic classification of cable trays and conduit as Category I (L) is discussed in Section 3.2.1 of this supplement. The cable tray design criteria corresponding to this categorization includes: limiting the allowable vertical bending moment to 80% of the ultimate capacity of the tray, limiting the allowable horizontal moment to a value corresponding to a ductility factor of three, maintaining a minimum factor of safety of three for dead load effects alone, and designing for the load combination of dead load plus SSE. A description of the study performed by EQE to develop a program plan for the qualification of cable trays at Watts Bar, the design criteria for Category I cable tray supports and Category I (L) cable trays and back up calculations for the criteria, are included with the applicant's December 18, 1990 letter (Reference E). The applicant has not provided specific design criteria for conduit. Because the staff has not accepted the categorization of conduit cable trays as I (L), as as discussed in Section 3.2.1, the design criteria for these commodities remains an open item.

References

A. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.29, "Seismic Design Classification", Rev. 3, September 1978.

C. U.S. Nuclear Regulatory Commission, "Safety Evaluation Report Related to the Operation of Watts Bar Nuclear Plant, Units 1 and 2," Docket Nos. 50-390 and 50-391, NUREG-0847, June 1982.

D. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.84, "Design and Fabrication Code Case Acceptability, ASME Section III, Division 1", Rev. 27, November 1990.

E. Letter from E. G. Wallace (TVA) to USNRC, Subject: Watts Bar Nuclear Plant Units 1 and 2 -- Documentation of Resolutions to NRC Open Issues -- WBN Final Safety Analysis Report Amendment 64, Docket Nos. 50-390 and 50-391, December 18, 1990.

F. U.S. Nuclear Regulatory Commission, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," NUREG-0800, dated July 1981.

References, cont'd

G. Institute of Electrical and Electronic Engineers, "IEEE Recommended Practices for Seismic Qualification of Class IE Equipment for Nuclear Power Generating Stations," IEEE Standard 344-1975.

K. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.92 (Rev. 1), "Combining Modal Responses and Spatial Components in Seismic Response Analysis", February 1976.

P. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.61, "Damping Values for Seismic Design of Nuclear Power Plants", October 1973.

R. Letter from S. Black (USNRC) to O. Kingsley (TVA), Subject: HVAC Duct Calculations, Unresolved Item 88-12-07, Docket Nos. 50-327 and 50-328, August 25, 1989.

S. U.S. Nuclear Regulatory Commission, Inspection Report Nos. 50-390/89-21 and 50-391/89-21, May 10, 1990.

T. U.S. Nuclear Regulatory Commission Memorandum, "On-Site Audit on Watts Bar Seismic Analysis Corrective Action Program Plan, TAC No. R00514", October 10, 1990.

U. U.S. Nuclear Regulatory Commission IE Bulletin 88-11, "Pressurizer Surge Line Thermal Stratification", December 20, 1988.

V. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.48, "Design Limits and Loading Combinations for Seismic Category I Fluid System Components".

W. Institute of Electrical and Electronic Engineers, "Guide for Seismic Qualification of Class 1 Electric Equipment for Nuclear Power Generating Stations", IEEE 344-1971.

AA. Nuclear Regulatory Commission, IE Bulletin 79-02, "Pipe Support Baseplate Designs Using Concrete Expansion Anchor Bolts," dated March 8, 1979 including Supplement No. 1 dated August 20, 1779.

References, cont'd

AB. Nuclear Regulatory Commission, letter from E.G. Adensam to H.G. Parris (TVA), "Flexibility Requirement in Pipe Support Base Plate Design Using Concrete Expansion Anchors at Watts Bar Nuclear Plant, Units 1 and 2", June 28, 1985.

AC. TVA Letter, J.A. Domer to E. Adensam (NRC), August 22, 1985.

AE. TVA Letter from E. G. Wallace to USNRC, "Watts Bar Nuclear Plant Units 1 and 2 -- Validation Program Using Worst Case, Critical Case, and Bounding Calculation Methodology," Docket Nos. 50-390 and 50-391, dated September 14, 1990.

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Dated: December 31, 1990

MATERIALS AND CHEMICAL ENGINEERING BRANCH

WATTS BAR FSAR AMENDMENT 64

FSAR SECTION	DISPOSITION
3.2.2.5	This amendment documents the use of later editions and addendas than the code of record. No changes to the SER or supplements needed.
Table 3.2-6	This amendment documents the requirements imposed on round and rectangular high velocity duct.
3.6A.1.1.4	This changes documents the use of NCIG-01, Revision 2, and NCIG-02 Revision 0 Standards in the welding of structural components. No changes to the SER or supplements needed.
3.8.1.2.12	This changes documents the use of NCIG-01, Revision 2, and NCIG-02 Revision 0 Standards in the welding of structural components. No changes to the SER or supplements needed.
3.8.2.2.1	This amendment documents that two welds on the containment sleeves at the Unit 1 RHR sump have radiographic indications exceeding ASME Section III acceptance criteria. In addition, the amendment documents that ASME Code cases 1431, 1517, 1529, 1493, and 1769 were used in the design of the containment vessel. No changes to the SER or supplements needed.
3.8.2.6.1	The changes and merely editorial and clarification which do not change the intent of the original FSAR material. A supplement to the SER is not required.
3.8.2.6.2	The changes and merely editorial and clarification which do not change the intent of the original FSAR material. A supplement to the SER is not required.
3.8.2.6.3	The changes and merely editorial and clarification which do not change the intent of the original FSAR material. A supplement to the SER is not required.

3.8.3.2	The changes and merely editorial and clarification which do not change the intent of the original FSAR material. A supplement to the SER is not required.
3.8.3.2.14	This changes documents the use of NCIG-01, Revision 2, and NICG-02 Revision 0 Standards in the welding of structural components. No changes to the SER or supplements needed.
3.8.4.2.1	The changes and merely editorial and clarification which do not change the intent of the original FSAR material. A supplement to the SER is not required.
3.9.3.4.2(c)(5)	This amendment documents the ASME Code Case N-318-3 in the design of integral welded attachments to the piping pressure boundary. No changes to the SER or Supplement are needed.
3.10.3.3.2	This changes documents the use of NCIG-01, Revision 2, and NCIG-02 Revision 0 standards in the welding of structural components. No changes to the SER or supplements needed.

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Dated: November 21, 1990

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STRUCTURAL AND GEOSCIENCES BRANCH
REVIEW OF WATTS BAR FSAR AMENDMENTS 54-64
Section 3.8 "Category I Structures"

1.0 INTRODUCTION

There has been close to three hundred amendments all together. Most of the amendments concern editorial changes and corrections of typographical errors. There are several significant changes from the original FSAR and the staff found that some of them require further evaluation by the staff and possibly additional work by the applicant. They are:

1. "Codes, Load Combination etc." (item 1 in Section 2 "evaluation").
2. Stress Allowables in Sections 3.8.4 to 3.8.6 (item 8 in Section 2).

Other open items are listed below for a resolution.

2.0 EVALUATION

1. P. 3.8-3, Section 3.8.1.2 "Applicable Codes, Appendix 3.8 E: "CODES LOAD DEFINITIONS AND LOAD COMBINATIONS FOR THE MODIFICATION AND EVALUATION OF EXISTING STRUCTURES AND FOR THE DESIGN OF NEW FEATURES ADDED TO EXISTING STRUCTURES AND THE DESIGN OF STRUCTURES INITIATED AFTER JULY 1979"

   This is a new appendix to amendment 64. Ductility factors are based on AISC-N690 which the staff has not reviewed.

2. P. 3.8-3 Section 3.8.1.2, "Applicable Codes Standard and Specifications".

   The following items are not consistent with or are not in the SRP.
   a) tangential shear
   b) ACI chimney code (ACI 307-09)
   c) ACI 214-27

3. P. 3.8-5, NCIG-02, Revision 0, cited by the applicant is not the revision accepted by the staff. NCIG-02, Revision 2, is the revision accepted by the staff in a letter dated April 9, 1987, to the Nuclear Construction Issues Group. Our letter of April 9, 1987 also stipulated limitations on the applications of NCIG-02, Revision 2 which have not been addressed by the applicant. This should be considered an open item to be resolved by the applicant.

4. Table 3.8.4-2, Section 1b. At elevation 741 ft, equipment loads of 175 psf was reduced to 100 psf, explanation must be given by the applicant.

5. Table 3.8.4-6. "Manways in RHR Sump Value Room" This table is changed without explanation. Reasons should be provided.

6. Table 3.8.3-3. "Personnel Access Doors in Crane Wall" is eliminated in the proposed FSAR change. Reasons should be stated.

7. Table 3.8.4-5 is dropped from previous FSAR without explanation.

8. Table 3.8.4-6 thru Table 3.8.4-22. "Allowable Stresses of Various Structural Components" and Tables 3.8.5-1 thru 3.8.5-2 "Crane Allowable Stresses". They require justification.

9. P. 3.8.4-22. "Control Room Shield Doors". "These accelerations" are not specified.

10. P. 3.8.4-26. "Railroad Access Hatch Cover" & "Railroad access Doors". Same comments as above (Item 9).

3.0 CONCLUSION

Amendments 54-64 are acceptable with ten open items as discussed above. These open items need to be resolved.

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