TENNESSEE VALLEY AUTHORITY
CHATTANOOGA, TENNESSEE 37401
400 Chestnut Street Tower II

February 19, 1981

Director of Nuclear Reactor Regulation
Attention: Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Schwencer:

In the Matter of the Application of) Docket Nos. 50-390
Tennessee Valley Authority) 50-391

In a letter dated December 5, 1980, from R. L. Tedesco to me, TVA was requested to provide additional clarification with respect to the Watts Bar Nuclear Plant Containment Vessel Building Analysis. Enclosed is the requested information.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

L M Mills

L. M. Mills, Manager
Nuclear Regulation and Safety

Sworn to and subscribed before me
this 19th day of Feb. 1981

Bryant M. Lowery
Notary Public
My Commission Expires 4/4/82

Enclosure

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SEND DRAWINGS to:
BC (AFTER filming)
Aperture Dist.

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ENCLOSURE

WATTS BAR NUCLEAR PLANT UNITS 1 AND 2
CONTAINMENT VESSEL BUILDING ANALYSIS

Introduction

Before proceeding with the responses to the revised Nuclear Regulatory Commission questions, additional design and analysis data on the containment vessel are presented to demonstrate the adequacy of the design. An overview of your comments to our responses indicates that your concern is primarily with the shell stability around major penetrations and the accuracy of decoupling the dynamic response of the locks and hatch from the primary structure under pressure transient and seismic excitation.

The Watts Bar containment is unstiffened longitudinally with the exception of the span between elevations 703'-9-3/8" and 716'-7-3/8" and around major penetrations. In the area of these penetrations, the containment shell is heavily reinforced with 1-3/8-inch by 22-inch stiffeners as shown on the attached Chicago Bridge and Iron (CBI) drawings 46 and 213 with supporting drawings 43, 55, 83, 84, 85, 89, 91, 92, 96, 99, 200, 202, and 209 to define stiffener sizes.

Table 1 (copy attached) gives a summary of maximum stress intensities in the shell around the major penetrations resulting from the most severe load combination. The column labeled "inertial stress" is the stress in the shell from the decoupled analysis of the locks and equipment hatch. The column labeled "initial stress" is the stress in the area of the penetrations from the combined affects of design basis accident (pressure transient), seismic, and dead loads. Note that even if the inertial stresses are multiplied by a factor of 2, the total stress intensity would be less than the ASME code allowables.

Apart from their role in carrying the general membrane stress around the penetrations, the local stiffening around the personnel locks and equipment hatch are very effective in suppressing the adverse effect of local buckling. This is especially true if the mesh of the reinforcement is smaller than the minimum local buckle region. Furthermore, the stiffening reduces the shell stresses in the panels between stiffeners whereas the allowable buckling stress for the panel is higher than for an unstiffened cylinder. The minimum allowable buckling stress for axial compression for the panels containing the equipment hatch and personnel locks is 14.9 kips per square inch (k/in^2) compared to an equivalent allowable buckling stress of 9.7 k/in^2 in areas of the shell without vertical stiffeners.

Table 1 is a list of the stress intensities in the containment shell in the area of the locks and hatch. These stress intensities are calculated from the maximum tension and compressive stresses and are less than the stress intensities in the general shell. The maximum compressive stresses in the area of the locks and hatch were not tabulated, but due to the additional stiffening, they will be less than the compressive stress in the general shell.

Figure 6 (copy attached) of the response to the original questions shows that the buckling ratios were less than 1 for all areas of the general shell. The additional membrane compressive stresses in the area of the locks and hatch due to the local response of the locks and hatch will be less than or equal to the maximum membrane (P_m) "inertial stress" of 1.6 k/in^2 shown in table 1. Even if this maximum compressive stress is multiplied by a factor of 2, it will still be much less than the incremental allowable buckling stress of 5.2 k/in^2 (14.9 - 9.7) between the local area around the locks and hatch and the general shell. Therefore, the buckling ratio of the shell in the area of the locks and hatch is less than 1 and this area of the containment meets the specification buckling criteria.

Question 2:

Provide a description of how the buckling curves contained in the report were applied to the buckling of the containment vessel. The description should include the application of these buckling curves to asymmetric dynamic loads in the areas where penetrations are present.

Review of answer 2:

We are still concerned for the reliability of the buckling analysis. The behavior of the shell in the vicinity of the penetrations does not appear to have been modeled accurately in both the dynamic and buckling analysis. Thus, the effect of stress concentrations near the openings and the adequacy of the stiffening around the opening are uncertain. There is virtually nothing in the literature on the amount of stiffening required to nullify the opening from a buckling point of view. The present analysis therefore assumes that the stiffening has the desired result without any verification.

Response:

The circumferential stiffeners on the Watts Bar containment are designed to have sufficient stiffnesses to enforce nodes at the circumferential stiffeners so as to preclude a general instability mode of buckling failure. Vertical and additional circumferential stiffening was designed (see CBI drawings 46 and 213) so as not to compromise the areas around the major penetrations from a stress intensity or buckling viewpoint. The area replacement of the opening, according to ASME code, section III, subsection NE, combined with the special stiffening essentially nullifies the effects of the opening. Refer to the introduction for further discussion of buckling relating to the locks and hatch.

Question 4:

Provide a description of the assumptions involved in modeling the containment vessel in order to use the programs identified in question 3. This description should include a discussion of any convergence and/or accuracy checks that were made.

Review of answer 4:

For the axisymmetric shell, the convergence check is acceptable. However, for the shell containing penetrations, it appears that no checks for convergence or accuracy were carried out for the stresses in the area of the penetration. Since the stresses around the penetration may trigger buckling, the solution accuracy should be investigated.

Response:

As described in the introduction, the shell stresses in the areas of the locks and hatch have been evaluated and meet the specifications and ASME code criteria.

Question 6:

Explain the procedure of obtaining the stress distribution in the shell using lumped mass beam model instead of a shell model for the dynamic seismic analysis.

Review of answer 6:

The use of the Timoshenko shear beam as an analog for a perfect (without penetrations) shell of revolution is acceptable; however, for the containment vessel under discussion there is no documentation or justification that this simplistic approach is applicable and that it will not suppress shell modes in the real structure that will be excited by seismic ground motion.

Response:

The large masses attached to the containment vessel are the two personnel locks and the equipment hatch. In the area of these penetrations, the containment shell is heavily reinforced with 1-3/8-inch by 22-inch stiffeners as shown on attached CBI drawings 46 and 213. These stiffeners restrict the response of the shell to dynamic movements of the locks and hatch. Therefore, these dynamic motions of the locks and hatch will be very local and not be associated with significant shell modes of the structure. Under these conditions, the shell modes of the real structure will not be significantly different from the shell modes of an axisymmetric model and will not be significantly excited by seismic loads.

Question 7:

Explain the justification for using an axisymmetric geometry computer program for the containment vessel.

Review of answer 7:

Although the answer to question 7 states that the approach to analyzing the locks and hatches as a supported subsystem was used for the dynamic analysis of nuclear plants, it does not address the question of the accuracy of this approach for dynamic buckling analysis. Further justification of this approach is needed.

Response:

As shown on attached CBI drawings 46 and 213, the areas around the personnel locks and equipment hatch are heavily reinforced with 1-3/8-inch by 22-inch stiffeners. These stiffeners in conjunction with the 3-inch thick nozzle for the equipment hatch and the 2-inch thick nozzles for the personnel locks will preclude buckling of the containment shell in these areas.

Question 9:

Explain in detail the criteria and its justification for determining the interaction effects between the containment shell and the attached equipment.

Review of answer 9:

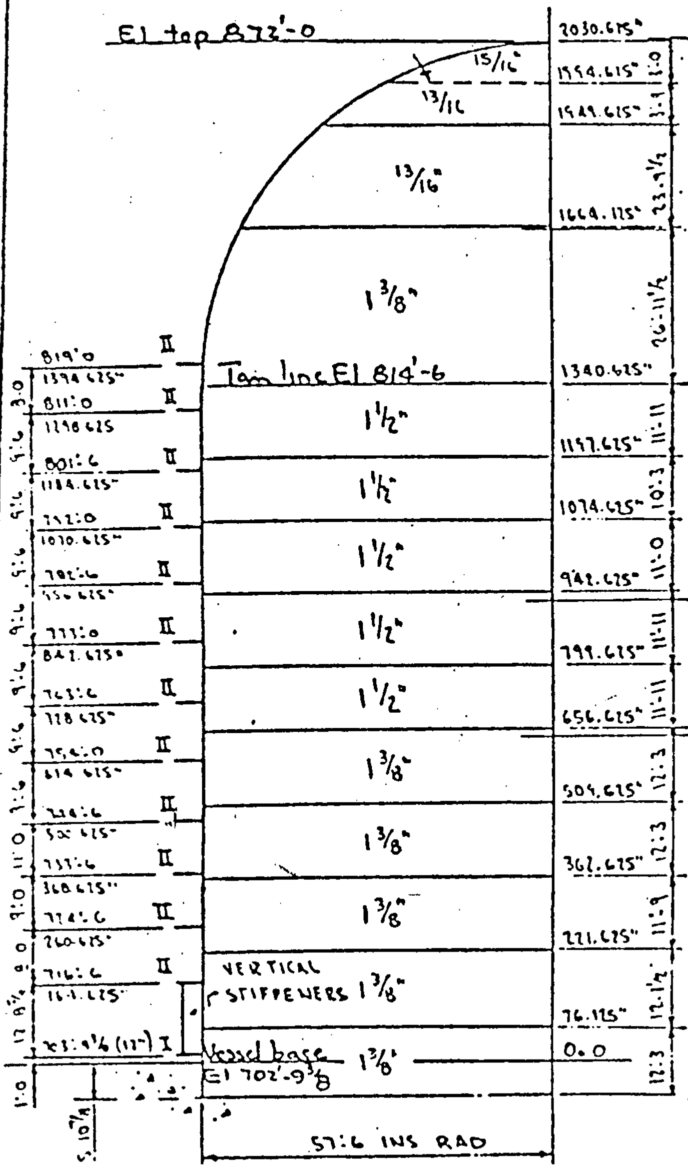
By doing a separate analysis for the supported equipment, the effect of the equipment on the containment shell is neglected. Thus, the effects of interaction between the motion of the shell and its attachments are not properly handled. Recent studies in the published literature (PO, BSSA, April 1979) have shown that significant interaction can develop under seismic excitation even if the mass ratio of the equipment is on the order of 1 percent of the main structure.

Response:

The study in the published literature reference (PO, BSSA, April 1979) shows a maximum error on the nonconservative side of 94 percent when an uncoupled analysis is performed in lieu of a coupled analysis. It was shown in the introduction that the stresses from the uncoupled analysis can be increased by 100 percent without exceeding specifications and ASME code allowables for stress intensity and buckling. This further substantiates the adequacy of the Watts Bar containment design.

TABLE 1
WATTS BAR NUCLEAR PLANT
MAXIMUM STRESS INTENSITY AT MAJOR PENETRATIONS

Description	Membrane (P_m) Surface ($P_m + P_b + Q$)	Location	Inertial Stress in Shell	Initial Stress in Shell	Total Stress	Allowable Stress
Upper personnel lock	P_m	At barrel - shell intersection (Point 7)	1.60 k/in^2	3.44 k/in^2	5.04 k/in^2	1.5 S_m 26.25 k/in^2
	$P_m + P_b + Q$		18.9 k/in^2	3.44 k/in^2	22.34 k/in^2	3.05 S_m 52.5 k/in^2
	P_m	At 0.5 Rt (Point 4)	1.03 k/in^2	13.07 k/in^2	14.10 k/in^2	1.1 S_m 19.25 k/in^2
	$P_m + P_b + Q$		2.7 k/in^2	13.07 k/in^2	15.77 k/in^2	3.0 S_m 52.5 k/in^2
Lower personnel lock	P_m	At barrel - shell intersection (Point 6)	0.66 k/in^2	16.44 k/in^2	17.10 k/in^2	1.5 S_m 26.25 k/in^2
	$P_m + P_b + Q$		16.6 k/in^2	16.44 k/in^2	33.04 k/in^2	3.0 S_m 52.5 k/in^2
	P_m	At 0.5 Rt (Point 2)	0.38 k/in^2	16.53 k/in^2	16.91 k/in^2	1.1 S_m 19.25 k/in^2
	$P_m + P_b + Q$		11.10 k/in^2	16.53 k/in^2	27.63 k/in^2	3.0 [illegible] 52.5 k/in^2
Equipment hatch	P_m	At insert barrel - shell intersection (Points 7 and 8)	0.66 k/in^2	15.04 k/in^2	15.70 k/in^2	1.5 S_m 26.25 k/in^2
	$P_m + P_b + Q$		3.30 k/in^2	15.36 k/in^2	18.66 k/in^2	3.0 S_m 52.5 k/in^2
	P_m	At 0.5 Rt (Point 4)	0.58 k/in^2	17.11 k/in^2	17.69 k/in^2	1.1 S_m 19.25 k/in^2
	$P_m + P_b + Q$		4.10 k/in^2	17.11 k/in^2	21.21 k/in^2	3.0 S_m 52.5 k/in2



Combination	Ratio	Azimuth/Time	Remarks
AXIAL + BEND	(91%) .91	270/.22	BREAK IN HL# 4
AXIAL + BEND	(90%) .90	270/.24	BREAK IN HL#3
AXIAL + BEND	(85%) .85	270/.24	BREAK IN HL#3
AXIAL+BEND+TORS	(84%) .84	270/.24	BREAK IN HL#3
Axial+bend+Tors	(96%) .96	225/.13	Break in HL#6

FIG 6
GOVERNING BUCKLING RATIOS

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