B. Supplementary Seismic Design Information

I. Introduction

This amendment provides additional information pertinent to Dresden Units 2 and 3. The information presented herein is to amplify data regarding the seismic design of the plants as presented in previous amendments and associated discussions.

2. Piping Systems - Dynamic Analysis

"Provide an expanded analysis of the main steam, main feed, and recirculation piping in accordance with discussions at the most recent meeting on seismic analysis."

The seismic analyses performed on the Dresden Main Steam, Feedwater, and Recirculation Systems have been performed using analytical techniques discussed in the response to Question 2.9 of Amendment 7/8. At the present time an expansion of these analyses is underway using techniques recommended by the AEC Staff Consultant to assure these systems have been conservatively designed for seismic purposes. These analyses will be made available to the AEC Staff when completed.

Two comparative analyses have been performed on similar main steam piping systems. It is expected these comparative analyses and the Dresden analysis expansion will clearly show the Dresden piping system identified above to be designed in a conservative manner.

The information shown in Tables 2-1 and 2-2 is a summary of the results of the comparative analyses performed by the two methods on the two similar main steam piping systems. These comparisons indicate that there is little difference between the results of the two methods. Method #2 (used in the Dresden analysis) gives results that lead to an adequate design.

Method 1

The pipe loops were idealized as mathematical models consisting of lumped masses connected by elastic members (Figures 2-1 and 2-2). Lumped masses are located at carefully selected points in order to adequately represent the dynamic and elastic characteristics of the pipe system. Using the elastic properties of the pipe the flexibility matrix for the pipe is determined. The flexibility calculations include the effects of torsional, bending, shear, and axial deformations as well as change in flexibility due to curved members.

Once the flexibility and mass matrices of the mathematical model are calculated, the frequencies and mode shapes for all significant modes of vibration are determined. All modes having a period greater than 0.05 seconds were used in the analysis. The mode shapes and frequencies are solved in accordance with the following equation:

$$(K - w_n^2 M)\ \phi_n = 0$$

in which:

K = square stiffness matrix of the pipe loop

M = mass matrix for the pipe loop

w_n = frequency for the n^{th} mode

ϕ_n = mode shape matrix of the n^{th} mode

After the frequency is determined for each mode, the corresponding spectral acceleration is read from the appropriate response spectrum for the pipe. Using these spectral accelerations, the response for each mode is found by solving the following equation:

$$Y_n max = \frac{R_n\ Sa_n\ D}{M_n w^2{}_n}$$

in which:

$Y_n max$ = response of the n^{th} mode

R_n = participation factor for the n^{th} mode = $\Sigma M_i\ \phi_{in}$

REPRESENTATIVE PROJECT #1 LOOP B MAIN STEAM LINE COMPARISON OF SALIENT RESULTS

TABLE 2-1

Joint[1] Number	Max. Seismic Stress (PSI) Method 1	Max. Seismic Stress (PSI) Method 2	Approx.Modal Contribution (% of total)[2] 1st Mode	2nd Mode	3rd Mode	4th Mode
219.1	1,100	1,400	24	65	8	Nil
220	~~1,100~~ 1,200	1,500	26	67	6	Nil
221	3,000	3,100	27	64	7	Nil
222	2,800	3,500	22	76	Nil	Nil
222.1	600	1,000	45	33	22	Nil
223	2,700	2,800	13	71	16	Nil
	Period (seconds)		0.89	0.15	0.27	0.20
	Spectral Accel. (g)		0.13	0.25	1.05	1.35

(1) See mathematical model Figure 2-1
(2) A total of 11 modes used to obtain seismic stresses.

REPRESENTATIVE PROJECT #2 MAIN STEAM LINE COMPARISON OF SALIENT RESULTS

TABLE 2-2

Joint[1] Number	Max.Seismic Stress (PSI) Method 1	Max.Seismic Stress (PSI) Method 2	Approx.Modal Contribution (% of total)[2] 1st Mode	2nd Mode	3rd Mode	4th Mode
25	6,940	7,640	99	Nil	Nil	Nil
26	4,170	4,170	99	Nil	Nil	Nil
27	3,470	3,470	99	Nil	Nil	Nil
28	~~3,740~~ 3,470	3,470	99	Nil	Nil	Nil
29	4,170	4,860	99	Nil	Nil	Nil
30	9,030	10,400	96	Nil	Nil	3
	Period (seconds)		0.43	0.23	0.20	0.13
	Spectral Accel. (g)		1.46	0.68	0.56	00.50

(1) See mathematical model Figure 2-2
(2) A total of 7 modes used to obtain seismic stresses.

The stresses in curved pipes will differ from those calculated for straight pipes with equal bending moments. This stress increase is given by the stress intensification factor:

$$B = 0.90 / h^{2/3} \geq 1.00$$

in which:

B = stress intensification factor

h = bend characteristic

Method 2

This method is described in detail in response to Question 2.9 of Amendment 7/8.

3. Piping Systems - Static Analysis

"Show the details of the static analysis technique using an example system giving conservatism in the method. For all other systems analyzed statically give the coefficient and maximum stresses and state the method of analysis used if different from the example shown."

A. Introduction

The following is a typical application of the static seismic design method used for Dresden Class I piping larger than 10 inches in diameter except main steam, feedwater and the recirculation system. The piping system chosen as typical is the 14 inch HPCI pump discharge line. A step by step discussion of the HPCI discharge line is presented along with tabulated maximum stresses for all other systems analyzed by this same method. A general description of the static design method is presented in Amendment 13/14, pages A.2-12 through A.2-24. It is recommended that reference be made to that general discussion before attempting to understand the following presentation.

G. Maximum Stresses in all Other Statically Analyzed Piping

Figure 3-6 is a tabulation of the maximum stresses calculated in the other statically analyzed system. The method used to obtain stresses, restraint loads, etc. was exactly the same as for the HPCI Pump Discharge described herein.

4. Torus Ring Header Analysis

A. "State whether or not the reported analysis of the ring header included the snubbers"

The dynamic analysis performed on the Suppression Chamber Ring Header reflects the effects of the 12 shock suppressors (snubbers).

B. "Explain the lack of interaction between the ring header modes whose frequencies are very close"

The possible interactive effects of having several modes as close as they are in the first three modes could result in the physical condition of a direct addition of modal contributions. Investigation of these modes shows the first mode to be a predominantly Z-direction (global coordinates) mode, the second to be a Y-direction mode and the third to be another Z-direction mode. The participation factors for the first and third modes are really equal. It is also noted that there is a sign reversal in the modal displacements from mode to mode at the points of maximum modal displacement. That is to say that the signs of the modal displacements at the two points representing the maximum modal displacement, in the first and third modes for the first mode are plus and plus; in the third mode they are plus and minus. Stresses thus might be more appropriately determined at one point by an absolute sum of these two modes, but at the other point a vector sum may be more appropriate. Appropriate means of modal combination in this case seem uncertain. If the more conservative absolute sum method is used,