OYSTER CREEK **NUCLEAR GENERATING STATION**

JCP&L GPU

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September 2, 1981

Mr. Dennis M. Crutchfield, Chief
Operating Reactors Branch No. 5
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington,D.C. 20555

Dear Mr. Crutchfield:

Subject: Oyster Creek Nuclear Generating Station
Docket No. 50-219
Systematic Evaluation Program (SEP)
Topic III-6, Seismic Considerations, and
III-11, Component Integrity

The following enclosures are in response to your letter of March 20, 1981, which requested information on the seismic design of the Oyster Creek plant:

1. Evaluation of CRD Return Line and Main Steam Piping Seismic Analyses

2. Oyster Creek Nuclear Generating Station Recirculation Pump Seismic Restraint Capability

3. Evaluation of Containment Spray Heat Exchanger Bolts

If you have any further questions concerning this matter, please contact Mr. J. Knubel of my staff at (201) 299-2264.

Very truly yours,

J. T. Carroll Jr.

J. T. Carroll, Jr.
Acting Director - Oyster Creek

JTC:lse

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EVALUATION OF CRD RETURN LINE AND MAIN STEAM PIPING SEISMIC ANALYSES

Purpose:

To evaluate the results of seismic analyses performed for the U.S. NRC by their contractor, EG&G, Idaho, Inc., for the Oyster Creek Control Rod Drive (CRD) return line piping and the main steam piping.

Background:

U.S. NRC letter, dated March 20, 1981, to Jersey Central Power & Light Company requested evaluation of a number of items identified in NUREG/CR-1981, "Seismic Review of the Oyster Creek Nuclear Power Plant as Part of the Systematic Evaluation Program." This report states in paragraph 2.3 that results of analyses reported in EG&G Idaho Report EGG-EA-5211 (July 1980) indicate the following:

- Stresses in the main steam piping are within allowable limits during an SSE event. However, possible overloading of several snubbers was indicated.

- Maximum stresses in the CRD return piping exceed ASME Code allowables at several points for the SSE loadings. The high stresses were primarily at socket weld fittings with high stress intensification factors.

Evaluation:

The main steam and CRD return piping analyses presented in EG&G Report EGG-EA-5211 have been reviewed. These results are conservative for two main reasons:

- The ground motion input for the generation of the floor response spectra used in these analyses was a Reg. Guide 1.60 spectra anchored at a Zero Period Acceleration (ZPA) of 0.22g. The site specific response spectra recommended for Oyster Creek by the NRC in their letter to the SEP Owners, dated June 8, 1981, is a narrower spectra having a ZPA of 0.165g. On this basis, the results calculated using the 0.22g Reg. Guide spectra can be scaled down by the ratio of 0.165g/0.22g, or 0.75.

- The reactor building floor response spectra used by EG&G in the piping analyses are somewhat higher than the final floor response spectra provided in Appendix B of NUREG/CR-1981. Specifically, the amounts by which the spectra used in the EG&G analyses exceed the final values are given below:

Building Locati	EG&G Spectra Peak gs	NUREG Spectra Peak gs	Ratio EG&G/ NUREG
51' elevation, horiz., 3% damping - used for steam piping	2.2	1.8	1.22
51' elevation, horiz., 2% damping - used for CRD piping	2.7	2.25	1.20
All elevations, vert., 3% damping - steam piping	1.3	1.2	1.08
All elevations, vert., 2% damping, CRD piping	1.5	1.4	1.07

Based on these values, it is conservatively estimated that the spectra used by EG&G are at least 10% over conservative considering that the inputs included two horizontal and one vertical component of motion.

The net result of the two effects outlined above are to reduce the calculated stresses and support loads presented in EG&G Report EGG-EA-5211 by a factor of 0.75 x 0.90, or 0.675. The effect of this reduction on main steam line snubber loads and CRD piping stresses are as follows:

1. Main Steam Snubbers

   The maximum calculated snubber reaction load given in NUREG/CR-1981 due to both SSE and relief/safety valve discharge loads is 18,900 lbs. When corrected to reflect the latest input, this maximum load becomes 0.675 x 18,900, or 12,760 lbs. The installed snubbers have a normal design load rating of 11,000 lbs and a load capacity at yield stress of at least 2 times the normal design rating. In addition, one of the snubbers was load tested without any damage to 20,000 lbs. As a result, the calculated snubber reactions are well within the faulted load capability of the snubbers.

2. CRD Return Piping

   The maximum calculated stresses in the CRD return piping are presented in Table 33 of the EG&G report. The maximum stress in straight pipe and that due to the stress intensification factor of 2.1 at a socket weld elbow are given below, together with the values reduced by the factor of 0.675 to reflect the latest input. The allowable stress is also indicated.

Component	Reported Stress (ksi)	Corrected Stress (ksi)	Allowable Stress (ksi)
Straight pipe	51.4	34.7	42.0
Socket weld elbow	62.0	41.8	42.0

As indicated above, the corrected stress values meet the appropriate allowables. It should be noted in this regard that the stress in straight pipe is well within the allowable. The stress of 41.8 ksi due to the 2.1 intensification factor on the socket weld elbow is considered to be even less significant from a structural margin standpoint than the somewhat lower stress reported for the most highly stressed straight pipe. The reason for this is that the intensified stress at the elbow is a highly localized stress which is of concern primarily in a high cycle fatigue application. For the limited number of cycles associated with an SSE event (several hundred), fatigue is not a major concern. From the above evaluation, it is concluded that, in actuality, considerable structural margin exists and the CRD return piping is acceptable for the SSE loadings without modification.

OYSTER CREEK NUCLEAR GENERATING STATION
RECIRCULATION PUMP SEISMIC RESTRAINT CAPABILITY

1. Introduction and Summary

This report presents the results of a dynamic analysis which was performed to determine the loadings on the Oyster Creek recirculation pump seismic restraints during a Safe Shutdown Earthquake (SSE).

In summary, the analysis was performed by the response spectra method using PIPESD, Revision 6.1, December 31, 1980. An entire recirculation loop was modeled, including the pump suction line from its connection to the reactor vessel, the pump discharge line to its connection with the reactor vessel, and the pump itself with seismic restraints.

The Safe Shutdown Earthquake was represented by three response spectra; one for the horizontal motions at the recirculation line connections to the reactor vessel, a separate spectrum for horizontal motions at the pump restraints, and a third spectrum for vertical motions. A specific description of each spectrum is described in a subsequent section of this report.

The analysis was performed for the SSE acting in two horizontal (X,Z) directions and the vertical (Y) direction simultaneously. The contributions from each direction were combined using the square root of the sum of the squares (SRSS) of individual contributions.

The remaining sections of this report include:

- 2. Conclusions, which summarizes the results of the analysis and the conclusions.
- 3. Discussion, which includes a summary description of:
  - -- A recirculation loop and the pump restraints.
  - -- The seismic response spectra.
  - -- The analysis method.
  - -- The analysis results.
- 4. References, which identifies the reference documents used in the analysis.
- 5. Figures, including Figure 1 which shows the recirculation loop analysis model, and Figure 2, which gives the PIPESD output.

2. Conclusions

The analysis indicates that the maximum loading experienced by any single pump restraint due to an SSE is 13,270 pounds. Each of the pump restraints has a nominal rating of 11,000 pounds, and a load capacity at yield strength of twice this value. As a result, an acceptable load for SSE conditions is considered to be at least twice the nominal rating, or 22,000 pounds. Accordingly, the maximum restraint loading of 13,270 pounds is well below the acceptable loading for SSE.

3. Discussion

a. Recirculation Loop and Pump Restraint Description

Major features of each of the five recirculation loops are given in Reference (1), and are summarized as follows:

. The recirculation suction and discharge piping is 24.03 inches inside diameter, 0.982 inch thick, and fabricated of Type 316 stainless steel.

. The piping runs are primarily vertical, except for short horizontal runs and associated elbows (1) at the reactor vessel suction line nozzle (el. 53.25 feet), (2) below the pump (el. 12.25 feet), (3) at the pump discharge (el. 15.5 feet), and (4) at the reactor vessel discharge line nozzle (el. 46.75 feet).

. The maximum total weight of pump and motor is 47,000 pounds, when the reactor coolant system is cold, and filled with water. The weight of the motor itself is 13,000 pounds.

. A valve weighing 10,000 pounds is located in the suction piping. A valve weighing 7,800 pounds is located in the discharge piping.

. Constant load hangers provide upward forces of (1) 46,300 pounds at the pump, (2) 28,300 pounds at the suction line, and (3) 19,800 pounds at the discharge line. These hangers were ignored for the seismic evaluation.

Major features of the seismic restraints for each recirculation pump are given in Reference (2), and are summarized as follows:

. Two horizontal snubbers are provided for the pump casing. They are attached to the reactor vessel concrete support wall at elevation 14 feet, 11 inches.

. Two horizontal snubbers are provided at the top of the pump motor. They are attached to the reactor vessel concrete support wall at elevation 29 feet, 11 inches.

. A single vertical snubber is provided below the pump, ... attaches to the floor at elevation 10 feet, 3 inches. It is inclined at a slight angle, about 20 degrees, from the vertical.

. The rating of each restraint is 11,000 pounds.

In addition, horizontal spring supports are provided for the recirculation suction and discharge piping at elevation 29 feet. Each support consists of two springs, each preloaded to 1,000 pounds and with a spring constant of 1,000 pounds per inch. These horizontal springs were conservatively neglected for the analysis.

b. Seismic Response Spectra

Three different seismic response spectra were employed for the analysis, i.e., (1) a horizontal spectrum at the connections of the recirculation lines to the reactor vessel, (2) a horizontal spectrum at the pump horizontal supports, and (3) a vertical spectrum at the pump vertical support and the reactor vessel nozzles. These spectra are described below.

(1) Horizontal Spectrum at Reactor Vessel

The original seismic evaluation of the reactor vessel in Reference (3) indicated a vessel natural period of 0.13 seconds. Paragraph 6.3.1 of Reference (4) indicates that at this natural period, the reactor vessel acceleration during an SSE would be 0.63g. The response spectra in Reference (4) were based on a Regulatory Guide 1.60 ground response spectrum with a zero period acceleration (ZPA) of 0.22g, while the site specific spectrum recommended by the NRC has a ZPA of 0.165g. This site specific spectrum is enveloped by a Regulatory Guide 1.60 spectrum anchored at a ZPA of 0.165g. Accordingly, the floor response spectra acceleration in Reference (4) may be reduced by the ratio of 0.165g to 0.22g, or by a factor of 0.75, to 0.47g.

The current evaluation employs a response spectrum for a single sinusoidal forcing function with 0.13 second period, and a peak acceleration of 0.47g. This acceleration is multiplied by a factor of 1.5 to account for the possible contribution of lower period reactor vessel vibration modes, which are neglected using the single vessel period of 0.13 seconds.

The use of a factor of 1.5 is consistent with the requirements of Standard Review Plan 3.7.2, Seismic System Analysis, for the equivalent static load method of analysis. In particular, the equivalent static load is obtained by applying a factor of 1.5 to the

peak acceleration of the applicable response spectrum. It is noted from the reactor building floor response spectra in Reference (4) that at all periods below 0.13 seconds, the acceleration is less than the value at 0.13 seconds. Further, all vibration modes of the reactor vessel will be at periods lower than the fundamental period of 0.13 seconds. Accordingly, the peak of the reactor vessel response spectrum is the acceleration at a period of 0.13 seconds.

In summary, the horizontal response spectrum at the reactor vessel is the response spectrum for a single sinusoidal forcing function with 0.13 second period and peak acceleration of 1.5 x 0.47, or 0.71g. A damping of 3 percent was used in accordance with Regulatory Guide 1.61 for large piping systems.

(2) Horizontal Spectrum at Pump Supports

The horizontal response spectrum at the recirculation pump supports is obtained from Reference (4). In particular, the response spectra for the reactor building at elevation 23 feet, 6 inches are employed. This elevation is approximately midway between the elevation of the pump casing supports (14 feet, 11 inches) and the pump motor supports (29 feet, 11 inches).

Again, since the response spectra in Reference (4) were based on a ZPA of 0.22g, rather than on a ZPA of 0.165g, the response spectra of Reference (4) were multiplied by a factor of 0.75. The spectrum for 3 percent damping was used, in accordance with Regulatory Guide 1.61 for large piping systems.

(3) Vertical Spectrum

The reactor building vertical response spectrum in Reference (4) for elevations 19 feet, 6 inches to 119 feet, 3 inches and 3 percent damping was employed. This spectrum was multiplied by 0.75. This vertical spectrum is employed at the reactor vessel nozzles, and at the pump vertical restraint.

c. Analysis Method

The analysis was performed using PIPESD, Revision 6.1, December 31, 1980. This version of PIPESD includes a "Multiple Support Excitation" option (MSE), which permits use of different response spectra for different support locations. This option of PIPESD was used with the specific spectra identified in Section 3.b above. The physical model employed for the analysis is shown in enclosed Figure 1, "Oyster Creek Recirculation Loop, Sheets 1 and 2".

Other major features of the analysis are as follows:

- All modes with frequencies under 100 cycles per second were considered.
- Model responses were combined using the "closely-spaced frequency" method in Regulatory Guide 1.92.
- The earthquake was assumed to occur in two horizontal (X, Z) directions and the vertical (Y) direction simultaneously. The X, Y, Z responses were combined using SRSS.
- The responses due to employing different excitation at various supports were combined using SRSS.
- Each of the horizontal pump restraints was assumed to prevent translation in the horizontal directions (X, Z), but to provide no rotational restraint or translation restraint in a vertical (Y) direction.
- The vertical pump restraint was assumed to prevent translation in a vertical direction, but to provide no rotational restraint or translation restraint in the horizontal (X, Z) directions.
- The PIPESD output for each horizontal restraint is a reaction load in the X and Z directions. The total restraint load is the SRSS of the X and Z loads.
- The PIPESD output for the vertical restraint is a reaction load in the vertical direction. Since this restraint is inclined 20 degrees from vertical, the reaction load is the Y load divided by the cosine of 20 degrees.

b. Analysis Results

The reaction loads at each pump restraint are given in the PIPESD output which is enclosed as Figure 2. The total reaction load for each of the pump restraints is as follows:

(1) Pump casing horizontal restraints
First restraint load: 12,360 pounds
Second restraint load: 13,270 pounds

(2) Pump motor horizontal restraints
First restraint load: 2,730 pounds
Second restraint load: 3,520 pounds

(3) Pump vertical restraint
Restraint load: 4,850 pounds

4. References

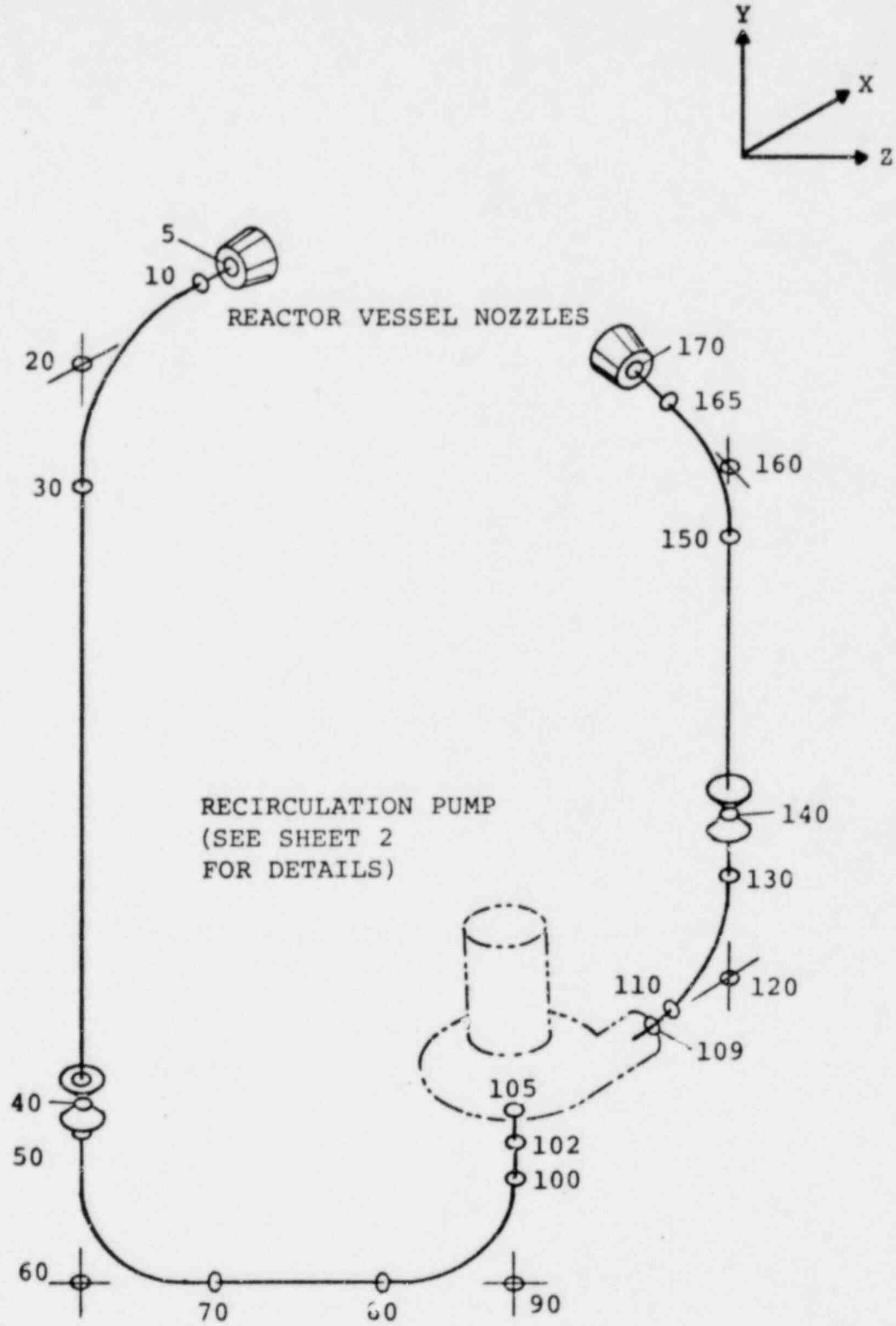
(1) General Electric Company drawing 107C 5076, Revision 1, "Stress Analysis Recirculation Piping"

(2) General Electric Company drawing 237E 907, Revision 3, "Suspension System for Recirculating Loops"

(3) John A. Blume Associates, "Jersey Central Reactor Project - Earthquake Analysis: Reactor Pressure Vessel," March 16, 1966.

(4) NUREG/CR-1981, UCRL-53018, "Seismic Review of the Oyster Creek Nuclear Power Plant as Part of the Systematic Evaluation Program," R. C. Murray, T. A. Nelson, S. M. Ma, J. D. Stephenson

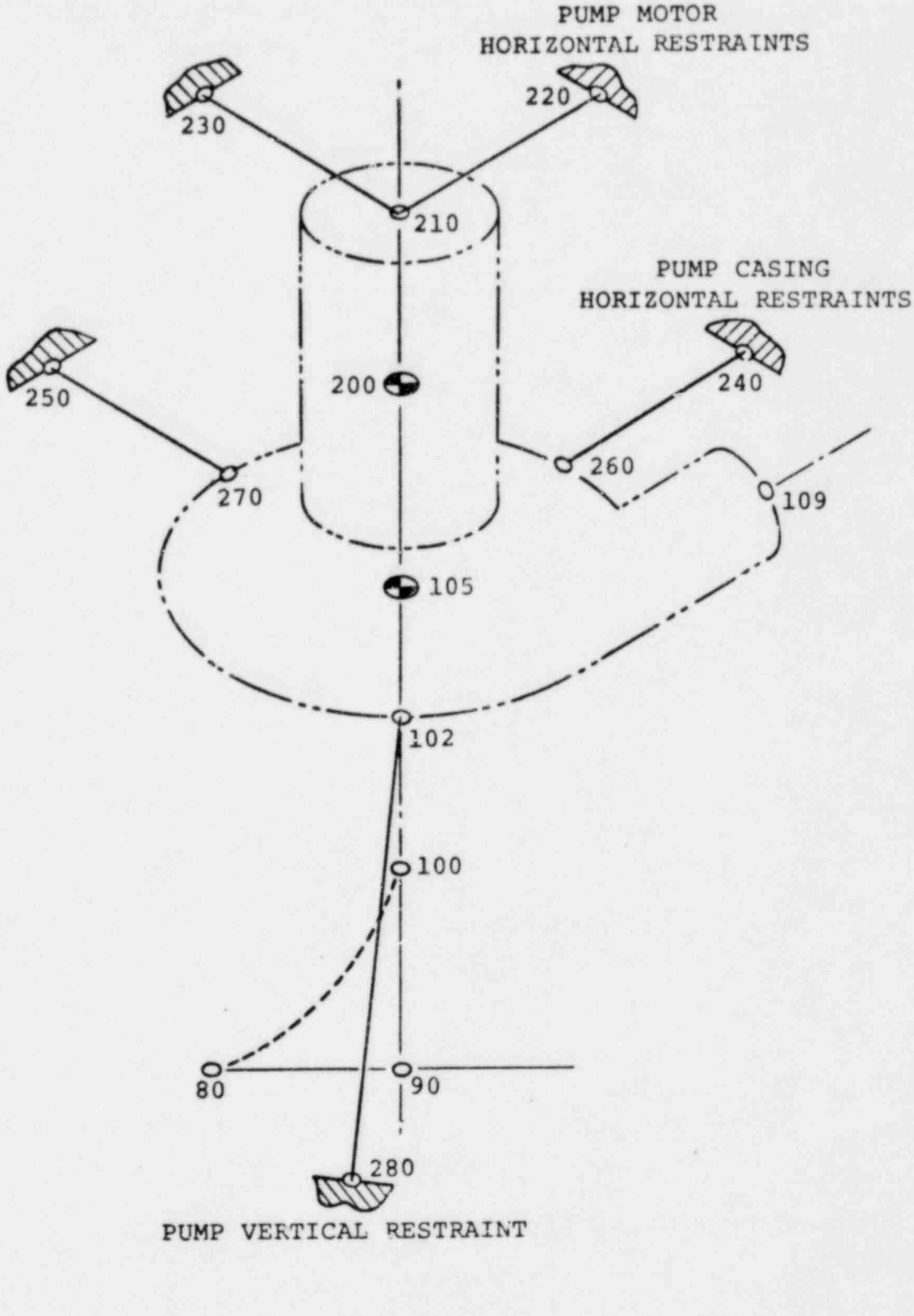
5. Figures



OYSTER CREEK
RECIRCULATION LOOP

FIGURE 1

SHEET 1 OF 2



OYSTER CREEK
RECIRCULATION LOOP

FIGURE 1

RECIRC PUMP ANALYSIS

1.1 E L A S T I C S U P P O R T R E A C T I O N S (LOAD CASE 1)

X-Y-Z SSE

EARTHQUAKE RESPONSE = TOTAL X, Y AND Z RESPONSES COMBINED BY SQSS SUM.
TOTAL X, Y AND Z RESPONSES WERE FORMED BY CSF SUMMATION OF 13 MODES.

SUPPORT	/---------FORCE (LB.	)---------/		/--------MOMENT (IN-LB)---------/		
JOINT	X	Y	Z	X	Y	Z
5	3720.	6910.	5592.	162715.	288935.	257393.
170	3555.	4830.	3367.	174664.	199603.	203527.
220	2680.	0.	521.	0.	0.	0.
230	1247.	0.	3287.	0.	0.	0.
240	11137.	0.	5353.	0.	0.	0.
250	5417.	0.	12112.	0.	0.	0.
280	0.	4561.	0.	0.	0.	0.

<u>PIPESD OUTPUT</u>

FIGURE 2

EVALUATION OF CONTAINMENT SPRAY HEAT EXCHANGER ANCHOR BOLTS

Purpose:

To evaluate the adequacy of the Oyster Creek containment spray heat exchanger anchor bolts for seismic loads due to the Safe Shutdown Earthquake (SSE).

Background:

Paragraph 6.3.1.3 of the Senior Seismic Review Team (SSRT) report on Oyster Creek (NUREG/CR-1981) indicates that:

(1) The calculated horizontal and vertical seismic accelerations from Figures B-1e and B-2b are 0.38g and 0.25g, respectively.

(2) The design analyses performed by the heat exchanger manufacturer (Reference 73 of NUREG/CR-1981) used seismic inputs of 0.24g horizontal and 0.146g horizontal.

(3) The increased seismic loads result in a maximum bolt shear stress of 32.6 ksi for the worst N-S and E-W loading, as compared to an allowable for the 1" A325 bolts of 30.4 ksi.

Evaluation:

The basis for the acceleration values of 0.38g horizontal and 0.25g vertical determined in the aforementioned NUREG are not clear. The report correctly assumes that the containment spray heat exchangers are located at the 23'-6" elevation in the reactor building and that their response will be essentially as rigid bodies to the floor motion. However, the report figures noted (Figures B-1e and B-2b) are not applicable to the 23'-6" elevation of the reactor building. (See attached figures from NUREG/CR-1981). The correct figures for horizontal and vertical accelerations appear to be Figures B-2a for horizontal accelerations and B-2d for vertical accelerations. These figures show rigid body accelerations of 0.30g horizontal and 0.25g vertical.

The heat exchanger manufacturer's design calculations have been revised for these accelerations. The revised loads are shown in the attached Figure 3 from his original report (Reference 73 of NUREG/CR-1981). The maximum horizontal shear loads for the worst loading case are as follows:

Radial Load, P $= 7.66$ kips

Circumferential Load, $V_e = 14.47$ kips

Bolt Area $= 0.551 \text{ in}^2$

Bolt Shear Stress $= \dfrac{\sqrt{7.66^2 + 14.47^2}}{0.551} = 29.71$ ksi

This value is less than the allowable given in NUREG/CR-1981 of 30.4 ksi.

The maximum tensile stress in the bolts is increased from 36.3 ksi in the original design calculations to $36.3 \times \frac{23.51}{20.01}$, 42.6 ksi, which is still well below the original allowable of 70 ksi.

From the above analyses, it can be concluded that the heat exchanger bolting is acceptable for the seismic loadings calculated by Lawrence Livermore Laboratory (LLL) and presented in NUREG/CR-1981. However, it is significant to note that the ground motion spectra used by LLL in their evaluation was a 0.22g Reg. Guide 1.60 spectra. This 0.22g Reg. Guide spectra significantly exceeds the Site Specific Spectra developed by both JCP&L (URS/Blume) and the U.S. NRC. The Reg. Guide 1.60 spectra which envelopes the NRC Site Specific Spectra at all periods is one which is anchored at 0.165g. On this basis, the floor response spectra developed by LLL and included in NUREG/CR-1981 can be reduced by the ratio $\frac{0.165g}{0.22g}$ or 0.75. This reduction will further reduce the containment spray heat exchanger bolt stresses below applicable allowables. In addition, if the horizontal acceleration of 0.38g noted in paragraph 6.3.1.3 of NUREG/CR-1981 is correct, the scale factor reduction of 0.75 would reduce the actual predicted acceleration to 0.75 x 0.38g, or 0.285g, which is less than the value of 0.30g used in the above evaluation. Therefore, the containment spray heat exchanger bolts are acceptable for the corrected acceleration values given in paragraph 6.3.1.3 of the NUREG, as well as those accelerations shown on the attached floor response spectra.

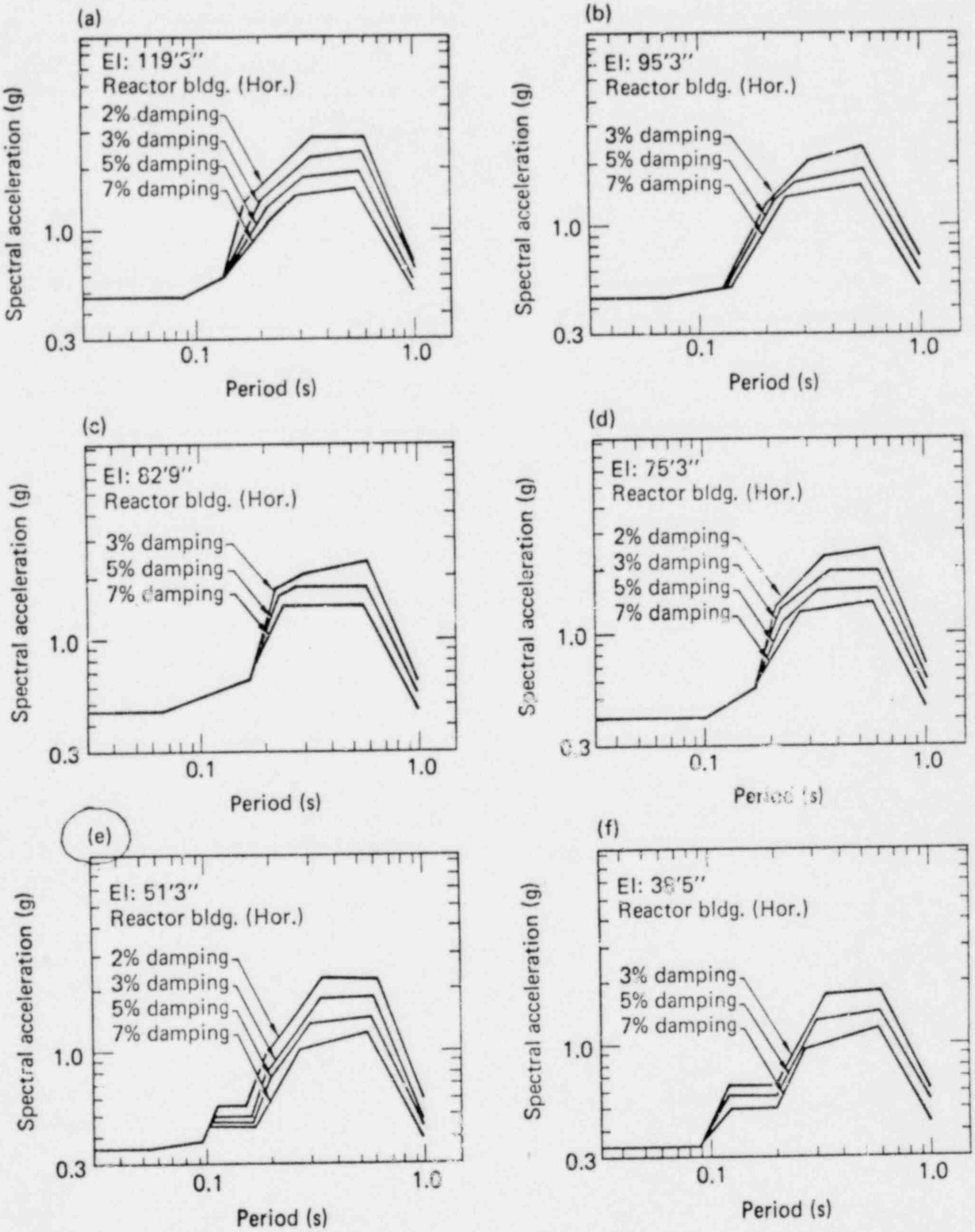


FIG. B-1. Spectral curves (horizontal and vertical components) with selected percentages of damping used in reanalysis of equipment in the turbine building.

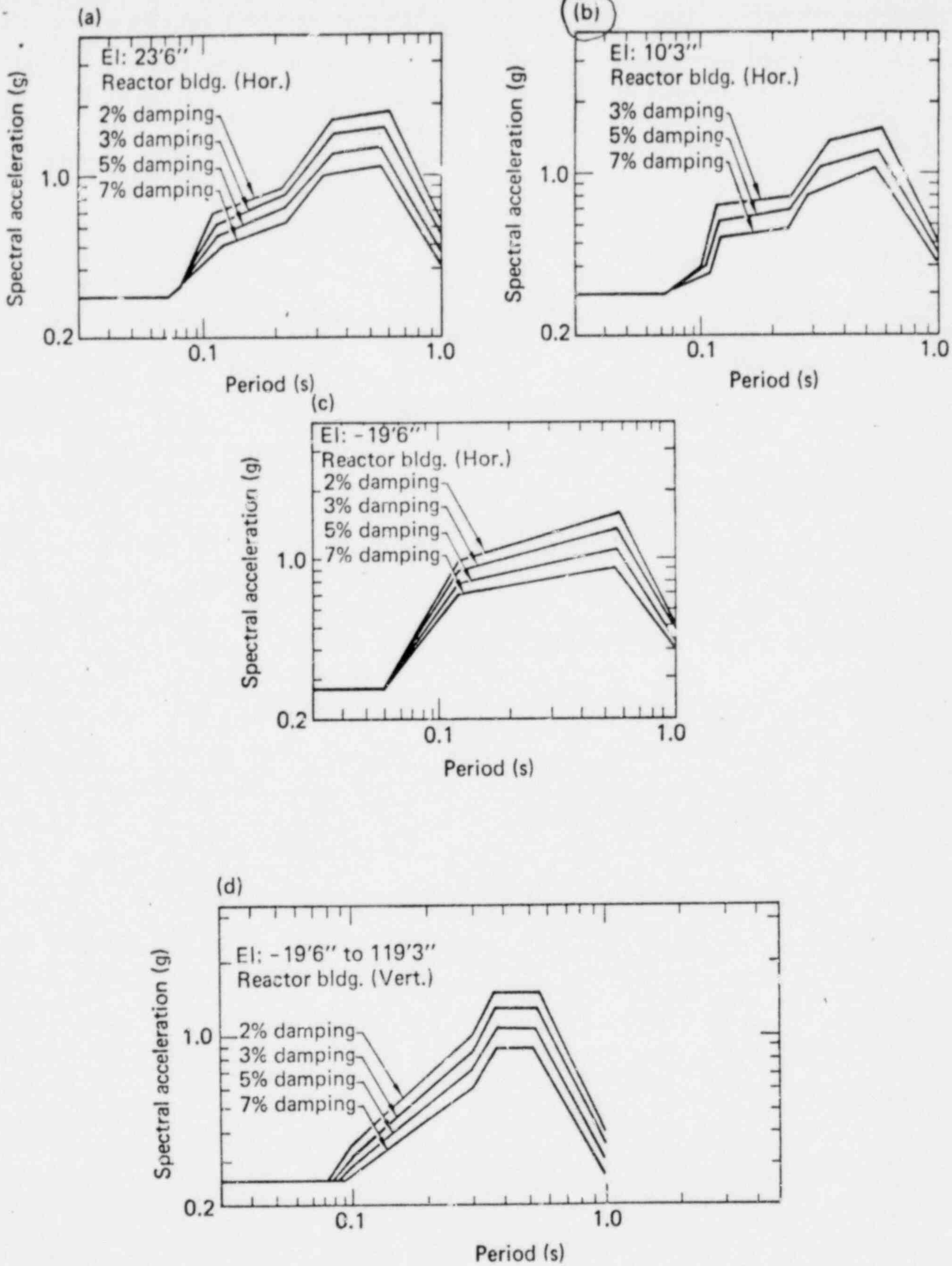


FIG. B-2. Spectral curves (horizontal component) with selected percentages of damping used in reanalysis of equipment in the reactor building at selected elevations from 23'6" to -19'6"; vertical spectral curves used at all elevations analyzed.

	P	V_c	V_L	P	V_c	V_L	P	V_c	V_L	P	V_c	V_L
A			-14.50			-14.50			-14.50			-14.50
B (Seis)			3.63 ~~2.12~~			3.63 ~~2.12~~			3.63 ~~2.12~~			3.63 ~~2.12~~
C (Seis)	4.35 ~~3.48~~	4.35 ~~3.48~~	9.94 ~~7.95~~	4.35 ~~3.48~~	4.35 ~~3.48~~	9.94 ~~7.95~~	4.35 ~~3.48~~	4.35 ~~3.48~~	9.94 ~~7.95~~	4.35 ~~3.48~~	4.35 ~~3.48~~	9.94 ~~7.95~~
D	3.31		10.59		3.31		3.31		10.59		3.31	
E (a)		3.50			3.50			3.50			3.50	
E (b)		3.31		3.31		10.59		3.31		3.31		10.59
F (a)			3.31			3.31			3.31			3.31
F (b)			7.00						7.00			
G		3.31			3.31			3.31			3.31	
H			6.85						6.85			
I						6.85						6.85
TOTALS:												
W/SEIS.	7.66 ~~6.79~~	11.16 ~~10.29~~	-52.51 ~~-49.01~~ ~~+20.01~~ 23.51	7.66 ~~6.79~~	14.47 ~~13.60~~	-48.82 ~~-45.32~~ ~~+16.32~~ 19.82	7.66 ~~6.79~~	11.16 ~~10.29~~	-52.51 ~~-49.01~~ ~~+20.01~~ 23.51	7.66 ~~6.79~~	14.47 ~~13.60~~	-48.82 ~~-45.32~~ ~~+16.32~~ 19.82
W/O SEIS.	3.31	6.81	-38.94 +9.94	3.31	10.12	-35.25 +6.25	3.31	6.81	-38.94 +9.94	3.31	10.12	-35.25 +6.25

SUPPORT REACTIONS

FIGURE 3 (REVISED 6/2/81)

From Ref(73)