ADDITIONAL INFORMATION

ON

JUSTIFICATION OF MARK II LEAD PLANT

SRV LOAD DEFINITION

May 15, 1979

Stone & Webster

2268 227

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TABLE OF CONTENTS

2268 228

1. INTRODUCTION

The report entitled "Justification of Mark II Lead Plant SRV Load Definition" submitted to the NRC on March 30, 1979 (SNRC-374) demonstrates the conservatism present in the Ramshead Load Definition. The concerns expressed by the NRC regarding SRV bubble phasing and frequency characteristics are addressed and furthermore, comparisons of the effects on the plant are made with those resulting from a conservatively constructed load definition based on the KWU T-Quencher. This T-Quencher is the actual discharge device installed in Shoreham and other lead plants.

This report presents additional information specifically requested in a recent communication (1) with the NRC based upon a review of the March 30 report.

The two specific NRC requests of Shoreham were the following:

1. Shoreham to complete Table 2 of the SRV load report by including the same information for the low frequency piping systems presented in Table 3.
2. Submittal by Shoreham concerning a discussion of modal participation for piping analysis. Detailed analysis results are required for the low frequency systems presented in Table 3 concerning how much modal participation there is for the fundamental modes. This data is required in order to resolve uncertainties about low frequency piping system responses.

(1) Telephone communication on April 27, 1979 between NRC, CG&E, S&W and S&L.

2. Low Frequency Piping Results

2.1 Response to NRC Request No. 1:

Table 1 presents the support load and pipe stress comparisons at three (3) selected locations for the four (4) low frequency subsystems identified in table 3 of the original report. Since it is impractical to present detailed information for all piping locations, the following selection criteria, in order of priority, were used:

1. Locations of high stress.
2. Locations representing all types of piping components.
3. Locations evenly distributed along piping subsystem.

It is emphasized that the results at these selected locations are representative of the higher stress locations. Results at low stress locations are relatively unimportant to plant safety and therefore not presented here (see section 6.3 of the original report).

2.2 Response to NRC Request No. 2:

This section contains a discussion of modal participation in the dynamic response of piping systems to SRV loads. Particular consideration is given to systems which have fundamental frequencies low enough to have one or more modes in the frequency range in which the T-Quencher (TQ) ARS may be greater than the Ramshead (RH) ARS.

The modal response of a multi-degree of freedom system subject to dynamic support motion (such as a piping system subject to SRV actuation building vibrations) depends on two basic parameters. The first is the modal participation factor which is a function of physical characteristics, i.e., geometry and mass distribution. The second parameter is related to the amplitude (G's) of the support acceleration at the modal frequency, i.e., the ARS value. For a typical piping system with complex geometry (three dimensional pipe routing, multiple bends, numerous interior pipe supports unevenly spaced, branch lines, etc.) and many concentrated masses (valves, reducers, elbows, tees, equipment, etc.) the amplitudes of the modal participation factors are quite varied with significant factors associated with many modes from the very low to the very high frequencies. Large modal responses will occur at modes with both significant modal participation factors and significant ARS amplitudes. The total response is contributed to by many modes of comparable significance over a wide range of frequencies. For the complex piping systems in the Shoreham Nuclear Power Station the contribution from the fundamental (lowest frequency) mode is of no special significance. It may be among the most or least important depending on the parameters discussed above.

Tables 2 through 6 present the mode-by-mode contributions to resultant bending moments (acting on the pipe cross section) in typical piping systems when subject to SRV building vibrations. These systems include one 'higher' frequency system (Table 2) for comparison of behavior with the four 'low' frequency systems (Tables 3 through 6). The data presented on these tables is based upon the actual building amplified response spectra (ARS) for both the RH and TQ loads. These building ARS are applied simultaneously in the plant N-S, E-W and vertical directions and vary from elevation to elevation within the reactor building. Figure 6-1 presented in the original report from which the NRC has requested additional information is identified as an "Idealized ARS" and was presented in order to show the major features of response. It should not be used to make quantitative comparisons for specific piping systems even though it does reflect overall trends. Inspection of the tabulated results confirms the following important points:

1. Many modes contribute significantly to the total response regardless of the fundamental frequency, the location of piping, or the discharge device.
2. The contribution from the fundamental mode is of no special consequence.
3. For the system with all frequencies above 7 HZ (Table 2) all modal responses from the TQ load are less than the modal responses from the RH load.
4. For systems with lower frequencies all modal responses below 7 HZ from the TQ load are greater than those from the RH load, while all modal responses above about 15 HZ are higher from the RH load. From 7 to 15 HZ results are comparable.

5. Systems with the lowest fundamental frequencies have only a small percent of their significant modes below 7 HZ.
6. Because many modes contribute to the total response, the RH load provides conservative results even when a few modes occur in the frequency range where T-Q response is the greater.

2268 233

CONCLUSION

The detailed analysis results presented in this report demonstrate that the RH load provides conservative results even when the fundamental mode of a piping system is low enough that a few modes occur in the frequency range where the TQ ARS is greater than the RH ARS. The primary reason is that so many modes contribute to the total system response that the contribution from those in the low frequency range is only a small part of the total. It is therefore concluded that piping systems designed to ramshead load can adequately accommodate the T-Quencher load. This document further reinforces the justification of using ramshead SRV load definition as the Mark II lead plant SRV load definition for plant component design.

The additional information presented in this report is intended to resolve uncertainties regarding the response of low frequency piping systems and complete the documentation involving the Lead Plant SRV Ramshead Load Definition as delineated in the March 30, 1979 submittal.

2268 234

TABLE 1
TYPICAL RESULTS AT SELECTED LOCATIONS
PART 1 SUPPORT LOAD COMPARISON

PIPING SUBSYSTEM	COMPONENT	$N+SRV_{RH}+OBE$ (lb or ft-lb)	$N+SRV_{TQ}+OBE$ (lb or ft-lb)	$\frac{SRV_{RH}}{SRV_{TQ}}$
Control Rod Drive 1265	Restraint 65 Resultant Force	42	35	1.44
	Restraint 85 Resultant Force	16	13	1.40
	Restraint 110 Resultant Force	34	33	1.09
Closed Loop Cooling Water 031	Restraint 95 Resultant Force	1,815	1,801	1.08
	Restraint 175 Resultant Force	2,041	2,013	1.18
	Anchor 5 Resultant Moment	3,131	3,052	1.17
Reactor Water Cleanup 013	Anchor 184 Resultant Moment	649	424	1.91
	Snubber 186 Axial Force	567	417	1.40
	Snubber 623 Axial Force	338	279	1.44
Main Steam 2500	Anchor 340 Resultant Moment	147,000	135,000	1.11
	Restraint 365 Resultant Force	33,000	30,000	1.12
	Snubber 400 Axial Force	13,000	10,300	1.31

TABLE 1
PART 2 PRIMARY STRESS INTENSITY COMPARISON

PIPING SUBSYSTEM	COMPONENT	$N+SRV_{RH}+OBE$ (psi)	$N+SRV_{TQ}+OBE$ (psi)	$\frac{SRV_{RH}}{SRV_{TQ}}$
Control Rod Drive 1265	Valve 1	8,076	7,631	1.08
	Elbow 50	4,353	4,176	1.07
	Run 185	6,658	6,355	1.17
Closed Loop Cooling Water 031	Elbow 10	4,720	4,689	1.07
	Tee 205	3,078	2,932	1.16
	Run 275	5,706	4,645	1.38
Reactor Water Cleanup 013	Valve 151	8,206	7,319	1.50
	Run 919	7,795	7,280	1.39
	Reducer 339	10,207	9,807	1.22
Main Steam 2500	Valve 345	8,793	8,409	1.23
	Elbow 415	8,893	8,783	1.27
	Run 440	13,161	12,978	1.22

2268 235

TABLE 2

FW 301 MODE-BY-MODE CONTRIBUTION
RESULTANT MOMENTS

MODE	FREQUENCY (HZ)	REDUCER 65 RH (ft-kip)	REDUCER 65 TQ (ft-kip)	TEE 67 RH (ft-kip)	TEE 67 TQ (ft-kip)	ELBOW 84 RH (ft-kip)	ELBOW 84 TQ (ft-kip)
1	7.1	1.5	0.9	0.6	0.4	0.9	0.5
2	9.0	8.2	8.1	16.6	16.4	12.2	12.0
3	9.4 (2)	1.2	1.2	4.4	4.3	2.9	2.9
4	11.9	10.3	7.4	4.5	3.2	6.3	4.5
5	13.7	4.4	3.4	4.0	3.1	3.2	2.9
6	16.4	19.2	5.9	9.4	2.9	4.7	1.5
7	19.6	6.9	4.7	3.7	2.5	5.1	3.4
8	22.7	10.7	7.3	7.5	5.2	2.0	1.4
9	24.4	3.6	3.2	1.9	1.7	2.3	2.0
10	26.3	4.7	2.6	4.6	2.6	0.9	0.5
11	26.5	0.8	0.5	0.7	0.4	0.1	0.1
12	28.6	2.5	1.6	8.7	5.5	4.5	2.8
13	30.3	5.9	3.3	6.4	3.6	10.4	5.9
14	32.3 (3)	2.0	1.4	1.2	0.8	3.2	2.2
15	33.3	7.9	5.1	13.2	8.6	8.8	5.7
16	34.5	6.7	3.8	0.6	0.3	9.7	5.4
17	37.0	2.9	2.3	1.8	1.4	0.3	0.2
18	38.5	2.8	2.2	2.9	2.3	4.6	3.6
19	40.0	4.1	3.0	4.5	3.3	5.7	4.1
20	40.0	1.8	1.2	0.6	0.4	0.9	0.6
21	43.5	3.8	2.9	1.0	0.6	1.3	0.9
24	58.8	1.4	0.9	1.8	1.2	0.8	0.6
25	58.8	0.6	0.4	0.3	0.2	0.2	0.2
(4) SRSS Above		31.1	18.7	29.1	22.3	25.2	18.6
(5) Combine All Modes		35.6	22.3	36.7	28.0	32.2	23.6

Notes:
(1) Low frequency modes below 7 Hz, TQ > RH.
(2) Intermediate frequency modes between 7 to 15 Hz, TQ ≈ RH.
(3) High frequency modes above 15 Hz, RH > TQ.
(4) For reference only, contributions from other modes are less significant.
(5) Basis for stress calculation, moments are combined by Reg. Guide 1.92 Grouping Method.

2268 236

TABLE 3

CRD 1265 MODE-BY-MODE CONTRIBUTION RESULTANT MOMENTS

MODE	FREQUENCY (HZ)		VALVE 1 RH (ft-lb)	VALVE 1 TQ (ft-lb)	ELBOW 50 RH (ft-lb)	ELBOW 50 TQ (ft-lb)	RUN 185 RH (ft-lb)	RUN 185 TQ (ft-lb)
1	2.9		0.0	1.1	0.0	0.0	0.0	4.5
2	5.1	(1)	1.0	9.0	0.0	2.4	0.0	4.5
3	6.6		2.2	9.0	1.0	2.2	2.0	9.9
4	8.0		2.2	2.4	0.0	0.0	3.6	5.0
5	10.0	(2)	7.3	15.3	2.0	3.5	2.2	5.9
6	11.8		7.1	19.0	2.0	4.4	1.4	4.1
7	12.5		12.2	23.1	3.2	4.5	2.0	2.2
8	15.2		36.9	16.5	7.3	3.5	16.5	8.0
9	16.7		2.0	1.5	1.0	1.1	1.0	1.1
10	19.2		1.4	1.5	0.0	0.0	1.0	1.1
11	25.0		0.0	0.0	0.0	0.0	3.0	1.9
12	27.0		11.2	5.6	1.0	1.1	3.2	2.2
13	27.8		3.6	1.5	0.0	0.0	7.0	2.2
14	32.3	(3)	11.9	6.1	0.0	0.0	1.0	1.1
15	37.0		11.2	8.9	1.0	1.1	0.0	0.0
16	38.5		12.5	9.4	1.0	1.1	1.4	0.0
17	47.6		1.0	0.0	0.0	0.0	7.0	5.5
18	50.0		1.0	1.1	0.0	0.0	3.0	2.2
19	50.0		2.2	1.1	1.0	1.1	2.0	2.2
20	58.8		3.3	2.4	1.0	1.1	1.0	0.0
21	62.5		20.3	16.8	9.1	7.8	1.0	1.1
22	66.7		4.2	2.2	1.0	1.1	0.0	0.0
(4) SRSS Above			51.4	46.0	12.7	12.0	20.9	18.5
(5) Combine All Modes			53.8	50.8	13.6	12.9	22.8	19.6

2268 237

Notes:

See Table 2 for Footnotes.

TABLE 4

CLCW 031 MODE-BY-MODE CONTRIBUTION RESULTANT MOMENTS

MODES	FREQUENCY (HZ)	ELBOW 10 RH (ft-lb)	ELBOW 10 TQ (ft-lb)	TEE 205 RH (ft-lb)	TEE 205 TQ (ft-lb)	RUN 275 RH (ft-lb)	RUN 275 TQ (ft-lb)
1	3.6	10.	61.	4.	19.	4.	19.
2	4.3	12.	85.	5.	32.	7.	45.
3	4.9 (1)	11.	113.	11.	122.	17.	183.
4	5.5	21.	288.	6.	83.	5.	76.
5	6.1	7.	45.	105.	710.	9.	55.
6	8.8	72.	108.	31.	46.	7.	11.
7	8.9	153.	286.	64.	120.	21.	39.
8	9.8	36.	37.	44.	46.	46.	47.
9	10.0	65.	70.	19.	20.	28.	29.
10	11.2 (2)	112.	101.	24.	28.	12.	13.
11	11.8	283.	350.	16.	20.	22.	28.
12	12.7	54.	63.	51.	58.	21.	25.
13	14.1	301.	274.	138.	125.	24.	22.
14	14.8	210.	141.	102.	69.	35.	23.
15	17.5	465.	256.	9.	6.	3.	2.
16	18.2	245.	180.	2.	2.	5.	3.
17	19.2 (3)	6.	4.	1041.	711.	1280.	867.
18	24.0	2.	1.	740.	507.	425.	292.
22	30.3	4.	3.	608.	446.	2698.	1977.
24	32.7	1.	1.	17.	13.	60.	48.
(4) SRSS Above		736.	734.	1433.	1238	3018.	2190.
(5) Combine All Modes		1004.	935.	1468.	1262.	3055.	2220.

Notes:

See Table 2 for Footnotes.

2268 238

TABLE 5

RWCU 013 MODE-BY-MODE CONTRIBUTION
RESULTANT MOMENTS

MODES	FREQUENCY (HZ)	VALVE 151 RH (ft-lb)	VALVE 151 TQ (ft-lb)	RUN 919 RH (ft-lb)	RUN 919 TQ (ft-lb)	REDUCER 339 RH (ft-lb)	REDUCER 339 TQ (ft-lb)
1	4.9	0.	2.	6.	83.	6.	83.
2	6.5 (1)	0.	0.	0.	0.	0.	0.
3	6.6	0.	1.	10.	43.	10.	44.
4	6.8	0.	0.	0.	0.	0.	0.
5	7.7	1.	1.	63.	58.	17.	17.
6	7.9	6.	11.	0.	0.	0.	0.
7	8.0	0.	0.	0.	0.	0.	0.
8	9.0	4.	4.	44.	53.	28.	34.
9	11.1	1.	2.	0.	0.	0.	0.
10	11.4 (2)	3.	3.	0.	0.	0.	0.
11	11.8	76.	147.	0.	1.	0.	0.
12	12.5	14.	17.	0.	0.	0.	0.
13	12.8	19.	28.	0.	0.	0.	0.
15	14.1	8.	8.	22.	21.	13.	11.
17	15.6	127.	50.	35.	13.	13.	4.
18	16.1	138.	61.	79.	34.	24.	11.
20	16.8	8.	3.	66.	26.	30.	12.
23	19.4	138.	74.	15.	8.	3.	1.
25	21.6	381.	196.	23.	11.	2.	1.
27	22.9	71.	44.	108.	66.	4.	2.
28	23.0	160.	111.	73.	51.	20.	14.
29	24.1	235.	169.	254.	184.	15.	11.
30	25.0	37.	25.	29.	20.	108.	73.
31	25.0 (3)	61.	42.	24.	15.	63.	43.
32	26.6	110.	84.	188.	143.	8.	7.
35	28.6	291.	198.	18.	12.	2.	1.
37	31.3	6.	3.	42.	28.	11.	7.
39	32.3	10.	4.	22.	14.	12.	7.
42	37.0	78.	57.	45.	33.	21.	15.
44	38.5	19.	14.	6.	4.	29.	24.
47	43.5	68.	60.	5.	4.	2.	1.
48	43.5	174.	125.	21.	15.	5.	3.
51	47.6	78.	65.	3.	2.	2.	1.
57	55.6	2.	1.	7.	4.	55.	37.
(4) SRSS Above		664.	437.	378.	286.	155.	143.
(5) Combine All Modes		938.	615.	466.	334.	213.	173.

Notes: See Table 2 for Footnotes.

2268 239

TABLE 6

MS 2500 MODE-BY-MODE CONTRIBUTION
RESULTANT MOMENTS

MODE	FREQUENCY (HZ)	VALVE 345 RH (ft-kip)	VALVE 345 TQ (ft-kip)	ELBOW 415 RH (ft-kip)	ELBOW 415 TQ (ft-kip)	RUN 440 RH (ft-kip)	RUN 440 TQ (ft-kip)
1	5.1 (1)	0.2	0.8	1.1	4.1	2.8	10.9
2	13.5	4.6	5.3	3.8	4.3	3.3	3.5
3	14.5 (2)	3.5	6.0	0.6	1.0	0.3	0.5
4	15.2	12.4	20.0	0.9	1.5	0.6	0.9
5	16.7	4.5	3.3	18.4	13.4	14.9	10.9
6	17.9	39.3	23.7	0.3	0.2	0.2	0.1
7	20.8	2.1	1.2	9.2	5.2	9.3	5.3
8	23.8	8.2	5.2	9.0	5.7	10.2	6.5
9	26.6	36.5	17.7	2.7	1.3	3.6	1.7
10	29.4	22.2	31.4	1.3	1.8	0.4	0.6
11	30.3 (3)	1.9	2.1	1.2	1.4	1.6	1.8
12	35.7	3.7	2.7	22.0	16.2	15.3	11.3
13	37.0	6.8	5.4	20.3	16.0	14.3	11.3
14	43.4	0.9	0.6	2.9	2.3	27.7	21.4
15	43.5	0.1	0.1	1.3	1.1	44.2	37.7
16	43.5	0.8	0.6	3.1	2.5	27.3	22.3
17	45.5	0.8	0.6	6.4	5.5	2.6	2.2
18	52.6	2.5	2.2	15.0	12.8	2.1	1.8
19	55.5	2.3	2.1	15.1	12.3	3.8	3.1
SRSS (4) Above		61.1	49.2	44.0	34.1	66.2	54.6
(5) Combine All Modes		63.5	51.8	48.4	38.0	105.7	86.7

Notes:

See Table 2 for Footnotes.

2268 240