MARK II HYDRODYNAMIC LOADS CONFIRMATORY PROGRAM

ADDITIONAL PIPING AND SUPPORT EVALUATIONS

SHOREHAM NUCLEAR POWER STATION - UNIT 1

LONG ISLAND LIGHTING COMPANY

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1. INTRODUCTION

The objective of the Shoreham Mark II hydrodynamic load confirmatory program is to evaluate the plant with respect to the final generic Long Term Program (LTP) hydrodynamic load definitions. An evaluation program was performed during 1981 and results were presented in Appendix L of Shoreham's Plant Design Assessment Report (DAR), Revision 5 (Reference 1). The generic LTP load definitions, including NUREG-0808 (Reference 2) for condensation oscillation (CO) and chugging loads, and NUREG-0802 (Reference 3) for KWU T-quencher load, were implemented. A reactor building structural dynamic analysis was performed to provide the amplified response spectra (ARS) at various structural locations for plant component qualification. The containment structures, the secondary structures, and representative plant components were evaluated and found to have sufficient design margins to accommodate the load revisions of the Mark II generic LTP load definitions. The detailed description of the confirmatory program completed in 1981 as well as the conclusions of the plant evaluation are contained in the DAR (Reference 1).

There are approximately 280 essential piping subsystems (segments of systems subdivided for the purpose of stress analysis, each of which is designated as an AX) and approximately 3000 associated pipe supports in the Shoreham reactor building. The confirmatory program described in the DAR included a complete reanalysis of 30 piping subsystems selected to represent those with minimum overall design margin of safety.

This report contains the results of an evaluation of an expanded sample (namely, 67 additional subsystems) based on the criterion of expected loading increase which has been performed to address NRC comments on the program described in the DAR (see Reference 5).

These two programs have evaluated two categories of piping subsystems that would be most critically affected by the generic LTP hydrodynamic loads. The evaluation therefore provides conclusive analytical results to assure that the program objective of confirming piping and support design adequacy is achieved.

2. SCOPE OF REVIEW

The piping subsystems selected for evaluation during the 1981 confirmatory program were based on the existence of the smallest design margins. It is the purpose of the additional evaluations discussed herein to evaluate piping subsystems based on the criterion of largest loading increases expected from the generic LTP hydrodynamic load definitions.

The Shoreham containment building is schematically discretized into 18 structural nodes for the purpose of ARS generation. The locations and their alphabetical notations are shown in Figure 1.

The peak amplified response spectra (ARS) from the generic LTP loads and the design basis loads are compared at each structural node. Only the peaks in the frequency range above 40 Hz are used since this is the range of the load increases of concern.

A review of the ARS peaks shows that the three primary containment locations, namely,

Node H at el 106 ft
Node J at el 83 ft
Node L at el 21 ft

have the largest increases. After discussion with NRC staff, it was agreed that a reevaluation of all piping subsystems attached at the three locations of concern would be performed (Reference 5).

All essential piping subsystems inside the reactor building were reviewed to identify those affected by response at node H, J, and L. Table 1 shows the ASME III Class 1 subsystems, and Table 2 shows the ASME III Class 2 and 3 subsystems that are affected. An AX is a piping subsystem and the SRV-LOCA curve name includes the alphabetical notations of the structural nodes that affect the subsystem (the numerals indicate the damping values for SRV and LOCA, respectively). For example, curve CGHPQ12 indicates that the piping subsystem is attached at nodes C, G, H, P, and Q and is analyzed for 1 percent damping SRV curves and 2 percent LOCA curves.

Out of a total of 277 AXs in the reactor building, 90 are identified in Tables 1 and 2. Of these, 23 were part of the 30 originally analyzed and were discussed in the DAR. The remaining 67 have been analyzed in this additional evaluation effort.

3. EVALUATION PROCEDURE

The characteristics of the Mark II generic LTP hydrodynamic loads are such that the Shoreham containment structural nodes H, J, and L have the most significant loading (ARS) increases. A piping dynamic analysis has been performed for each of the 67 subsystems not analyzed in the DAR to provide quantitative evidence that all subsystems designed to the design basis loads can accommodate the generic LTP hydrodynamic loads.

The significant increase in the CO load is partially due to the conservative nature of the load definition. The load definition, as prescribed in Reference 2, is a direct application of the 4TCO (Temporary Tall Test Tank Condensation Oscillation) test data to the Shoreham pool boundary. A conservative spatial distribution in conjunction with a synchronized in-phase oscillation are specified. The 4TCO test facility is a full-scale test facility constructed to provide test data to be used for evaluation of all Mark II plants. The pool area per vent for the 4TCO facility is significantly less than that for Shoreham. NUREG-0808 (Reference 2) has acknowledged the conservatism inherent in the load definition and has allowed credit to be taken for the pool size effect.

A plant unique assessment was performed to quantify an appropriate CO load reduction factor for the Shoreham containment in order to compensate for the pool size effect. The acoustic model developed for Mark II Improved Chugging Methodology (Reference 6) was used to calculate the Shoreham containment basemat pressure and the 4TCO bottom pressure and hence to arrive at the reduction ratio. This approach is the same as that previously used for the LaSalle plant (Reference 4). The CO load reduction factor calculated for Shoreham is 0.7.

NUREG-0808 also allows credit to be taken for pool temperature range effect. Shoreham has not elected to take credit for this effect at this time.

A conservatism also exists in the Shoreham confirmatory chugging load. The generic LTP chugging definition, as discussed in Reference 2, prescribes that the average of the seven key chugs and their larger-adjacent chugs from the 4TCO data may be used in the chugging source strength definition. The averaging is appropriate since it accounts for the observed vent-to-vent amplitude variation within a multivent pool chug. Shoreham's confirmatory chugging load was developed before Reference 2 became available and only the key chugs were used as the source strength. This is acceptable in accordance with Reference 2, since it is conservative. The conservative factor is estimated to be about 30 percent but is retained in the load definition.

As was the case throughout the engineering design process, structural analyses have generally employed simplifying assumptions that are also conservative in nature. A specific example is the treatment of axisymmetric hydrodynamic loads such as the CO load definition. The support excitation to a piping subsystem that is attached to the containment wall is in reality a one-directional radial excitation. Design analyses have been generally conservatively performed with the full amplitude of radial excitation applied in two perpendicular horizontal directions. The chugging load definition is not purely axisymmetrical. However, the tangential excitation is almost an order of magnitude smaller than the radial excitation. The design analyses for chugging also employed the same conservative simplifying procedure and applied the full amplitude of radial excitation in two horizontal directions. These substantial conservatisms have been removed in the additional piping dynamic analyses performed and discussed herein.

By comparison of ARS peaks, it is observed that the higher acceleration values from the generic LTP loads occur in the frequency ranges above 40 Hz at certain specific locations on the primary containment wall. The peak accelerations vary significantly between structural nodes. The piping analysis method used by Shoreham is to assume all support points are subjected to an envelope of the highest acceleration from individual support points at all frequencies. Results so produced are very conservative. Previous experience indicates that piping response in a multiple support system is generally attenuated rapidly outward from a high excitation source. For a piping subsystem that has a high excitation at one support point and a significantly low excitation at all other support points, the high responses are typically observed to occur only on the segments that are within a certain influence zone of the high excitation support point. The precise zone of influence cannot be established without actually performing the piping dynamic analysis. However, for the purpose of screening pipe supports for this additional confirmatory review, it is assumed that the high response will be attenuated beyond two support points from the high excitation support point at the primary containment. Therefore, a pipe support that is separated from the primary wall attachment point by at least two other supports is assumed outside the influence zone and the high acceleration at the primary wall will not experience a significantly increased support load. In defining the influence zone, a one-directional support oriented vertically or nearly tangentially in the horizontal direction is excluded since such a support is not affected by the predominantly radial excitation of the generic LTP hydrodynamic loads.

Approximately one-third of the pipe supports within the reactor building are on the 90 piping subsystems affected by the responses at structural nodes H, J, & L. The practicality of the design and construction procedure is to use an available component which has a capacity which equals or exceeds the exact value arrived at by a calculation. This general practice has resulted in substantial design margins in a large number of pipe supports. Understanding that the purpose of this additional confirmatory evaluation is to demonstrate that the pipe supports can accommodate the potential load increase due to the generic CO and chugging loads where CO and chugging account for part of the faulted condition loads, it is prudent to review the design margins that existed in the design of these supports.

Since the maximum peak acceleration increase is approximately 1.4 and realizing that the piping response is the combination of contributions from all response modes, it is concluded that a factor of 1.4 is appropriate to account for the potential faulted load increase.

Based on the above discussion, a pipe support that is within the influence zone of the primary containment wall and does not have an apparent design margin of 1.4 on the faulted design load is selectively identified for detailed quantitative evaluation.

Following is a summary of the steps of the piping and support evaluation procedure:

1. A reanalysis of all 67 piping subsystems to account for the generic LTP SRV, CO, and chugging loads

2. A piping primary stress analysis to verify that all piping components meet ASME Code Section III allowables for the faulted condition

3. A screening of pipe supports to identify those subject to load increase and having a calculated design margin of less than 40 percent.

4. A regeneration of the loads for these pipe supports

5. A pipe support reevaluation to verify that all components of these supports can accommodate the reanalyzed piping support loads

4. SIGNIFICANT RESULTS

The results for the 67 AXs selected for review and reanalysis are presented in this report.

Table 3 summarizes the characteristics of piping subsystems contained in the 67 AXs and presents results for the most highly stressed piping components on each AX. In all cases, the ratios of the calculated stresses to the allowable stresses for the faulted condition, as indicated by Faulted Stress Ratio in Table 3, are less than unity. The faulted condition stresses are well within ASME Code allowables.

The 67 AXs analyzed contain a total of 534 pipe supports; of these,

77 are spring hangers, which are not affected by the dynamic support of the pipe;

322 are determined to be outside the influence zone of the primary containment wall radial excitations;

95 are determined to be inside the influence zone and are demonstrated to have sufficient design margins to accommodate a 40 percent increase in the design basis faulted load condition.

40 are inside the influence zone and are reviewed quantitatively for design adequacy of the support components when subject to the recalculated loads.

534 toal scope.

For the 40 pipe supports which required quantitative reviews, the complete support design process was repeated using the new loads generated from the generic LTP hydrodynamic load definitions. Sufficent margins were found to exist in all of the components within each pipe support. Table 4 provides the list of these pipe supports, the components that are most critical, and the ratios of the calculated stresses to the allowable stresses for the faulted condition. It is noted that several of the supports have a new design margin of greater than 40 percent, indicating that the new support load is actually less than the design basis analysis.

5. CONCLUSIONS

The Shoreham plant has been evaluated with respect to the Mark II generic LTP hydrodynamic load definition and results were presented in DAR Revision 5. An extensive additional pipe stress and support evaluation program has been completed, in addition to the original program, to cover the plant piping that was determined to be the most affected by the LTP loads. The evaluation results are presented in this report.

In all cases, plant piping and support components that were designed to the original Shoreham design basis load definition were found to have sufficient design margins to accommodate the load revisions of the Mark II generic LTP hydrodynamic loads. This program, therefore, provides positive confirmation of the design adequacy of Shoreham plant piping and supports.

6. REFERENCES

1. Plant Design Assessment Report for SRV and LOCA Loads, Shoreham Nuclear Power Station - Unit 1, Revision 5, December 1981.

2. Mark II Containment Program Load Evaluation and Acceptance Criteria, NUREG-0808, August 1982.

3. Safety/Relief Valve Quencher Loads Evaluation Report - BWR Mark II and III Containment, NUREG-0802, Draft, November 1981.

4. Mark II Containment Lead Plant Program Load Evaluation and Acceptance Criteria, NUREG-0487, Supplement 2, February 1981.

5. Letter from J. L. Smith, LILCO to H. R. Denton, NRC. Subject: "SER Item No. 1 - Pool Dynamic Loads," letter No. SNRC-755, August 20, 1982.

6. Mark II Improved Chugging Methodology, General Electric Report NEDE-24822-P, May 1980.

TABLE 1

ASME CLASS 1 SUBSYSTEMS AFFECTED BY STRUCTURAL NODES H, J, ND L

System* No.	AX No.	SRV-LOCA Curve Name	H	J	L	Noted if Aanalyzed in the DAR
1G33	1C	CGHPQ12	X			
1E21	10A	ABCHQRS12	X			
1N21	30A	ACHJQRS12	X	X		
	30B	ABCHJ12	X	X		DAR
	30G	HJQRS12	X	X		
	30H	ABCHJ12	X	X		DAR
1E51	2A	BCJHQRS12	X	X		DAR
1E32	60B	JQR12		X		DAR
	60B	JQR12		X		DAR
	60E	JQR12		X		DAR
	60F	JQR12		X		DAR
1C41	9A	BCGH12	X			
	9B	GHPQ12	X			
1E41	11G	JKRS12		X		DAR
1B21	24A	ABCDJK12		X		DAR
1E11	8A	ACDHJK12	X	X		DAR
	8C	JKLQRST12		X	X	DAR
	8F	HJKLPQRST12	X	X	X	DAR
	8H	HJKLQRST12	X	X	X	DAR
	8L	ABCJHGQRS12	X	X		DAR
	8N	ABCDJK23		X		DAR
1B21	25A	JQR23		X		
	25F	CDJKQR12		X		
Total	23		13	19	3	15

*1G33 - Reactor Water Cleanup
1E21 - Core Spray
1N21 - Feedwater
1E51 - Reactor Core Isolation Cooling
1E32 - Main Steam Leakage Control
1C41 - Standby Liquid Control
1E41 - High Pressure Coolant Injection
1B21 - Main Steam
1E11 - Residual Heat Removal

TABLE 2

ASME CLASS 2 AND 3 SUBSYSTEMS AFFECTED BY STRUCTURAL NODES H, J, AND L

System* No.	AX No.	SRV-LOCA Curve Name	H	J	L	Note if Analyzed In the DAR
1M50	524AK	JKQRS12		X		
	524AM	JKQRS12		X		
	524AQ	JKRS12		X		
	524AS	CDJK12		X		
	524AY	HJQR12	X	X		
	524U	JKRS12		X		
	524W	CDJK12		X		
	524X	CDJK12		X		
	524Y	CDJK12		X		
1E51	02C	KLST12			X	DAR
	02D	KLST12			X	
	02G	KL12			X	
	02H	KL12			X	
	02J	KL12			X	
1P42	03AD	CDJK12		X		DAR
	03AE	CDJK12		X		DAR
	03AF	JKPQRS12		X		
	03M	JKRS12		X		
	03N	JKRS12		X		
	03T	CDJK12		X		DAR
	03W	CDJK12		X		DAR
1B21	04N	ABCHJ12	X	X		
1G41	07E	KLST12			X	
	07X	KL12			X	
1E11	08AA	KL12			X	
	08AD	KL12			X	
	08AG	KL12			X	
	08AH	H-LP-T12	X	X	X	
	08B	KLMST23			X	
	08D	H12	X			
	08E	H12	X			
	08K	KLRST12			X	
	08R	KLRST12			X	
	08S	DEKL12			X	
	08Z	KL12			X	
1E21	10B	KLST12 & RST12			X	
	10D	KLST12			X	
	10G	KL12			X	
1E41	11A	KLST12			X	
	11B	KLST23			X	
	11J	KL12			X	

TABLE 2 (Continued)

System* No.	AX No.	SRV-LOCA Curve Name	H	J	L	Noted if Analyzed I the DAR
1C11	12D	CDHJ12	X	X		
	12E	CDHJ12	X	X		
	12F	HJQR12	X	X		
	12G	HJQR12	X	X		
	12H	HJQR12	X	X		
	12J	HJQR12	X	X		
	12K	HQR12	X			
	12L	JKRS12		X		
	12N	HJQR12	X	X		
	12S	CDHJ12	X	X		
1G11	18AE	DEKL12			X	
	18M	BCDKLG12			X	
1B21	24B	ABCDJ12		X		DAR
	24C	ABCDJ12		X		
	24D	ABCDEFJKLM12		X	X	DAR
	24E	ABCDJ12		X		DAR
1T24	84C	KLRS12			X	
1T23	99A	KL12			X	
1E51	99C	KL12			X	
1E11	99D	KL12			X	
1Z91	99F	KL12			X	
1T48	132A	JKLRS12		X	X	
	132C	KLQRS12			X	
	132D	JKLQRST		X	X	
	132E	JKRS12		X		
1E32	60D	JQR12		X		
Total	67		9	35	33	8

*1M50 - Reactor Building Air Cooling, Purge and Heating
1E51 - Reactor Core Isolation Cooling
1P42 - Reactor Building Closed Loop Cooling Water
1B21 - Main Steam
1G41 - Fuel Pool Cooling and Cleanup
1E11 - Residual Heat Removal
1E21 - Core Spray
1E41 - High Pressure Coolant Injection
1C11 - Reactor Control Rod Drive
1G11 - Radwaste Equipment Drains
1T24 - Primary Containment Inerting
1T23 - Drywell Floor Seal Pressure Monitoring
1Z91 - Instrumentation and Control
1T48 - Primary Containment Air Control
1E32 - Main Steam Leakage Control

TABLE 3 CONFIRMATORY BOP PIPE STRESS SUMMARY

System No.	AX No.	ASME Code Class	Pipe Size (inches)	Fundamental Frequency (Hz)	Piping Node Number	Component Type	Faulted Stress Ratio
1G33	1C	1	6	8.2	197	REDUCER	0.47
1E51	2D	2	8	7.8	5	ELBOW	0.23
	2G	2	6	33.2	5	RUN	0.41
	2H	2	8	20.0	115	RUN	0.40
	2J	2	2	41.5	125	RUN	0.29
1P42	3AF	3	10	5.1	135	RUN	0.37
	3M	2	4	13.1	5	RUN	0.36
	3N	2,3	4,6	8.0	55	RUN	0.24
1B21	4N	2	3/4	10.1	17	RUN	0.64
1G41	7E	2	10	11.4	592	TEE	0.33
	7X	2	10	7.2	8	ELBOW	0.33
1E11	8AA	2	16	6.7	1	RUN	0.47
	8AD	2	20	13.0	6	ELBOW	0.78
	8AG	2	10	55.9	7	RUN	0.37
	8AH	2	6	21.4	632	TEE	0.21
	8B	2	20	6.6	237	TEE	0.35
	8D	2	12	6.7	1	RUN	0.51
	8E	2	12	10.7	5	RUN	0.34
	8K	2	16	7.6	35	TEE	0.47
	8R	2	8	8.7	177	TEE	0.27
	8S	2	6	6.3	5	ELBOW	0.21
	8Z	2	16	39.0	3	ELBOW	0.18
1C41	9A	1	1 1/2	4.7	15	RUN	0.44
	9B	1	1 1/2	6.3	552	RUN	0.47
1E21	10A	1,2	10	4.9	8200	RUN	0.69
	10B	2	14	12.3	160	TEE	0.21
	10D	2	3	7.8	65	RUN	0.30
	10G	2	12	9.8	8	ELBOW	0.46
1E41	11A	2	16	6.0	65	RUN	0.40
	11B	2	18	8.0	84	TEE	0.36
	11J	2	18	18.6	70	ELBOW	0.34
1C11	12D	2	1	5.1	79	RUN	0.37
	12E	2	1	5.3	1	RUN	0.34
	12F	2	1	7.8	45	REDUCER	0.22
	12G	2	3/4	2.0	260	RUN	0.27
	12H	2	1	3.8	280	RUN	0.58
	12J	2	3/4	4.2	31	RUN	0.42
	12K	2	3/4	3.9	118	RUN	0.45
	12L	2	2	5.5	5	RUN	0.24
	12N	2	1	4.6	125	RUN	0.28
	12S	2	3/4	5.1	79	RUN	0.32
1G11	18AE	2	4	5.6	5	RUN	0.20
	18M	2,3	3	5.1	11	ELBOW	0.22

TABLE 3 (CONT'D)

System No.	AX No.	ASME Code Class	Pipe Size (inches)	Fundamental Frequency (Hz)	Piping Node Number	Component Type	Faulted Stress Ratio
1B21	24C	2	24	7.4	645	TEE	0.47
1B21	25A	1	24	4.9	435	RUN	0.50
	25F	1	3	5.5	488	RUN	0.52
1N21	30A	1	20	7.0	3540	REDUCER	0.48
	30G	1	20	8.3	107	RUN	0.77
1E32	60D	2	3	5.5	6540	RUN	0.51
1T24	84C	2	18	5.3	385	RUN	0.25
1T23	99A	2	1	20.7	280	RUN	0.25
1E51	99C	2	1 1/2	100.0+	5	RUN	0.13
1E11	99D	2	2	100.0+	5	RUN	0.21
1Z91	99F	2	1	100.0+	25	RUN	0.07
1T48	132A	2	4	4.8	57	RUN	0.95
	132C	2	6	3.3	53	RUN	0.94
	132D	2	6	5.7	162	RUN	0.43
	132E	2	6	4.9	199	ELBOW	0.35
1M50	524AK	2	4	5.8	8055	REDUCER	0.52
	524AM	2	6	16.2	510	REDUCER	0.37
	524AQ	2	4,8	6.1	179	REDUCER	0.45
	524AS	3	3	17.3	190	RUN	0.25
	524AY	2	6	5.6	40	ELBOW	0.49
	524U	3	4	6.1	120	RUN	0.28
	524W	2	2,3,4	5.2	350	RUN	0.35
	524X	2,3	4	5.1	210	RUN	0.39
	524Y	2	2,3,4	6.3	460	RUN	0.40

TABLE 4

CONFIRMATORY BOP PIPE SUPPORT SUMMARY

System No.	AX No.	Pipe Support No.	Component Type	Faulted Stress Ratio
1G33	1C	PSA 010	Anchor Bolts	0.61
1E51	2D	PSR 049	Weld	0.67
1E51	2H	PSR 039	Anchor Bolts	0.45
1P42	3AF	PSR 070	Anchor Bolts	0.64
1P42	3AF	PSR 071	Strap	0.66
1P42	3AF	PSR 130	Weld	0.88
1P42	3M	PSA 087	Weld	0.74
1P42	3M	PSA 096	Weld	0.97
1P42	3N	PSA 314	Base Plate	0.84
1P42	3N	PSR 479	Anchor Bolts	0.89
1E11	8B	PSR 097	Weld	0.53
1E11	8D	PSA 002	Weld	0.89
1E11	8E	PSA 011	Weld	0.88
1E11	8K	PSR 069	Weld	0.77
1E11	8K	PSR 070	Tube Steel	0.85
1E11	8K	PSR 071	Weld	0.90
1E11	8R	PSA 309	Weld	0.66
1E21	8K	PSR 025	Weld	0.58
1E11	8S	PSA 222	Base Plate	0.78
1E11	8S	PSA 225	Weld	0.98
1E21	10A	PSR 030	Weld	0.92
1E21	10A	PSSP 806	Snubber Capacity	0.54
1E21	11A	PSA 016	Weld	0.70

TABLE 4 (CONT'D)

System No.	AX No.	Pipe Support No.	Component Type	Faulted Stress Ratio
1E11	11B	PSR 004	Anchor Bolts	0.97
1C11	12L	PSA 108	Weld	0.66
1C11	12N	PSA 006	Anchor Bolts	0.99
1N11	25A	PSSP 841	Weld	0.57
1B21	25F	PSR 906	Weld	0.30
1B21	25F	PSA 890	Weld	0.95
1G33	30A	PSSP 242	Snubber Capacity	0.70
1N21	30G	PSA 481	Weld	0.84
1N21	30G	PSR 499	Strut Capacity	0.53
1T48	132A	PSR 075	Anchor Bolts	0.85
1T48	132C	PSR 067	Anchor Bolts	0.76
1T48	132D	PSA 027	Weld	0.84
1T48	132E	PSR 017	Adapter Plate	0.27
1T48	132E	PSR 019	Anchor Bolts	0.72
1T48	132E	PSR 025	Anchor Bolts	0.92
1T47	524AK	PSR 079	Weld	0.72
1P42	524AM	PSA 544	Anchor Bolts	0.82