LIMERICK GENERATING STATION UNITS 1 & 2

DESIGN ASSESSMENT REPORT

REVISION 2 PAGE CHANGES

The attached pages, tables, and figures are considered part of a controlled copy of the Limerick Generating Station DAR. This material should be incorporated into the DAR by following the instructions below.

After the revised pages are inserted, place the page that follows these instructions in the front of the Volume 1.

REMOVE	INSERT
VOLUME 1	
Pages S-iii, -iv, -v	Pages S-iii, -iv, -v
Pages 1.3-1 & -2	Pages 1.3-1 & -2
Table 1.3-1 (pgs3 thru 7)	Table 1.3-1 (pgs 3 thru 7)
Table 1.3-2 (pgs 1 thru 18)	Table 1.3-2 (pgs 1 thru 10)
Table 1.4-1 (pgs 2)	Table 1.4-1 (pgs 2)
Pages 2.2-3	Pages 2.2-3
Pages 4.2-9 & -10	Pages 4.2-9 & -10
Pages 4.2-13 & -14	Pages 4.2-13 & -14
Table 4.4-3 & -4	Table 4.2-3 & -4
Table 4.2-8	Table 4.2-8
Table 4.2-10	Table 4.2.10
Figure 4.2-17	Figure 4.2-17
Figure 4.2-21	Figure 4.2-21
Figure 4.2-23	Figure 4.2-23
Pages 5-i & -ii	Pages 5-i & -ii
Pages 5.8-1	Pages 5.8-1
table 5.8-1	Pages 5.8-1
Table 5.10-1 (pg1)	Table 5.10-1 (pg 1)
Pages 6-i	Pages 6-i
Pages 6.8-1 & -2	Pages 6.8-1 & -2
Pages 7-ii thru -v	Pages 7-ii thru -v
Pages 7.1-5 thru -8	Pages 7.1-5 thri -8
Pages 7.1-19 thru -31	Pages 7.1-19 thru35
Figure 7.1-12 thru -15	Figure 7.1-12 thru 15
Pages 7.2-1 thru -6	Pages 7.2-1 thru -6
Pages 220.17-1	Pages 220.17-1 thru 220.20-1
------------	Page 480.63-1
Page 480.67-1	Page 480.68-1
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Page 480.69-1	Page 480.70-1
Page 480.70-1	Page 480.71-1
VOLUME 2	
Pages F-i	Pages F-i thru Table F.1-1

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THIS DAR SET HAS BEEN UPDATED TO INCLUDE REVISIONS THROUGH 2 DATED 03/83.

1.3 MARK II CONTAINMENT PROGRAM

Philadephia Electric is a member of the Mark II owners group that was formed in June 1975 to define and investigate the dynamic loads due to SRV discharge and LOCA. The methods for calculating these hydrodynamic loads are described in the DFFR (Reference 1.3-1). The DFFR also specifies load combinations for plant design assessment. The methods provided in the DFFR are based on a combination of analytical models, test data, and engineering judgment. The methods and information provided are sufficient for use in a conservative evaluation of the design adequacy of Mark II structures and components.

The Mark II Owners Group Containment Program concentrated initially on the tasks required for the licensing of the lead plants (Zimmer, LaSalle, and Shoreham). This Lead-Plant Program established interim bounding loads appropriate for the anticipated life of each of the lead plants. The NRC acceptance criteria for the lead plant LOCA and SRV load definitions are described in NUREG 0487 (Reference 1.3-2) and NUREG 0487 Supplements 1 and 2 (References 1.3-3 and 1.3-4, respectively).

The remainder of the Mark II Owners Group Program concentrated on the tasks required to license the long-term plants, which include LGS. The NRC acceptance criteria for the long-term plant LOCA and SRV load definitions are described in NUREG 0808 (Reference 1.3-5) and NUREG 0802 (Reference 1.3-6), respectively. The objectives of the Long-Term Program were (a) to provide justification, by tests and analyses, for refinement of selected lead-plant bounding loads, and (b) to provide additional confirmation of certain loads used in the Lead-Plant Program.

As a task separate from the Mark II Owners Group Program, a Mark II SRV discharge line T-quencher device and load specification was developed in 1978 by Kraftwerk Union (KWU) for Pennsylvania Power and Light (PP&L) for use in the Susquehanna Steam Electric Station (SSES). The T-quencher provides a reduction in the containment wall loads as compared to the loads generated by the original Ramshead quencher design. The T-quencher also promotes effective heat transfer and condensation of discharge steam in the suppression pool. Philadelphia Electric Company decided to use the same T-quencher design for LGS. Following this decision, KWU compared the LGS and SSES SRV-related parameters and concluded that the same T-quencher load specification could be used by Philadelphia Electric for the LGS containment analysis. The LGS and SSES SRV-related parameters are compared in Table 4.1-1.

The quencher load specification was submitted to the NRC by PP&L in April 1978. In addition, a full-scale SSES-unique unit cell test (Chapter 8) was performed by KWU in 1979. This test verifies KWU's design approach for the quencher load specification used for LGS.

Table 1.3-1 provides a summary of the LGS licensing basis as a result of the Mark II Containment Program.

Table 1.3-2 presents a summarizing review of the LGS suppression pool dynamic loadings. This is achieved by comparing the NRC Acceptance Criteria with the LGS plant-unique position.

1.3.1 REFERENCES

1.3-1 "Mark II Containment Dynamic Forcing Function Information Report", NEDO-21061, Revision 4, General Electric Co., November 1981.

1.3-2 "Mark II Containment Lead Plant Program Load Evaluation and Acceptance Criteria", NUREG-0487, NRC, October 1978.

1.3-3 "Mark II Containment Lead Plant Program Load Evaluation and Acceptance Criteria", NUREG-0487, Supplement 1, NRC, September 1980.

1.3-4 "Mark II Containment Lead Plant Program Load Evaluation and Acceptance Criteria", NUREG-0487, Supplement 2, NRC, February 1981.

1.3-5 "Mark II Containment Program Load Evaluation and Acceptance Criteria", NUREG-0808, NRC, August 1981.

1.3-6 "Safety/Relief Valve Quencher Loads: Evaluation for BWR Mark II and III Containments", NUREG-0802, NRC, October 1982.

TASK NUMBER	ACTIVITY	AC
A.22	A.16 SOURCE EVALUATION	Co 4T
A.29	V.B. MODEL	Me
A.30	RESPONSE TO BIENKOWSKI/NRC CHUGGING QUESTION	Lo fo
B.	SRV - RELATED TASKS	
B.1	QUENCHER EMPIRICAL MODEL	DF Su
B.2	RAMSHEAD MODEL	DF Su An
B.3	MONTICELLO IN-PLANT SRV TESTS	Pr Hy
B.5	SRV QUENCHER IN-PLANT CAORSO TESTS	Te Te Te Te
	Phase I	Te
	Phase II	Te
	Re-evaluate	AM
B.5.1	EXTENDED BLOWDOWN	Te

TABLE 1.3-1 (CONT'D)

TIVITY TYPE	DOCUMENTATION	DOC DATE	USED FOR LGS LICENSING
nfirm/Revise Source Based on 4TCO Data	NEDE-24302-P	4/81	Yes
CO Chugging Data - Six key runs	NEDE-24285-P	1/81	Yes
	NEDO-24285		Yes
thodology Report	NEDE-22178-P	8/82	Yes
	NEDO-22178	9/82	Yes
ad evaluation r frequency	Letter Report	4/82	Yes
FR Model	NEDE-21061-P	9/76	No
	NEDO-21061	9/76	No
pporting Data	NEDE-21078-P	5/75	No
	NEDO-21078	10/75	No
FR MODEL	NEDE-21061-P	9/76	No
	NEDO-21062	9/76	No
pporting Data	NEDE-21062-P	7/75	No
	NEDO-21062	7/75	No
alysis	NEDE-20942-P	5/75	No
	NEDO-20942	5/75	No
eliminary Test Report	NEDC-21465-P	12/76	No
	NEDO-21465	12/76	No
drodynamic Report	NEDC-21581-P	8/77	No
	NEDO-21581	8/77	No
st Plant	NEDM-20988 Rev. 2	12/76	No
st Plan Addendum 1	NEDM-20988 Rev.2, Add.1	10/77	No
st Plan Addendum 2	NEDM-20988 Rev.2, Add.2	4/78	No
st Summary	Letter Report	3/79	No
st Report	NEDE-25100-P	5/79	No
	NEDE-25100-P Errata	2/81	No
	NEDO-25100	8/79	No
	NEDO-25100 Errata	2/81	No
st Report	NEDE-24757-P	5/80	No
	NEDO-24757	7/80	No
N Report	NEDE-24835-P	3/81	No
st Report	NEDE-24798-P	7/80	No
	NEDO-24798	8/80	No

TASK NUMBER	ACTIVITY	AC
B.6	THERMAL MIXING MODEL	An
B.10	MONTICELLO FSI	An
B.11	DFFR RAMSHEAD MODEL TO MONTICELLO DATA	Da
B.12	RAMSHEAD SRV METHODOLOGY SUMMARY	An
C.	MISCELLANEOUS TASKS	
C.0	SUPPORTING PROGRAM	Su Su
C.1	DFFR REVISIONS (TASK C.18)	Re Re Re
C.3	NRC ROUND 1 QUESTIONS	DF DF DF
C.5	SRSS JUSTIFICATION	In SR
C.5.1	SRSS PROGRAM SUMMARY	SR
C.5.2	SRSS APPLICATION CRITERIA	SR SR
C.5.3	SRSS JUSTIFICATION CRITERIA	SR SR
C.5.4	BROOKHAVEN REPORT CRITIQUE	BN
C.6	NRC ROUND 2 QUESTIONS	DF DF

TIVITY TYPE	DOCUMENTATION	DOC DATE	USED FOR LGS LICENSING
alytical Model	NEDC-23689-P	3/78	No
	NEDO-23689	3/78	No
alysis of FSI	NEDO-23834	6/78	No
ta/Model Comparison	NSC-GEN 0394	9/77	No
alytical Methods	NEDO-24070	10/77	No
op Prog Report	NEDO-21297	5/76	No
op Prog Report Rev. 1	NEDO-21297 Rev. 1	4/78	No
vision 1	NEDE-21061-P Rev. 1	9/75	No
	NEDO-21061 Rev. 1	9/75	No
vision 2	NEDE-21061-P Rev. 2	9/76	No
	NEDO-21061 Rev. 2	9/76	No
vision 3	NEDE-21061-P Rev. 3	6/78	Yes
	NEDO-21061 Rev. 3	6/78	Yes
FR Rev. 2	NEDO-21061 Rev. 2	9/76	Yes
FR Rev. 2, Amendment 1	NEDO-21061 Rev. 2 Amendment 1	12/76	Yes
FR Round 1 Questions	Letter Report	6/78	Yes
terim Report	(NEDE-24010)	4/77	Yes
SS Report	NEDE-24010-P	7/77	Yes
	NEDO-24010	7/77	Yes
SS Executive Summary	Summary Report	4/78	Yes
SS Criteria Application	NEDO-24010, Supp. 1	10/78	Yes
SS Criteria Basis	NEDO-24010-P, Supp. 2	12/78	Yes
SS Justification Supp.	NEDO-24010, Supp. 3	8/79	Yes
SS Criteria Evaluation	Letter Report	1/80	Yes
L Critique	EDAC 134-242-03	1/80	Yes
FR Amend. 2	NEDE-21061-P Rev. 2 Amend. 2	6/77	Yes
	NEDO-21061 Rev. 2 Amend. 2	6/77	Yes
FR Amend. 2, Supp 1	NEDO-21061 Rev. 2	8/77	Yes

TASK NUMBER	ACTIVITY
C.7	JUSTIFICATION OF "4T" BOUNDING LOADS
C.8	SRV AND CHUGGING FSI
C.9	MONITOR WORLD TESTS
C.11	MASS ENERGY RELEASE
C.13	LOAD COMBINATIONS AND FUNCTIONAL CAPABILITY CRITERIA
C.14	NRC ROUND 3 QUESTIONS
C.15	SUBMERGED STRUCTURE CRITERIA
C.16	QUENCHER MASS ENERGY

ACTIVITY TYPE	DOCUMENTATION	DOC DATE	USED FOR LGS LICENSING
	Amend. 2 Supp. 1		
DFFR Amend. 2, Supp 2	NEDO-21061-P Rev. 2 Amend. 2 Supp. 2	9/77	Yes
DFFR Rev. 3, Appendix A-2	NEDE-21061-P Rev. 3 Appendix A-2		Yes
	NEDO-21061 Rev. 3 Appendix A-2		Yes
Chugging Loads Justification	NEDE 23617-P	7/77	Yes
	NEDO 23617	7/77	Yes
	NEDE 24013-P	6/77	Yes
	NEDO 24013	7/77	Yes
	NEDE 24014-P	6/77	Yes
	NEDO 24014	7/77	Yes
	NEDE 24015-P	6/77	Yes
	NEDO 24015	7/77	Yes
	NEDE 24016-P	6/77	Yes
	NEDO 24016	7/77	Yes
	NEDE 24017-P	6/77	Yes
	NEDO 24017	7/77	Yes
	NEDE 23627-P	6/77	Yes
	NEDO 23627	7/77	Yes
Prestressed Concrete Reinforced Concrete Steel	NEDE 21936-P	7/78	Yes
	NEDO 21936	8/78	Yes
Monitor Tests	None		No
SRV Pool Temperature Analysis Assumptions and Justification	Letter Report-Revision 0	4/80	Yes
	Letter Report-Revision 1	1/81	Yes
Methods for calculating mass and energy release for SRV discharges	Letter Report	5/81	Yes
Criteria Justification	NEDO 21985	9/78	Yes
Letter Report	Letter Report	6/78	Yes
DFFR Round 3 Questions	Letter Report	6/78	Yes
NRC Question Responses	Letter Report	4/80	Yes
Quencher Temperature	Letter Report	1/81	Yes

TASK NUMBER	ACTIVITY	AC
	CUTOFF	Li
C.18	DFFR REVISION	Re
1.	Formation and oscillation of a spherical gas bubble	AE
2.	Analytical model for clarification of pressure pulsation in the wetwell after vent clearing	AE
3.	Tests on mixed condensation with model quenchers	KW
4.	Condensation and vent clearing tests at GKM with quenchers	KW
5.	Concept and design of the pressure relief system with quenchers	KW
6.	KKB vent clearing with quencher	KW
7.	Experimental approach to vent clearing in a model tank	KW
8.	Anticipated data for blowdown tests with pressure relief system during the non-nuclear hot functional test at nuclear power station Brunsbuttel (KKB)	KW
9.	Results of the non-nuclear hot functional tests with the pressure relief system in the nuclear power station Brunsbuttel	KW
10.	Analysis of the loads measured on the pressure relief system during the non-nuclear hot functional test at KKB	KW

TIVITY TYPE	DOCUMENTATION	DOC DATE	USED FOR LGS LICENSING
mit			
vision 4	NEDO-21061-4	12/81	Yes
G - Report 2241	12/72	Yes	
G - Report 2208	3/72	Yes	
U - Report 2593	5/73	Yes	
U - Report 2594	5/73	Yes	
U - Report 2703	7/73	Yes	
U - Report 2796	10/73	Yes	
U - Report 3129	7/75	Yes	
U - Report 3141		Yes	
U - Report 3267	12/74	Yes	
U - Report 3346	4/75	Yes	

Document Number	Title	D
11.	KKB - Listing of test parameters and important test data of the non-nuclear hot functional tests with the pressure relief system	K
12.	KKB - Results from nuclear startup testing of pressure relief system	K
13.	Results of the non-nuclear hot functional tests with the pressure relief system in the nuclear power station Phillipsburg	K
14.	KKPI - Listing of test parameters and important test data of the non-nuclear hot functional tests with the pressure relief system	K
15.	KKB hot test results, loads on internals in pool of the suppression chamber during pressure relief processes	K

TABLE 1.3-1 (CONT'D)

ocumentation	Document Date	Used for LGS Licensing
WU - Working Report R 521/40/77	8/77	Yes
WU-Working Report R 142-136/76	9/76	Yes
WU - Working Report R 142-38/77	3/77	Yes
WU - Working Report R 521/41/77	8/77	Yes
WU - Working Paper R 113/203	11/74	Yes

Load or Phenomenon

I. LOCA Related Hydrodyna
Loads

A. Submerged Boundary
During Vent Clearin

B. Poolswell Loads

1. Poolswell Analyt
cal Model

a. Air-Bubble
Pressure

b. Poolswell
Elevation

c. Poolswell
Velocity

TABLE 1.3-2

COMPARISON OF LGS LICENSING BASIS WITH NRC ACCEPTANCE CRITERIA

	NRC Acceptance Criteria	Criteria Source	LGS Position
mic			
Loads g	24 psi overpressure added to local hydrostatic pressure below vent exit (walls and basemat) - linear attenuation to pool surface.	NUREG-0487 Supplement 1	Acceptable
i-			
	Calculated by the pool-swell analytical model (PSAM) used in calculation of submerged boundary loads.	NUREG-0487	Acceptable
	Use PSAM with polytropic exponent of 1.2 to a maximum swell height which is the greater of 1.5 x vent submergence or the elevation corresponding to the drywell floor uplift ΔP=2.5 psid.	NUREG-0487 Supplement 1	Acceptable
	Velocity history vs. pool elevation predicted by the PSAM used to compute impact loading on small structures and drag on gratings between initial pool surface and maximum pool elevation and steady-state drag between vent exit and maximum pool elevation. Analytical velocity variation is used up to maximum velocity.	NUREG-0487	Acceptable

Load or Phenomenon

d. Poolswell
Acceleration

e. Wetwell Air
Compression

f. Drywell
Pressure

2. Loads on Submerg
Boundaries

3. Impact Loads

a. Small
Structures

NRC Acceptance Criteria	Criteria Source	LGS Position
Maximum velocity applies thereafter up to maximum poolswell. PSAM predicted velocities multiplied by a factor of 1.1.		
Acceleration predicted by the PSAM. Pool acceleration is used in the calculation of acceleration loads on submerged components during poolswell.	NUREG-0487	Acceptable
Wetwell air compression is calculated by PSAM consistent with maximum poolswell elevation in B.1.b.	NUREG-0487 Supplement 1	Acceptable
Methods of NEDM-10320 and NEDO-20533 Appendix B. Used in PSAM to calculate poolswell loads.	NUREG-0487	Acceptable
Maximum bubble pressure predicted by the PSAM added uniformly to local hydrostatic pressure below vent exit (walls and basemat) - linear attenuation to pool surface. Applied to walls up to maximum poolswell elevation.	NUREG-0487	Acceptable
1.35 x Pressure-Velocity correlation for pipes and I beams based on PSTF impulse data and flat pool assumption. Variable pulse duration.	NUREG-0487	Acceptable

ed

Load or Phenomenon

b. Large Structures

c. Grating

4. Wetwell Air Compression

a. Wall Loads

b. Diaphragm Upward Loads

5. Asymmetric LOCA Pool

C. Steam Condensation Chugging Loads

1. Downcomer Latera Loads

a. Single-Vent Loads (24 in.

b. Multiple-Vent Loads (24 in.

NRC Acceptance Criteria	Criteria Source	LGS Position
None - Plant unique load where applicable.	NUREG-0487	Not Applicable No large structures
P drag vs. grating area correlation and pool velocity vs. elevation. Pool velocity from the PSAM. P drag multiplied by dynamic load factor.	NUREG-0487	Acceptable
Direct application of the PSAM calculated pressure due to wetwell compression.	NUREG-0487	Acceptable
5.5 psid for diaphragm loadings only.	NUREG-0808	Acceptable
Use 20 percent of maximum bubble pressure statically applied to 1/2 of the submerged boundary.	NUREG-0487 Supplement 1	Acceptable
Dynamic load to end of vent. Half sine wave with a duration of 3 to 6 ms and corresponding maximum amplitudes of 65 to 10 Klbf.	NUREG-0808	Acceptable
Prescribed variation of load per vent vs. number of vents. Determined from single vent dynamic load specification	NUREG-0808	Acceptable

and

1

Load or Phenomenon

c. Single/Multip
vent loads
(28 in.)

2. Submerged Bounda
Loads

a. High/Medium
Steam Flux Co
densation
Oscillation
Load

c. Low Steam Flu
Chugging Load

- Symmetric
Load

- Asymmetric
Load Case

NRC Acceptance Criteria	Criteria Source	LGS Position
and multivent reduction factor.		
Multiply basic vent loads by factor f=1.34	NUREG-0808	Not Applicable
Bounding CO pressure histories observed in 4TCO tests. Inphase application.	NUREG-0808	Acceptable
Conservative set of 10 sources derived from 4TCO tests. Applied to plants using the IWEGS/MARS acoustic model. Source desynchronization of 50 ms or alternate load using 7 sources derived from the 4TCO key chugs without averaging.	NUREG-0808	Acceptable
All vents use source of equal strength for each of the sources.		
Source strengths $S\pm = S(1\pm\alpha)$ applied to all vents on + and - side of containment. Sources based on the symmetric sources. Asymmetric parameter α based on rms moment method of interpreting experimental 4TCO single-vent and JAERI multivent data.		

Load or Phenomenon

II. SPV Related Hydrodynam
Loads

A. Pool Temperatures I

	NRC Acceptance Criteria	Criteria Source	LGS Position
ic			
imits	For plants using a discharge device with the exact hole pattern as described in the SSES DAR Section 4.1, the following limits shall apply:	NUREG-0783	
	1. For all plant transients involving SRV operations during which steam flux exceeds 94 lb_m/ft^2-sec, the local pool temperature shall not exceed 200°F.	NUREG-0783	Acceptable
	2. For all plant transients involving SRV operations during which steam flux is less than 42 lb_m/ft^2-sec, the local pool temperature shall be at least 20°F subcooled. This is equivalent to a temperature of 210°F with quencher submergence of 14 feet.	NUREG-0783	Acceptable
	3. For all plant transients involving SRV operations during which steam flux is between 42 and 94 lb_m/ft^2-sec, the local pool temperature can be determined by linear	NUREG-0783	Acceptable

Load or Phenomenon

B. Air Clearing Loads

NRC Acceptance Criteria	Criteria Source	LGS Position
interpolation between the temperatures defined in items 1 and 2 above.		
The T-quencher load specification described in Section 4.1 of the SSES DAR may be applied for evaluation of SRV containment boundary pressure loads with the following restrictions:	NUREG-0802	Acceptable
1. All valves load case	NUREG-0802	Acceptable
The DLV and DLWL combinations must lie below the limit line of Fig. A1 defined in the criteria where:		
a. DLV shall be equal to the arithmetic average of all discharge line volumes (m^3)		
b. DLWL shall be equal to the quencher submergence at high water level (m)		
2. ADS Load Case	NUREG-0802	Acceptable
The DLV and DLWL combinations must lie below the limit line of Fig. A2 defined in the criteria where:		
a. DLV shall be equal to the arithmetic average of all ADS discharge line		

Load or Phenomenon

C. T-Quencher
Tie Down Loads

NRC Acceptance Criteria	Criteria Source	LGS Position
volumes (m^3)		
b. DLWL shall be equal to the differences between the plant downcomer exit elevation and the quencher center line elevation (m)		
3. Frequency Range	NUREG-0802	Acceptable (DAR Section 4.1.4.1)
For the single valve and asymmetric load cases, the timewise compression of the design pressure signatures shall be increased to provide an overall dominant frequency range that extends up to 11 Hz.		
4. Vertical Pressure Distribution	NUREG-0802	Acceptable
The maximum pressure amplitudes shall be applied uniformly to the containment and pedestal walls up to an elevation 2.5 feet above the quencher centerline followed by linear attenuation to zero at pool surface.		
The T-quencher load specification described in SSES DAR Section 4.1 may be applied for evaluation of quencher and quencher support.	NUREG-0802	Acceptable

Load or Phenomenon

III. LOCA/SRV Submerged
Structure Loads

A. LOCA Downcomer Jet
Load

B. SRV T-Quencher Jet

C. LOCA Air Bubble
Drag Loads

NRC Acceptance Criteria	Criteria Source	LGS Position
Alternate methodology presented in Zimmer DAR may be applied.	NUREG-0487 Supplement 1	Acceptable
SRV T-quencher jet loads may be neglected beyond a 5 ft cylindrical zone of influence. Cylinder should be extended 10 hole diameters on the arm with holes in the end cap.	NUREG-0487	Acceptable
Calculate based on methods described in NEDE-21471 subject to the following constraints and modifications:	NUREG-0487	Applying plant-unique methodology defined in LGS DAR Section 4.2.1.5
1. To account for bubble asymmetry, accelerations and velocities shall be increased 10%.	NUREG-0487	Acceptable
2. For standard drag in accelerating flow fields, use draft coefficients presented in Zimmer FSAR attachment 1.k with following modifications:	NUREG-0487 Supplement 1	Acceptable
a. Use $C_H = C_m - 1$ in the F_A formula		
b. For noncylindrical structures, use lift coefficient for appropriate shape or C =1.6		

Load or Phenomenon

NRC Acceptance Criteria	Criteria Source	LGS Position
L		
c. The standard drag coefficient for poolswell and SRV oscillating bubbles should be based on data for structures with sharp edges.		
3. For equivalent uniform flow velocity and acceleration calculations, structures are segmented into small sections such that $1.0 \le L/D \le 1.5$. The loads are then applied to the geometric center of each segment. This approach, as presented in Zimmer FSAR attachment 1.k, may be applied.	NUREG-0487 Supplement 1	Acceptable
4. A detailed methodology on the approach for considering interference effects as presented in Zimmer FSAR Attachment 1.k may be applied.	NUREG-0487 Supplement 1	Acceptable
5. Formula 2-23 of NEDE-21730 shall be modified by replacing M_H by $\rho_{FB} V_A$ where V_A is obtained from Tables 2-1 & 2-2.	NUREG-0487	Acceptable

Load or Phenomenon

D. SRV Air Bubble Drag Load

E. Steam Condensation Drag Loads

IV. Secondary Loads

1. Sonic Wave Load
2. Compressive Wave Load
3. Fallback Load on Submerged Boundary
4. Thrust Loads
5. Friction Drag Loads on Vents
6. Vent Clearing Loads
7. Post Swell Wave Load
8. Seismic Slosh Load

NRC Acceptance Criteria	Criteria Source	LGS Position
No criteria specified for T-quencher		Applying plant-unique methodology defined in LGS DAR Section 4.1.4
No criteria specified		Applying plant-unique methodology defined in LGS DAR Section 4.2
Negligible Load	NUREG-0487	Acceptable
Negligible Load	NUREG-0487	Acceptable
Negligible Load	NUREG-0487	Acceptable
Momentum balance	NUREG-0487	Acceptable
Standard friction drag calculations	NUREG-0487	Acceptable
Negligible Load	NUREG-0487	Acceptable
Methodology for establishing loads resulting from post swell waves to be evaluated on a plant unique basis.	NUREG-0487	Load is negligible when compared to design basis loads (Section 4.2.3.6)
Methodology for establishing loads resulting from seismic slosh to be evaluated on a plant unique basis.	NUREG-0487	Load is negligible when compared to design basis loads (Section 4.2.3.7)

TABLE 1.4-1 (Cont'd) (Page 2 of 3)

Downcomer submergence, ft	
Low water level	10'
Normal water level	11'
High water level	12'-3"
Downcomer loss coefficient	2.18

SAFETY RELIEF VALVES

Number	14

Spring Set Pressures, Mass Flow Rates:

Valve	Set Pressure (psig)	Mass Flow (lbm/hr) at 103% of Spring Set Pressure
A	1150	917,000
B	1150	917,000
C	1150	917,000
D	1140	909,000
E*	1140	909,000
F	1150	917,000
G	1150	917,000
H*	1130	901,500
J	1130	901,500
K*	1140	909,000
L	1130	901,500
M*	1140	909,000
N	1130	901,500
S*	1140	909,000

*ADS Valves

2.2.5 BOP EQUIPMENT ASSESSMENT SUMMARY

Safety related BOP equipment in the containment, reactor enclosure, and control structure are assessed by the methods contained in Section 7.1.7. Loads are combined as shown in Table 5.8-1.

2.2.6 ELECTRICAL RACEWAY SYSTEM ASSESSMENT SUMMARY

The electrical raceway system located in the containment, reactor enclosure, and control structure is assessed for load combinations in accordance with Table 5.9-1. The assessment methodology and analysis results are presented in Chapter 7.

2.2.7 HVAC DUCT SYSTEM ASSESSMENT SUMMARY

The HVAC duct system located in the containment, reactor enclosure, and control structure is assessed for load combinations in accordance with Table 5.10-1. The assessment methodology and analysis results are presented in Chapter 7.

2.2.8 SUPPRESSION POOL TEMPERATURE MONITORING SYSTEM (SPTMS) ASSESSMENT SUMMARY

SPTMS adequacy assessment and suppression pool temperature response to SRV discharge are presented in Appendix I.

The poolswell fallback analysis of piping that has interference effects was performed by using the FORCE II computer code. The results indicate that the interference effects increase the vertical load component by a maximum of 16%, depending on the elevation.

4.2.2 CONDENSATION OSCILLATIONS AND CHUGGING LOADS

Condensation oscillation and chugging loads follow the poolswell loads in time. There are basically three loads in this secondary time period, i.e., from about 4 to 60 seconds after the break. Condensation oscillation is broken down into two phenomena, a mixed flow regime and a steam flow regime. The mixed flow regime is a relatively high mass flux phenomenon that occurs during the final period of air purging from the drywell to the wetwell when the mixed flow through the downcomer vents contains some air as well as steam. The steam flow portion of the condensation oscillation phenomena occurs after all the air has been carried over to the wetwell and a relatively high intermediate mass flux of pure steam flow is established.

Chugging is a pulsating condensation phenomenon that can occur either following the intermediate mass flux phase of a LOCA or during the class of smaller postulated pipe breaks that result in steam flow through the vent system into the suppression pool. A necessary condition for chugging to occur is that only pure steam flows from the LOCA vents. Chugging imparts a loading condition to the suppression pool boundary and all submerged structures.

4.2.2.1 Containment Boundary Loads Due to Condensation Oscillations

The containment boundary loads due to condensation oscillation are based on direct application of pressure measurements in the drywell and the suppression pool from the full-scale 4TCO tests, as described in Reference 1.3-1, section 4.3, and Reference 4.2-7.

The basic condensation oscillation load is a bounding load for any condensation oscillation condition expected during a hypothetical LOCA in the LGS plant. All 28 of the 4TCO test runs were analyzed to determine the bounding time periods. The criterion for the selection of these time periods was to bound the maximum power spectral density values observed at the bottom center pressure throughout the condensation oscillation period in

all runs -- in any 2.048-second block for all frequencies from 0 to 60 Hz -- in approximately 0.5 Hz increments. The selected time periods were independently confirmed to be bounding by the amplified-response-spectra analysis (Ref 4.2-7, Appendix A).

The pressure-response-spectrum envelope for the time periods selected is shown in Figure 4.2-8; the spatial pressure distribution is shown in Figure 4 2-9. The drywell pressure histories for the time periods defined in Reference 4.2-7 are applied uniformly throughout the drywell.

4.2.2.2 Pool Boundary Loads Due to Chugging

The Mark II generic chugging load definition was developed by applying the acoustic chugging methodology described in Reference 4.2-8 to the chugging data base provided by the Mark II 4T Condensation Oscillation (4TCO) Test Program (Reference 4.2-9). The definition of a chugging load starts with the identification of steam-bubble collapse as the fundamental excitation mechanism. The collapse produces acoustic responses in the suppression pool and the vents. The combined excitation of the suppression pool and vent response is characterized as a time-varying volumetric point source in the acoustic model. Point sources for the 4TCO facility are inferred from 4TCO wall pressures via the 4TCO acoustic model. These point sources can be applied to an acoustic model of the Mark II suppression pool because the bubble collapse and vent response in Mark II are correctly simulated by the prototypical 4TCO geometry and blowdown conditions. The multivent effects of variation in chug strength and chug time among vents are incorporated in the Mark II application (Reference 4.2-10).

Seven large (key) chugs from the 4TCO data base were used to develop design sources to be applied to the acoustic model of the Limerick containment. These design sources are to be applied desynchronized, using the set of chug start times having the smallest variance in one-thousand Monte Carlo trials drawn from a uniform distribution of start times having a width of 500 milliseconds (ms). The chug start times are randomly assigned to the vents in the Mark II containment.

The observation of vent desynchronization has been verified by determining the time delay between individual bubble collapses in the full-scale, 7-vent tests conducted by the Japan Atomic Energy Research Institute (JAERI). Conservatism is ensured by applying to the Mark II plant models a minimum estimate of the time window within which the individual bubble collapses must occur.

4.2.3.1 Downcomer Friction Drag Loads

Friction drag loads are experienced internally by the downcomers during vent clearing and subsequent air or steam flow. In addition, the downcomers experience an external drag load during poolswell. Using standard drag force calculation procedures, these loads are determined to be 0.6 and 0.3 kips per downcomer, respectively, and are not considered in the structural evaluation of the containment.

4.2.3.2 Sonic Waves

Immediately following the postulated instantaneous rupture of a large primary system pipe, a sonic wave front is created at the break location and propagates through the drywell to the vent system. This load has been determined to be negligible and, therefore, none is specified.

4.2.3.3 Compressive Wave

The compression of the air in the drywell and vent system causes a compressive wave to be generated in the downcomer water legs. This compressive wave propagates through the pool and causes a differential pressure loading on the submerged structures and on the wetwell wall. This load has been evaluated and is considered negligible.

4.2.3.4 Fallback Loads on Submerged Boundaries

During fallback, waterhammer-type loads could exist if the water slug remained intact during this phase. However, available test data indicate that this does not occur, and the fallback process consists of a relatively gradual setting of the pool water to its initial level as the air bubble percolates upward. This is based on visual observations during the EPRI tests (Ref 4.2-11) as well as indirect evidence provided by an examination of pool bottom pressure forces from the 4T, EPRI, foreign licensee, and Marviken tests. Thus, these loads are small and will not be considered.

4.2.3.5 Vent Clearing Loads on the Downcomers

The expulsion of the water leg in the downcomers at vent clearing creates a transient water jet in the suppression pool. This jet

formation may occur asymmetrically leading to lateral reaction loads on the downcomer. However, this load is bounded by the load specification during chugging and will not be considered for containment analysis.

4.2.3.6 Post-Poolswell Waves

Following the poolswell process, continued flow through the vent system generates random pool motion. The pool motion creates waves that have potential loading impingement effects on the LGS wetwell wall and internal components. In accordance with the response to Question M020.8 documented in Appendix A of the DFFR, Revision 3 (June 1978), this load is considered negligible when compared to the other design basis loads.

4.2.3.7 Seismic Slosh

The computer code SOLA-3D was used to estimate the suppression pool seismic slosh hydrodynamic loads. The results indicate that seismic slosh loads in the LGS plant are much less than the LOCA chugging loads or the SRV air clearing bubble oscillation loads (on the order of a few psi at a relatively low frequency depending on location and direction).

The maximum wave (sloshing) height is 1.6 feet. The nodal force close to the pool bottom oscillates between 112 to 88 kips (including static load). Therefore, the bottom pressure rises to about 1.2 psi above the static pressure due to sloshing. The dominant frequency of the sloshing motion is 0.1 Hz, whereas the dominant frequency of the seismic acceleration is about 2 Hz.

4.2.3.8 Thrust Loads

Thrust loads are associated with the rapid venting of air and/or steam through the downcomers. To determine this load, a momentum balance for a control volume consisting of the drywell, diaphragm floor, and vents is taken. Results of the analysis indicate that the load reduces the downward pressure differential on the diaphragm.

4.2.4 LONG-TERM LOCA LOADS

The loss-of-coolant accident (LOCA) causes pressure and temperature transients in the drywell and wetwell due to mass and energy released from the line break. The drywell and wetwell pressure and temperature time histories are required to establish

TABLE 4.2-3

LGS PLANT UNIQUE POOLSWELL CODE INPUT DATA

Downcomer area (each)	2.95 ft^2
Suppression pool free surface area (outside pedestal)	4973.89 ft^2
Maximum downcomer submergence	12.25 ft
Downcomer loss coefficient (without exit loss)	1.18
Number of downcomers	87
Initial wetwell pressure	15.45 psia
Wetwell free air volume	149,425 ft^3
Vent clearing time	0.7107 sec
Pool velocity at vent clearing	3.096 ft/sec
Initial drywell temperature	135°F
Initial drywell relative humidity	0.20
Downcomer friction coefficient, f	0.0115 (nominal)
Bubble initialization parameter (nominal)	50

TABLE 4.2-4

INPUT DATA FOR LGS LOCA TRANSIENTS

Drywell free air volume (including downcomers)	248,950 ft^3
Wetwell free air volume	149,425 ft^3
Maximum downcomer submergence	12.25 ft
Downcomer flow area (total)	256.5 ft^2
Downcomer loss coefficient	2.18
Initial drywell pressure	14.8 psia
Initial wetwell pressure	15.45 psia
Initial drywell humidity	100%
Initial pool temperature	90°F
Estimated DBA break size	3.538 ft^2
Number of vents	87
Minimum suppression pool mass	5.83 x 10^6 lb
Initial vessel pressure	1.055 psia
Vessel and internals mass	2,940,300 lb
Vessel and internals overall heat	484.9 Btu/sec °F
Vessel and internals specific heat	0.123 Btu/lb

TABLE 4.2-8

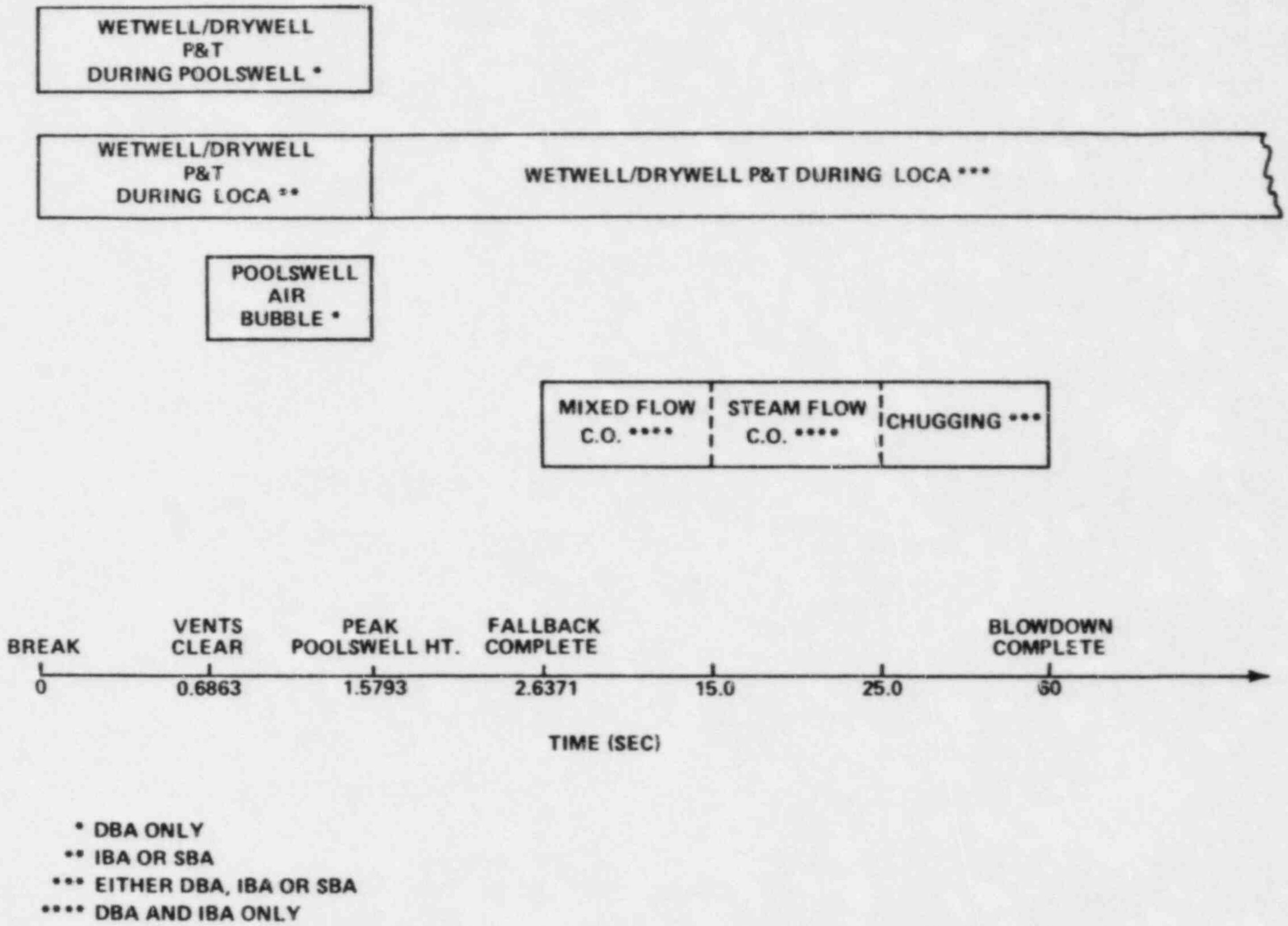
POOLSWELL WATER FRICTION DRAG LOADS

Friction drag loads on columns	
Number of columns	12
Surface area per column	214.55 ft^2
Friction force for 12 columns	5098 lbf
Shear stress	0.01375 lb /$in.^2$
Friction drag load on downcomers	
Number of downcomers	87
Surface area per downcomer	122.6 ft^2
Frictional drag coefficient	0.00216
Friction force for 87 downcomers	2112.2 lb
Friction drag load on MSRV pipes	1806 lb
Air friction drag inside downcomers	303 lb
Downcomer bracing fallback loads	
Vertical load (12 in. nominal diameter)	3720 lb /ft
Horizontal load (12 in. nominal diameter)	2823 lb /ft
Vertical load (10 in. nominal diameter)	2616 lb /ft
Horizontal load (10 in. nominal diameter)	2046 lb /ft

TABLE 4.2-10

MAXIMUM LOAD ON SUBMERGED STRUCTURES

Submerged Structure	Max CO Load (lb/in.)	Max Chugging Load (lb/in.)
MSRVDL	3.8	24.0
Downcomer	22.0	36.0
Bracer	0.8	25.2
Core spray discharge line	0.22	6.6
HPCI discharge line	22.0	22.0
RHR discharge line	2.2	16.0
Column	38.0	170.0



LIMERICK GENERATING STATION
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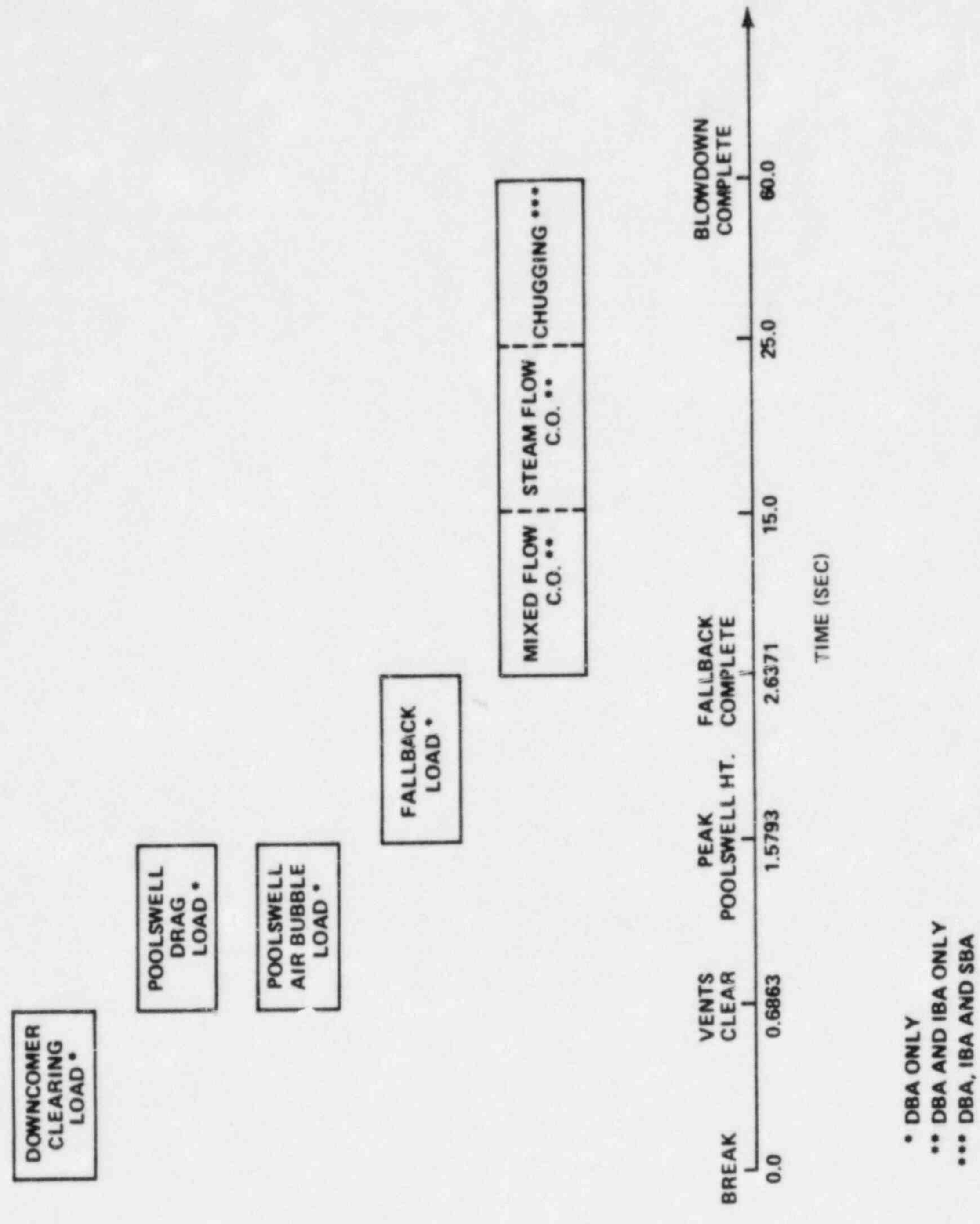
LOCA LOADING HISTORY
FOR THE CONTAINMENT WALL
AND PEDESTAL

FIGURE 4.2-17

REV. 2, 03/83



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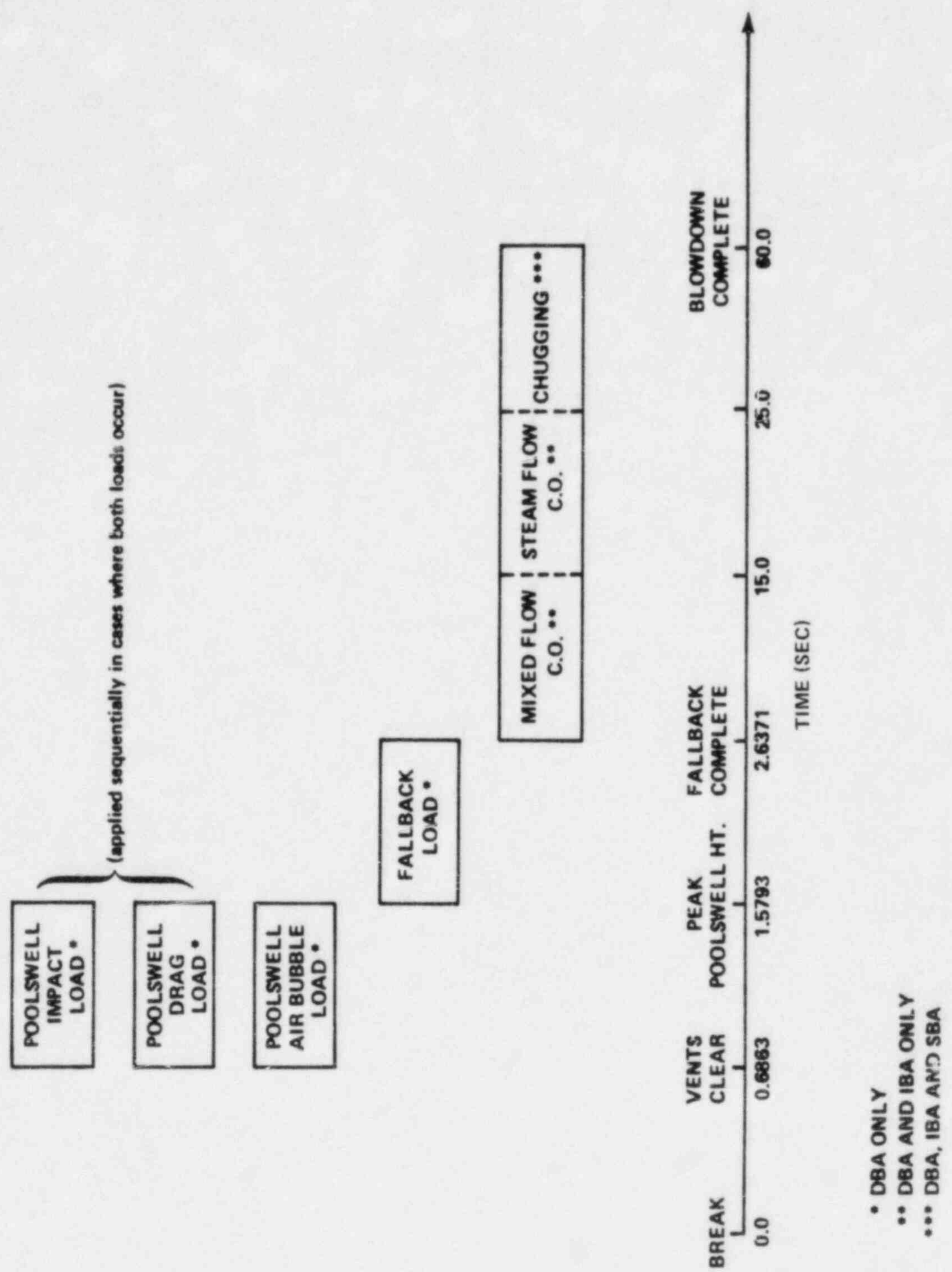
LOCA LOADING HISTORY FOR THE DOWNCOMERS

FIGURE 4.2-21

REV. 2, 03/83



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DESIGN ASSESSMENT REPORT

LOCA LOADING HISTORY
FOR THE WETWELL PIPING

FIGURE 4.2-23

REV. 2, 03/83

CHAPTER 5

LOAD COMBINATIONS FOR STRUCTURES, PIPING, AND EQUIPMENT

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5.8 BOP EQUIPMENT LOAD COMBINATIONS

Safety-related BOP equipment located within the primary containment, reactor enclosure, and control structure are assessed for the governing load combinations shown in Table 5.8-1.

TABLE 5.8-1

LOAD COMBINATIONS AND DAMPING VALUES FOR SAFETY-RELATED BOP EQUIPMENT IN THE PRIMARY CONTAINMENT, REACTOR ENCLOSURE, AND CONTROL STRUCTURE

Equation	Condition	Load Combination	Damping[1]
1	Upset	a. $N+[OBE^2 + SRV^2]^{1/2}$	2%
		b. N+OBE	0.5%
2	Emergency	a. $N+[OBE^2 + SRV^2 + SBA^2]^{1/2}$	2%
3	Faulted	a. $N+[OBE^2 + SRV^2 + IBA^2]^{1/2}$	2%
		b. $N+[SSE^2 + SRV^2 + IBA^2]^{1/2}$	2%
		c. $N+[SSE^2 + DBA^2]^{1/2}$	2%
		d. Envelope of a, b & c	2%
		e. N+SSE	1%
4	Worst	a. Envelope of 1a, 2 and 3d	2%

Notations:

N = Normal loads (dead weight + operating temp + operating press., etc.)
OBE = Operating basis earthquake loads
SSE = Safe shutdown earthquake loads
SRV = Safety relief valve discharge loads
SBA = Small break accident loads
IBA = Intermediate break accident loads
DBA = Design basis accident loads

(1) Where justified, a higher damping value may be used.

TABLE 5.10-1 (Page 1 of 2)

LOAD COMBINATIONS AND ALLOWABLE STRESSES FOR HVAC DUCT SYSTEMS

DUCTS

Equation	Condition	Load Combination	Allowable Stress
1	Normal	D+L+SRV	Fs
2	Normal	$D+P_M+SRV$	Fs
3	Abnormal	$D+P_T$	$1.25F_s$
4	Normal/Severe	$D+P_M+E$	$1.25F_s$ (1)
5	Normal/Severe	$D+P_M+E+SRV$	$1.25F_s$
6	Normal	D+Po	Fs
7	Normal/Severe	D+Po+E	$1.25F_s$
8	Normal/Extreme	D+Po+E'	(2)
9	Normal/Extreme	$D+P_M+E'+SRV$	(2)
10	Extreme/Abnormal	$D+P_O+P_A+E'+SRV+LOCA$	(2)
11	Extreme/Abnormal	When protection against tornado depressurization is required:	
		$D+P_O+W_D+SRV+LOCA$	(2)
12	Extreme/Abnormal	For ducts inside drywell of containment, the following additional load combination is also applicable:	
		$D+H_A+P_O+P_A+E'+SRV+LOCA$	(2)

DUCT SUPPORTS

Equation	Condition	Load Combination	Allowable Stress
1	Normal	D+L+SRV	Fs
2	Normal/Severe	D+E	$1.25F_s$ (1)
3	Normal/Severe	D+E+SRV	(2)
4	Extreme/Abnormal	D+E'+SRV+LOCA	(2)

CHAPTER 6

DESIGN CAPABILITY ASSESSMENT CRITERIA

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6.8 BOP EQUIPMENT CAPABILITY ASSESSMENT CRITERIA

All BOP equipment is required to withstand the dynamic loads resulting from seismic and hydrodynamic loads (SRV, SBA, IBA, and DBA) as follows:

a.	OBE alone	1/2% damping
b.	SSE alone	1% damping
c.	Combination of seismic and hydrodynamic loads	2% damping

Cases a and b are discussed in FSAR Section 3.7.3. Case c is considered in accordance with the load combinations shown in Table 5.8-1. The adequacy of the qualification is verified by the following methods:

a. Analysis

b. Testing

c. Combination of analysis and testing.

6.8.1 ANALYSIS

Safety-related equipment located in the primary containment, reactor enclosure, and control structure are analyzed to satisfy load combinations 1a, 1b, 2, 3d, and 3e of Table 5.8-1. The maximum load effects result from simultaneous excitation in all three principal directions for all combinations involving dynamic loads as detailed in Section 7.1.7.4.1.3.

6.8.2 TESTING

When safety-related equipment is qualified by testing, the test response spectrum (TRS) is to envelope the required response spectrum (RRS) for load combinations 1b, 3e, and 4 of Table 5.8-1. The minimum test sequence is to perform five runs for load combination 1b, followed by one run of load

combination 3e. The input motion for load combination 3e is such that the TRS generated for 2% damping envelopes the RRS for load combination 4. Qualification is achieved if the equipment does not fail or malfunction during the test. Operability is verified before and after the test sequence. Active components required to function during a dynamic event are also verified during the test.

6.8.3 COMBINED ANALYSIS AND TEST

Some equipment is qualified by a combination of analysis and testing procedures.

An analysis is conducted on the overall assembly to determine its stress level and the transmissibility of motion from the base of the equipment to the critical components. The critical components are removed from the assembly and subjected to a simulation of the environment on a test table.

Testing methods are used to aid the formulation of the mathematical model for any piece of equipment. Mode shapes and frequencies are determined experimentally and incorporated into a mathematical model of the equipment. The model and subsequent analysis will meet the requirements of Section 7.1.7.4.1.

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Bechtel in-house computer program MSPEC was used to compute the acceleration response spectrum obtained from DISQGE. The program also performs plotting and broadening of the spectrum.

A computer program ENVELOP was developed to envelope response spectra obtained from MSPEC.

Computer program SCALE was developed to scan the maximum absolute stresses generated by ANSYS (stress pass option). An explanation of SCALE is given in Section 7.1.1.1.1.6.2.

Verification of PREPRC1, PREPRC2, PREPRC3, DISQGE, ENVELOP, and SCALE are available for review.

7.1.1.1.1.5 Load Application

7.1.1.1.1.5.1 SRV Discharge Loads

The SRV discharge load used in the analyses was taken from the KWU load report (Ref. 4.1-2). The analyses were done for KWU SRV pressure traces 35, 76, and 82. Axisymmetric and asymmetric pressure distributions were considered. Chapter 4 contains a detailed SRV load definition. The load definition takes into account the variation in pressure amplitude and frequency in the input forcing functions by applying a change of key frequencies in the assumed range of 55 to 125 percent of original frequency content (included are 55, 67, 87, 100, and 125 percent of the original frequencies) and a pressure multiplier of 1.5 to each input load trace. A total of 15 axisymmetric load traces and 15 asymmetric load traces were used in the analyses.

7.1.1.1.1.5.2 LOCA Related Loads

The main LOCA loads that significantly affect the dynamic analysis are condensation oscillation (CO) and chugging loads.

Because CO and chugging are sequential nonsimultaneous events, formulation of the LOCA load is conservatively accomplished by enveloping the CO and chugging results obtained from dynamic analyses.

The CO analysis was performed for two cases: the basic CO case and the CO-ADS case. Both CO and CO-ADS load definitions are

based on direct application of measured pressure data from the 4TCO facility, a BWR Mark II prototypical unit cell used to produce expected bounding CO load data (Ref. 1.3-1). The CO load case is related to the basic CO load that covers all LOCA blowdown conditions resulting in CO, whereas the CO-ADS load case is data associated with the combination of CO and ADS events. Both events (CO and CO-ADS) produce wall pressure loading of axisymmetric nature. The wetwell pressure load vector was appropriately applied to the ANSYS model for a dynamic analysis. Also considered in the analysis is associated drywell pressure load defined in Reference 1.3-1, based on a direct application of the measured drywell acoustic pressure time histories. A total of 17 time segments of CO and two time segments of CO-ADS are considered in the analysis.

The LGS Mark II chugging load pressure transients were calculated by Bechtel proprietary computer code IWEGS/MARS-P using GE700 series CHUG source data supplied by General Electric Company (Reference 1.3-1). The source data were based on measured data from 4TCO test facility, a BWR Mark II prototypical unit cell used to simulate the chugging loads during a postulated Mark II LOCA. A total of 14 chugging time histories are considered in the chugging analyses.

7.1.1.1.1.6 Analysis

7.1.1.1.1.6.1 Response Spectra Generation

Acceleration time histories, maximum structural displacements and accelerations, and broadened acceleration response spectra are developed for the analysis of piping, equipment, and NSS systems. Gross acceleration time histories are generated at the interface between pedestal and diaphragm slab, the stabilizer location at the containment wall, the top of drywell at the refueling bellows, and at the interface between wetwell wall and base slab.

The maximum containment response to SRV axisymmetric loads is obtained by enveloping the acceleration response spectra of the 15 axisymmetric SRV cases. Likewise, the response spectra for the 15 asymmetric SRV cases are enveloped.

The maximum containment response to the condensation oscillation loads is obtained by enveloping the acceleration response spectra of the 17 CO segments. Likewise, the response spectra of the two CO-ADS segments are enveloped.

The maximum containment response to the chugging loads is obtained by enveloping the acceleration response spectra of the 14 chugging cases.

Enveloped floor response spectra of 8 damping values, between 0.5 and 20 percent of critical are generated. For clarity, these 8 enveloped floor spectra are grouped into two separate plot sets of 4 dampings each. The low damping plot sets, furnished in Appendix A, include damping ratios of 0.5, 1, 2, and 5 percent of critical. The high damping plot sets include damping ratios of 7, 10, 15, and 20 percent of critical. Floor response spectra of high damping values (i.e., greater than 7 percent critical) are generated for application to systems and components where larger system or material damping values are justified. Reference 7.1-11 provides an example of such an application. The spectra are broadened by ±15 percent to account for the uncertainties in the structural modeling techniques and material properties.

7.1.1.1.1.6.2 Stress Analysis

The ANSYS computer program (stress pass option) is used to compute the force and moment resultants due to SRV and LOCA - related loads. A postprocessor program called SCALE is used to scan for the maximum absolute values of forces and moments in the circumferential and meridional directions.

The forces and moments due to chugging and condensation oscillation loads are considered for the load combinations including the LOCA loads. The governing forces and moments from the six different frequencies are used in the stress analysis.

7.1.1.1.2 Seismic Loads

Seismic loads constitute a significant loading in the structural assessment. The same seismic loads as those used in the initial building design are used. In that design, a dynamic analysis was made using discrete mathematical idealization of the entire structure using lumped masses. The resulting axial forces, moments, and shear forces at various levels due to the operating basis earthquake and the safe shutdown earthquake are used (FSAR Section 3.7). The effects of the seismic overturning moment and vertical accelerations are converted into forces at the elements.

7.1.1.1.3 Static and Thermal Loads

The loads under consideration are the static loads (dead load and accident pressure) and temperature loads (operating and accident temperature) which are all axisymmetrical.

a. To analyze the above static loads, an in-house computer program, FINEL (FSAR Section 3.8.7), is used. Moments, axial forces, and shear forces are computed by FINEL in an uncracked axisymmetric finite element containment model.

b. The operating and accident temperature gradients are computed using ME 620 (FSAR Section 3.8.7) computer program (Bechtel program).

c. The results from a, b, and the hydrodynamic/seismic analysis are combined and applied to a containment element. The element contains data relative to rebar location, direction, and quantity and concrete properties. Within that wall element, force equilibrium and strain compatibility between the rebar and concrete is established by allowing the concrete to crack in tension. In this way, the stresses in the rebar and concrete are determined. The program used for this analysis is called CECAP (FSAR Section 3.8.7).

7.1.1.1.4 Load Combinations

All load combinations from equations 1 through 7a as presented in Table 5.2-1 have been analyzed.

The reversible nature of the structural responses due to the pool dynamic loads and seismic loads is taken into account by considering the peak positive and negative magnitudes of the response forces and maximizing the total positive and negative forces and moments governing the design.

Seismic and pool dynamic load effects (SRV and LOCA) are combined by conservatively summing the peak responses of each load by the absolute sum (ABS) method. Even though the square root sum of squares (SRSS) method is more appropriate because the peak effects of all loads may not occur simultaneously (Reference 7.1-4), the conservative ABS method is used in the design assessment of the containment and internal concrete structures to expedite licensing.

7.1.1.1.5 Design Assessment

Material stresses at the critical sections in the primary containment and internal concrete structure are analyzed using the CECAP computer program. Critical sections for bending moment, axial force and shear in three directions are located throughout the containment structure. Liner plate is not considered as a structural element. The CECAP program considers concrete cracking in the analysis of reinforced concrete

7.1.2.1.2.4 Static Load

Static loads, including dead load and thermal load, were considered in the column analysis.

7.1.2.1.2.5 Load Combinations

The load combinations and allowable stresses are in accordance with Section 5.3. The peak dynamic responses due to the seismic and pool dynamic load effects are combined by the SRSS method. The resulting combined dynamic loads are combined with the static loads by the absolute sum technique.

7.1.2.1.2.6 Design Assessment

The combined stresses due to axial force and bending moment were calculated and compared with allowable stresses.

7.1.2.2 Downcomer Bracing

The following covers the methodology used in the assessment of the bracing system at EL. 203' - 5" in the primary containment suppression pool.

7.1.2.2.1 Bracing System Description

The downcomer bracing system is designed as a two-dimensional truss system to provide horizontal support for 87 downcomers, 14 MSRV discharge lines, and other miscellaneous piping in the suppression pool. The bracing system is supported vertically by the 87 downcomers and at 12 anchor points around the RPV pedestal wall. The bracing system is made of stainless steel members connected to carbon steel collars at the downcomers and embeddment plates at the pedestal wall by high-strength stainless steel bolts. The bracing members consist of 10-inch and 12-inch diameter schedule 160 pipe sections, and 3-1/4 inch end connection plates. The bracing system is designed in accordance with Reference 7.1-10.

The bracing system layout and typical connection details are shown in Figures 7.1-9 and 7.1-10. The mathematical model used

in the bracing system is presented in Figure D.2-10 of Appendix D.

7.1.2.2.2 Loads

The bracing system is assessed for all plant operation induced loads described below. The basis for all hydrodynamic loads considered in the analysis is presented in Chapter 4.

7.1.2.2.2.1 SRV Discharge Loads

Discharge through the SRV discharge pipe creates horizontal as well as vertical loading on the bracing system due to unbalanced pressures. The horizontal (lateral) load is considered as acting on the downcomers and the SRV discharge pipes. The vertical load is considered acting on the bracing members alone. These loads are applied to the bracing system by considering them as equivalent static loads using a dynamic magnification factor which is obtained from the dynamic analysis of the downcomer, as described in Section 7.1.4.

The SRV discharge also induces hydrodynamic forces in the containment structure. Inertial forces of the bracing system, due to the response of the containment structure, are considered using hydrodynamic reponse spectra of the containment structure shown in Appendix A.

The lateral loads and the containment structure response form the complete SRV discharge load set on the bracing system.

7.1.2.2.2.2 LOCA Related Loads

Loss-of-coolant accidents are characterized by several phenomena that result with non-concurrent loadings on the bracing system as described in Section 4.2. These hydrodynamic loads induce accelerations of the containment structure, which in turn induce additional loads on the bracing system. These loads are obtained from the hydrodynamic acceleration response spectra shown in Appendix A.

In addition, the LOCA event induces lateral forces on the submerged portion and tip of downcomers. The loads include drag loads, pressure loads, and chugging tip load. The hydrodynamic

analysis of a single downcomer for the lateral loads is presented in Section 7.1.4. The resulting reaction forces at the bracing support are applied as equivalent static load in accordance with section 3.1 of Reference 7.1-6.

7.1.2.2.2.3 Seismic Loads

The forces due to the seismic accelerations of the downcomers, the SRV lines, and the bracing members are obtained by analysis of these structures using the response spectra developed for OBE and SSE as described in FSAR Section 3.7.2.

7.1.2.2.2.4 Static Loads

The dead load of the bracing members is considered with allowance for buoyancy.

7.1.2.2.2.5 Thermal Load

The operating and accident temperature considered is 90 and 210°F, respectively. The reference temperature of the system is assumed to be 60°F.

7.1.2.2.2.6 Load Combinations

The load combinations and allowable stresses are described in Table 5.3-1. Although the loads on the bracing system under consideration act in random horizontal directions, each individual load is applied on the system in the worst possible direction to find the maximum resultant forces.

7.1.2.2.3 Design Assessment

The two-dimensional truss model of the bracing system is analyzed for the static, thermal, and equivalent static hydrodynamic loads using the computer program STRUDL. The ASME truss model is analyzed for the containment structure inertia response due to seismic and hydrodynamic events using the computer program ANSYS. The bracing member forces calculated above for the various loading conditions are combined by the SRSS method and assessed in accordance with the loading combinations and stress allowables specified in Table 5.3-1.

7.1.2.3 ASME Class MC Steel Components

The assessment methodology used for hydrodynamic loads on MC components will be provided later.

7.1.3 LINER PLATE ASSESSMENT METHODOLOGY

FSAR Section 3.8.1.1.2 provides a description of the containment liner plate and its anchorage system.

The analysis and design of the liner plate anchorages for nonhydrodynamic loads is in accordance with Reference 7.1-7.

In the assessment of the concrete-backed liner plate and anchorages for hydrodynamic pressure loads, the controlling load on the liner plate and anchorage system is that due to the net negative pressure load if present. The net negative pressure load is determined from the dynamic negative pressure due to SRV actuation and/or LOCA chugging minus the static positive pressure due to the wetwell hydrostatic pressure and/or LOCA wetwell pressure. Figures 7.1-12 through 7.1-13 describe the loads on the suppression chamber liner plate for the normal and abnormal load conditions.

For the normal condition, the hydrostatic pressure on the base mat liner is 10.4 psi (positive) and the maximum negative pressure due to the actuation of all SRVs is 7.8 psi (negative). The distribution of these pressures on the suppression chamber wall is shown in Figure 7.1-12. The maximum net pressure is 2.6 psi (positive).

For the abnormal condition, the combined pressure distribution due to hydrostatic, LOCA wetwell pressure, SRV, and chugging loads is shown in Figure 7.1-13. The total positive pressure on the basemat linear is 35.4 psi which consists of 10.4 psi (positive) from hydrostatic pressure plus 25.0 (positive) from a small or intermediate break LOCA. The total cyclic pressure on the basemat liner is 17.6 psi (negative) due to the axisymmetric chugging and SRV loads. Although the maximum negative pressures due to SRV actuation and chugging are combined for conservatism, it is recognized that the probability of these two phenomena producing peak negative pressures at the same time is very low.

The assessment of the linear plate is contained in Section 7.2.1.5.

7.1.4 DOWNCOMER ASSESSMENT METHODOLOGY

7.1.4.1 Structural Model

There are 87, 24-inch OD, steel pipe downcomers running vertically down from the diaphragm slab. The downcomers are embedded in the diaphragm slab and extend downward to El. 193'-11", which is approximately 12 feet below high water level, as shown in Figure 1.4-2. All downcomers are supported laterally at El 203'-5" by the downcomer bracing system. Any vertical loads are transmitted by the bracing system to the downcomers and therefore to the diaphragm slab.

The structural model considers the downcomer as a vertical pipe fixed at the underside of the diaphragm slab with a spring in the horizontal direction at bracing level. This model is shown in Figure 7.1-16. The inertial effect of the water in the submerged portion of the downcomer (12 feet) was approximated by the addition of a equivalent mass of water lumped at the appropriate nodal points. The model is evaluated for three spring values for a representative support stiffness provided by the bracing system to the downcomers. The bracing spring is set to 50 k/in, 350 k/in, and 15000 k/in to represent the tangential mode, the radial mode, and rigid response of the bracing system.

7.1.4.2 Loads

The downcomer is subjected to static and dynamic loads due to normal, upset, emergency, and faulted conditions. Loading cases and combinations are described in Table 5.5-1. The basis for all hydrodynamic loads considered in the analysis is presented in Chapter 4.

7.1.4.3 Analysis

Downcomers are analyzed for the specified loading conditions using the Bechtel computer program BSAP. The downcomers are analyzed for both the hydrodynamic loads acting directly on the submerged portions and the inertial forces due to containment responses to the hydrodynamic and seismic loads.

The hydrodynamic load analyses, due to SRV discharge and LOCA related loads acting on the submerged portion of the downcomers, are performed using the mode-superposition time history

technique. The seismic and hydrodynamic load analyses, due to containment responses, are performed using the response-spectrum analysis procedure. Damping values used are equal to 2 percent of critical for OBE and SRV loads, and 7 percent of critical for SSE and LOCA loads.

7.1.4.4 Design Assessment

The resultant stresses in the downcomers due to the load combinations described in Table 5.5-1 are compared with the allowable stresses in accordance with the criteria given in Reference 6.4-2.

7.1.4.5 Fatigue Evaluation Of Downcomers In Wetwell Air Space

A fatigue analysis of the downcomers was conducted in accordance with ASME Section III, Division 1 (1979 Summer Addendum), subsection NB-3650. Only that portion of the downcomer in the air space of the suppression chamber need be evaluated for fatigue. Figures D.2-8 and D.2-9 of Appendix D show the number of cycles considered and the load histogram, respectively.

7.1.5 PIPING AND SRV SYSTEMS ASSESSMENT METHODOLOGY

The piping and SRV systems will be analyzed for the load combinations described in Table 5.6-1 using Bechtel computer program ME101. This program is described in FSAR Section 3.9. Static and dynamic analysis of the piping and SRV systems are performed as described in the paragraphs below.

Static analysis techniques are used to determine the stresses due to steady state loads and/or dynamic loads having equivalent static loads.

Response spectra at the piping anchors are obtained from the dynamic analysis of the containment subjected to LOCA and SRV loading. Piping systems are then analyzed for these response spectra following the method described in Reference 7.1-8.

Time history dynamic analysis of the SRV discharge piping subjected to fluid transient forces in the pipe due to relief valve opening is performed using Bechtel computer code ME101.

7.1.5.1 Fatigue Evaluation of MSRV Discharge Lines in Wetwell Air Volume

In an effort to evaluate the steam bypass potential arising from a failure of the MSRV discharge line in the wetwell air space, a complete fatigue analysis has been performed. Specifically, structural analyses of the MSRV discharge lines from the diaphragm slab penetration to the quencher was performed. Fatigue evaluations of flued head penetration, elbows, tees, taper transitions, and anchors were done. This analysis considered the cyclic loading acting on the MSRV discharge lines and is in accordance with the applicable portions of ASME Code. This evaluation is considered supplemental and does not displace the original design basis for these lines as set forth in the appropriate FSAR/DAR sections.

7.1.5.1.1 Loads and Load Combinations Used for Assessment

The MSRV discharge lines are subject to numerous dynamic and hydrodynamic loads from normal, upset, and LOCA-related plant operating conditions. For purposes of fatigue evaluation, the following loads are included: (1) significant thermal and pressure transients, (2) cyclic loads due to hydrodynamic effects including MSRV actuations, CO and chugging, and (3) seismic effects. The determination of load combinations as well as number and duration of each event is obtained from the applicable sections of the DFFR (Reference 1.3-1) and FSAR.

7.1.5.1.2 Acceptance Criteria

The design rules, as set forth in ASME Section III, subsection NB, were used for the fatigue assessment.

7.1.5.1.3 Methods of Analysis

The MSRV discharge lines in the wetwell air volume were analyzed for the appropriate load combinations and their associated number of cycles. The combined stresses and corresponding equivalent stress cycles were computed to obtain the fatigue usage factors in accordance with the equations of subsection NB-3600 of the ASME Code.

7.1.5.1.4 Results and Design Margins

The cumulative usage factors for flued head, elbows, tees, tapered transitions, and anchors are summarized in Appendix F, Table F.1-1.

7.1.6 NSSS ASSESSMENT METHODOLOGY

To be provided later.

7.1.7 BOP EQUIPMENT ASSESSMENT METHODOLOGY

Safety-related equipment located within the containment and the reactor enclosure and control structure are subjected to hydrodynamic loads due to SRV and LOCA (SBA, IBA, and DBA) discharge effects principally originating in the suppression pool of the containment structure. The equipment and equipment supports are assessed to verify their adequacy to withstand these hydrodynamic loads in combination with seismic and all other applicable loads in accordance with the load combinations given in Table 5.8-1.

7.1.7.1 Dynamic Loads

7.1.7.1.1 SRV Discharge Loads

Loadings associated with the axisymmetric and asymmetric SRV discharges are described in Chapters 3 and 4. Acceleration response spectra at the various elevations where the equipment are located have been generated for all appropriate pressure history traces (Figures 4.1-25 through 4.1-27) for damping values of 1/2, 1, 2, and 5 percent.

7.1.7.1.2 LOCA Related Loads

Loadings associated with loss-of-coolant accident (LOCA) are described in Chapters 3 and 4. The various LOCA loadings considered include condensation oscillation and chugging (Section 4.2.2). Acceleration response spectra at various elevations where the equipment are located have been generated for the above LOCA loads for damping values of 1/2, 1, 2, and 5 percent.

7.1.7.1.3 Seismic Loads

The details of seismic input and seismic loads are discussed in FSAR Section 3.7. The effects of both operating basis earthquake (OBE) and safe shutdown earthquake (SSE) are considered. These loads are provided in the form of acceleration response spectra at each floor for damping values of 1/2, 1, 2, and 5 percent for each of N-S, E-W and vertical directions.

7.1.7.2 Load Combinations

Seismic, SRV, and LOCA loads have been combined for various load combinations in accordance with Table 5.8-1 at all floor elevations. For the same equipment located at various elevations, the combined response spectra are enveloped into a single curve for a damping value of 2 percent. Such enveloped curves are generated for each of the N-S, E-W, and vertical directions.

7.1.7.3 Other Loads

In addition to hydrodynamic and seismic loads, other loads such as dead loads, live loads, operating loads, pressure loads, thermal loads, nozzle loads and equipment piping interaction loads, as applicable, are also considered.

7.1.7.4 Qualification Methods

The adequacy of the design of the equipment is assessed by one of the following:

a. Dynamic analysis

b. Testing

c. Combination of testing and analysis.

The choice is based on the practicality of the method depending upon function, type, size, shape, complexity, and nonlinear effects of the equipment and the reliability of the qualification method.

In general, the requirements outlined in Reference 7.1-9 are followed for the qualification of equipment.

7.1.7.4.1 Dynamic Analysis

7.1.7.4.1.1 Methods and Procedures

The dynamic analysis of various equipment is classified into three groups according to the relative rigidity of the equipment based on the magnitude of the fundamental natural frequency described below.

a. Structurally simple equipment - comprised of that equipment which can be adequately represented by one degree of freedom system.

b. Structurally rigid equipment - Comprised of that equipment whose fundamental frequency is:

    1) greater than 33 Hz for the consideration of seismic loads, and,

    2) greater than 100 Hz for the consideration of hydrodynamic loads.

c. Structurally complex equipment - Comprised of that equipment which cannot be classified as structurally simple or structurally rigid.

When the equipment is structurally simple or rigid in one direction but complex in the other, each direction may be classified separately to determine the dynamic loads.

The appropriate response spectra for specific equipment are obtained from the response spectra for the elevation at which the equipment is located in a building for OBE, SSE, and hydrodynamic loads. This includes the vertical as well as both the N-S and E-W horizontal directions.

For equipment that is structurally simple, the dynamic loading (either seismic or hydrodynamic) consists of a static load

corresponding to the equipment weight times the acceleration (in "g's") selected from the appropriate response spectrum. The acceleration selected from the response spectrum corresponds to the equipment's natural frequency, if the equipment's natural frequency is known. If the equipment's natural frequency is not known, the acceleration selected corresponds to the maximum "g" value of the response spectra.

For equipment that is structurally rigid, the seismic load consists of a static load corresponding to the equipment weight times the acceleration at 33 Hz, selected from the appropriate response spectrum and the hydrodynamic loading consists of a static load corresponding to the equipment weight times the acceleration at 100 Hz, selected from the appropriate response spectrum.

For the analysis of structurally complex equipment, the equipment is idealized by a mathematical model that adequately predicts the dynamic properties of the equipment, and a dynamic analysis is performed using any standard analysis procedures such as response spectrum modal analysis or a time history analysis. The responses of interest such as deflection, stress, acceleration, etc., are determined by combining each modal response considering all significant modes by the square root of the sum of the squares (SRSS). The absolute sum of similar effects is considered for closely spaced in-phase modes. Closely spaced modes are those with frequencies differing by 10 percent or less.

An acceptable alternative method of analysis is by static coefficient analysis for verifying structural integrity of frame type structures such as members physically similar to beams and columns that can be represented by a simple model. No determination of natural frequencies is made, and the response of the equipment is assumed to be the peak of the response spectrum at damping values in accordance with Section 7.1.7.4.1.2. This response is then multiplied by a static coefficient of 1.5 to take into account the effects of both multifrequency excitation and multimode response.

For nonlinear analysis that may be necessary to account for the nonlinear material properties or the geometry-related nonlinearities, the analysis will include a detailed justification for the approach used for the qualification. Alternatively, the testing method of qualification is used where the effects of nonlinearities are to be considered.

7.1.7.4.1.2 Appropriate Damping Values

The following damping values are used for the design assessment:

a. Load combinations involving OBE but not hydrodynamic loads	1/2%
b. Load combinations involving SSE but not hydrodynamic loads	1%
c. Load combinations involving hydrodynamic loads, or seismic and hydrodynamic loads	2%

Higher damping values may be used where justified.

7.1.7.4.1.3 Three Components of Dynamic Motions

The responses such as internal forces, stresses, and deformations at any point from the three principal orthogonal directions of the dynamic loads are combined as follows.

The response value used shall be the maximum value obtained by adding the response due to vertical earthquake with the larger value of the responses due to one of the horizontal earthquakes by the absolute sum method.

For the other dynamic loads, the response value shall be obtained by combining the response due to three orthogonal directions of an individual load by the square root of the sum of the squares (SRSS) method.

7.1.7.4.2 Testing

Qualification by testing is used in cases where operability requires verification and the effects of nonlinearities have to be considered. For these instances, dynamic adequacy is established by providing dynamic test data. Such data must conform to one of the following:

a. Performance data of equipment that has been subjected to equal or greater dynamic loads (considering appropriate frequency range) than those to be experienced under the specified dynamic loading conditions.

b. Test data from comparable equipment previously tested under similar conditions that has been subjected to equal or greater dynamic loads than those specified.

c. Actual testing of equipment in operating conditions simulating, as closely as possible, the actual installation, the required loadings and load combinations.

A continuous sinusoidal test, sine beat test, or decaying sinusoidal test is used when the applicable floor acceleration spectrum is a narrow band response spectrum. Otherwise, random motion test (or equivalent) with broad frequency content is used.

The equipment to be tested is mounted in a manner that simulates the actual service mounting. Sufficient monitoring devices are used to evaluate the performance of the equipment. With the appropriate test method selected, the equipment is considered to be qualified when the test response spectra (TRS) envelopes the required response spectra (RRS) and the equipment does not malfunction or fail. A new test does not need to be conducted if equipment requires only minor modifications such as additional bracings or change in switch model, etc, and if proper justification is given to show that the modifications would not jeopardize the strength and function of the equipment.

7.1.7.4.3 Combined Analysis and Testing

There are several instances where the qualification of equipment by analysis alone or testing alone is not practical or adequate because of its size, or its complexity, or large number of similar configurations. In these instances, a combination of analysis and testing is the most practical. The following are general approaches:

a. An analysis is conducted on the overall assembly to determine its stress level and the transmissibility of motion from the base of the equipment to the critical components. The critical components are removed from the assembly and subjected to a simulation of the environment on a test table.

b. Experimental methods are used to aid in the formulation of the mathematical model for any piece of equipment. Mode shapes and frequencies are determined experimentally and incorporated into a mathematical model of the equipemnt.

7.1.8 ELECTRICAL RACEWAY SYSTEM ASSESSMENT METHODOLOGY

7.1.8.1 General

The analysis and design of supports of electrical raceway systems for non-hydrodynamic loads are in accordance with Reference 7.1-12. SRV discharge and LOCA loads are considered similar to seismic loads by using appropriate floor response spectra for the hydrodynamic loads. For the abnormal/extreme load condition, a damping value of 10% of critical is used for cable tray support systems; 7% damping for conduit and wireway gutter trapeze type support systems; 5% damping for conduit and wireway gutter nontrapeze type support systems. A damping value of 3% critical is used for all raceway systems for the normal load condition involving SRV discharge loading only. The damping ratios used for the electrical raceway assessment are in accordance with Reference 7.1-12.

7.1.8.2 Loads

7.1.8.2.1 Static Loads

The static loads are the dead loads and live loads. For cable trays, the weight of the cable plus tray is considered to be 36 lb/ft (except unique situations where heavier weights are considered) and a concentrated live load of 200 lb applicable at any point on the cable tray span is used.

7.1.8.2.2 Seismic Loads

The details of the seismic motion input are discussed in FSAR Section 3.7. The effects of the operating basis earthquake (OBE) and the safe shutdown earthquake (SSE) are considered.

7.1.8.2.3 Hydrodynamic Loads

The details of the axisymmetric and asymmetric SRV discharge loads as well as LOCA loads including condensation-oscillation and chugging are discussed in Chapter 4.

The enveloped acceleration response spectra at each floor for N-S, E-W, and vertical directions have been generated and widened by ±15%. These curves form the basis for the hydrodynamic load assessment of the electrical raceway system. Examples of the response spectrum curves for the containment and reactor and control enclosures are presented in DAR Appendices A and B.

7.1.8.3 Analytical Methods

Electrical raceway systems are modeled as a three-dimensional dynamic system consisting of several consecutive supports complete with raceways and longitudinal and transverse bracing. The cable tray properties are determined from the load deflection tests. Member joints are modeled as spring elements having rotational stiffness with known spring values as determined from the test results.

Composite spectra are developed by enveloping the floor response spectra after broadening by ±15% for critical floors for seismic, SRV, and LOCA loading conditions. The design spectrum is obtained by adding these response spectra curves by either the squares root of the sum of the square (SRSS) method or the absolute method. A frequency variation of ±20% is used to further broaden the spectrum at the fundamental frequency of the electrical raceway system. The composite response spectra curves are obtained for vertical and two horizontal directions.

Modal and response spectrum analyses are performed using the Bechtel Structural Analysis Program (BSAP), which is a general purpose finite-element computer program. The total response due to the dynamic loads is calculated by determining the absolute sum of the vertical response and only the larger response of the two horizontal responses.

Dead and live load stresses are determined from a static analysis of a plane frame model using the BSAP computer program or hand calculation, and these results are combined with those from the response spectrum analysis. For normal load conditions, SRV discharge stresses are proportioned from the response spectrum

analysis of SSE plus SRV discharge plus LOCA loads according to their spectral acceleration ratios at the fundamental frequencies. Several different support types that are widely used have been analyzed by these methods.

An alternative method for analyzing other support types uses hand calculations by a response spectrum analysis technique. The support may be idealized as a single degree of freedom system. In general, the maximum peak spectral accelerations were used in the analysis. In some cases where the stresses are critical, a more refined value for the acceleration response was used corresponding to the computed system fundamental frequency and considering a frequency variation as explained earlier in this section. The total response due to the dynamic loads is calculated by determining the absolute sum of the vertical response and only the larger response of the two horizontal responses. The member stresses are kept within the elastic limit.

7.1.9 HVAC DUCT SYSTEM ASSESSMENT METHODOLOGY

The SRV discharge and LOCA loads are considered similar to seismic loads by using appropriate floor response spectra generated for the CO, chugging, and SRV loads described in Chapter 4.

A damping value of 5% of critical is used for load combinations involving SSE, SRV discharge, and LOCA loads, while a damping value of 3% of critical is used for load combinations involving OBE and/or SRV discharge loads. For a discussion of the seismic and hydrodynamic loads input for HVAC duct system assessment, refer to Sections 7.1.8.2.2 and 7.1.8.2.3, respectively. The HVAC duct system has been analyzed by determining the fundamental frequencies of the system in three directions. The inertia forces are determined from the composite spectra to establish member forces and moments due to hydrodynamic as well as seismic loads.

7.1.10 REFERENCES

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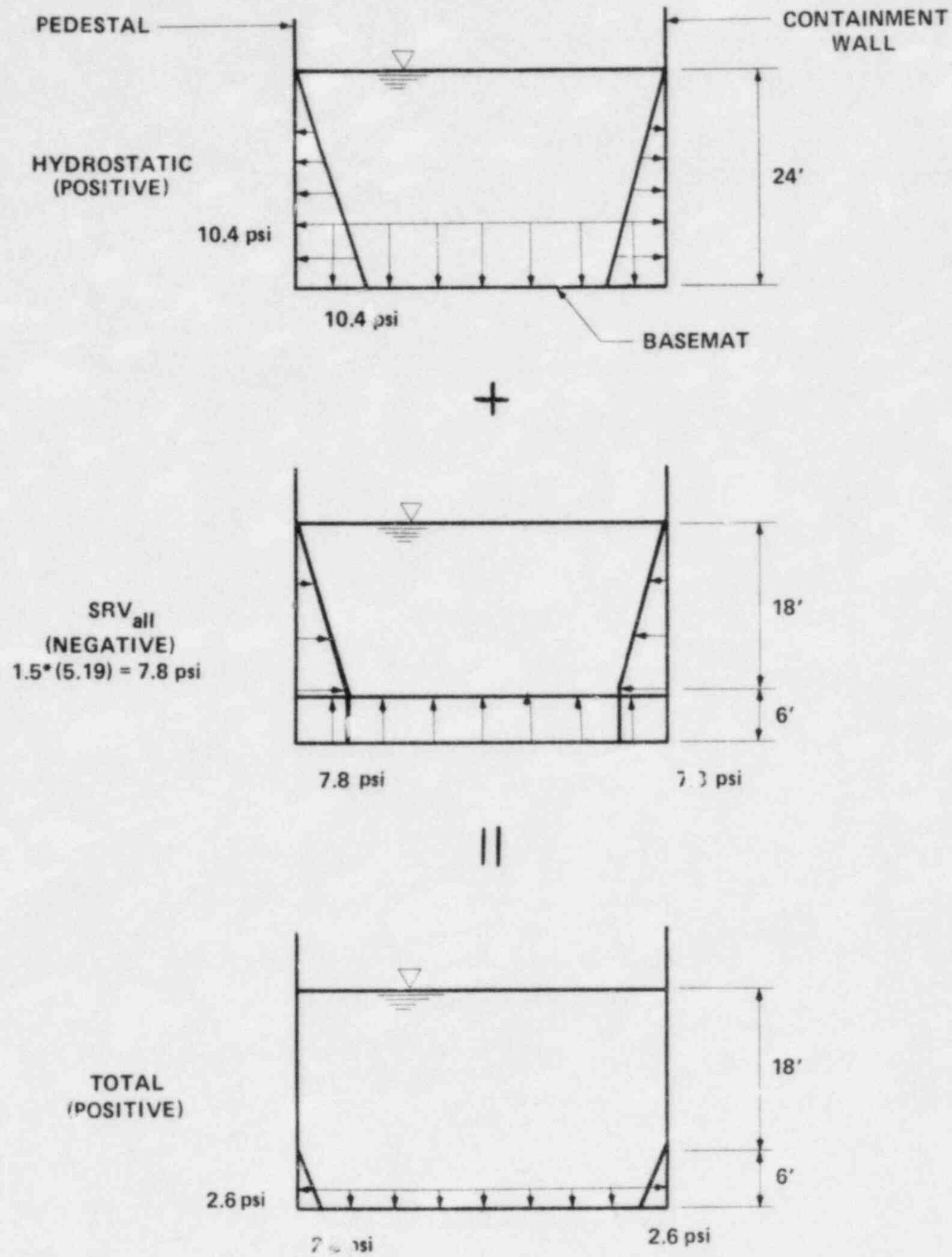
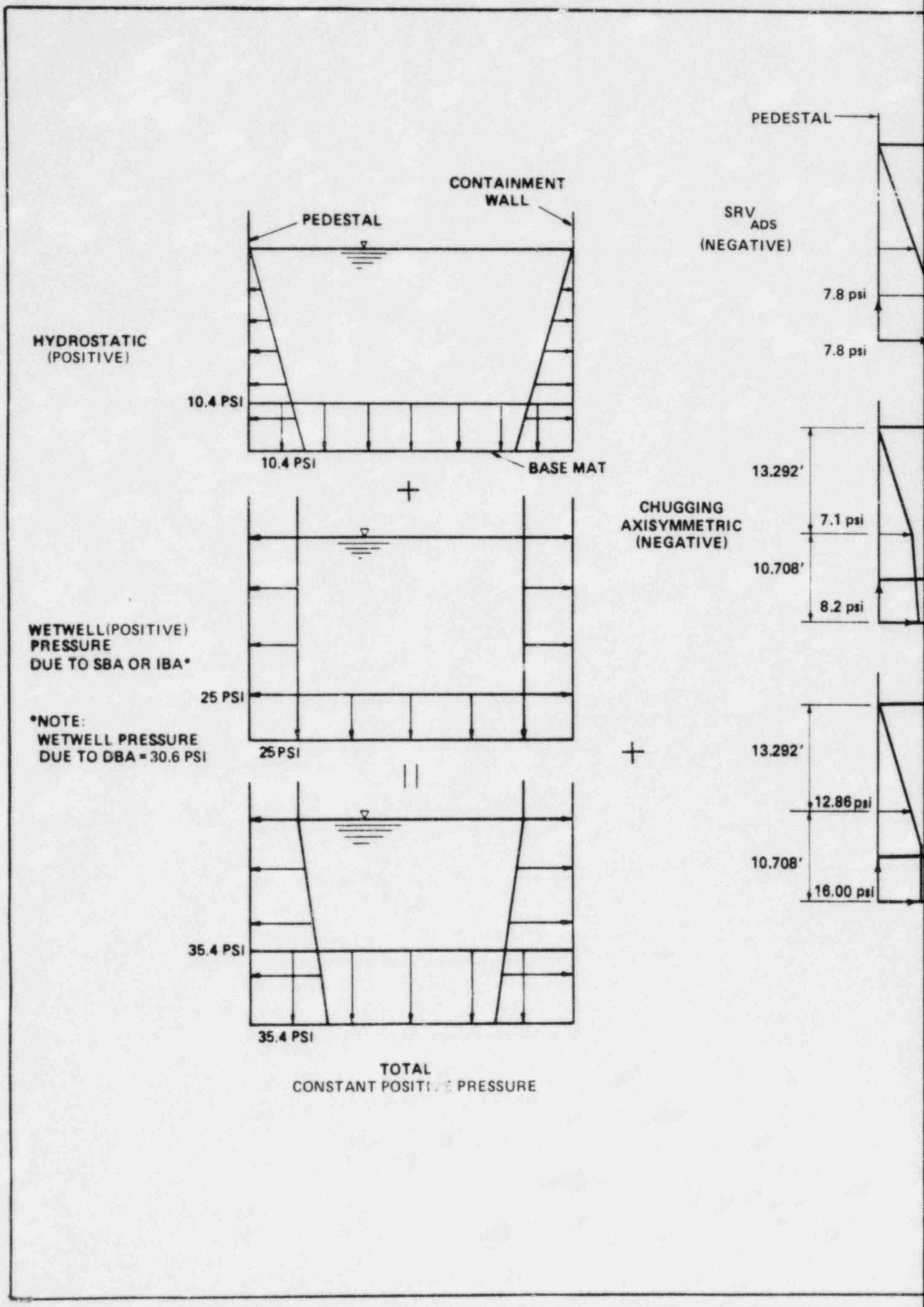


*PRESSURE MULTIPLIER

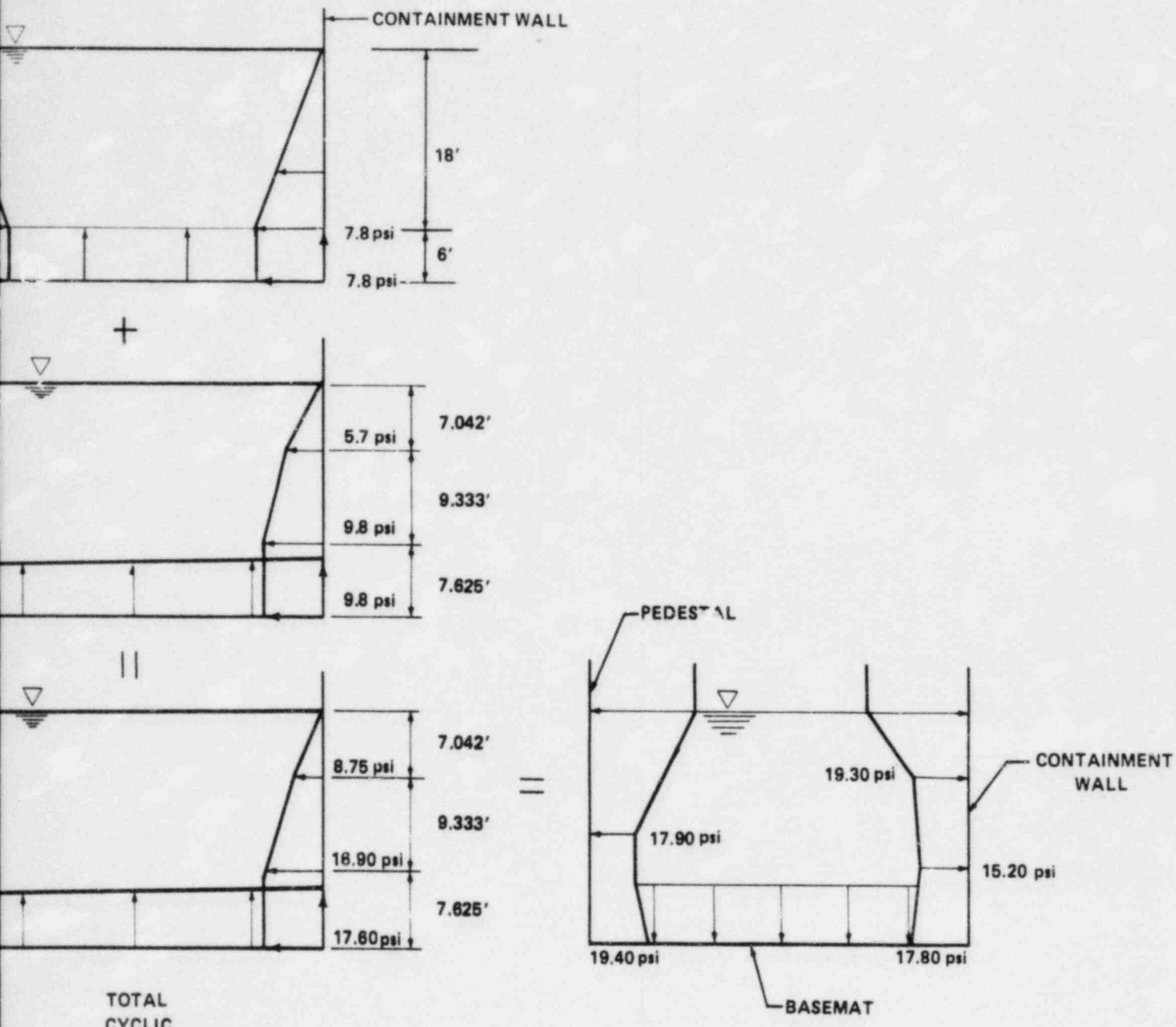
LIMERICK GENERATING STATION
UNITS 1 AND 2
DESIGN ASSESSMENT REPORT

LINER PLATE PRESSURES
NORMAL CONDITION

FIGURE 7.1-12 REV 2, 03/83



PEDESTAL
CONTAINMENT WALL
HYDROSTATIC (POSITIVE)
10.4 PSI
10.4 PSI
BASE MAT
WETWELL (POSITIVE) PRESSURE DUE TO SBA OR IBA*
*NOTE: WETWELL PRESSURE DUE TO DBA = 30.6 PSI
25 PSI
25 PSI
35.4 PSI
35.4 PSI
TOTAL
CONSTANT POSITI E PRESSURE
PEDESTAL
SRV
ADS
(NEGATIVE)
7.8 psi
7.8 psi
CHUGGING AXISYMMETRIC (NEGATIVE)
13.292′
7.1 psi
10.708′
8.2 psi
13.292′
12.86 psi
10.708′
16.00 psi



NET PRESSURE =
TOTAL POSITIVE PRESSURE + TOTAL NEGATIVE PRESSURE

LIMERICK GENERATING STATION
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DESIGN ASSESSMENT REPORT

LINER PLATE PRESSURES
ABNORMAL CONDITION

FIGURE 7.1-13 Rev. 2, 0?/83

DELETED

LIMERICK GENERATING STATION
UNITS 1 AND 2
DESIGN ASSESSMENT REPORT

LINER PLATE PRESSURES
ABNORMAL CONDITION

FIGURE 7.1-14

REV. 2, 03/83

DELETED

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UNITS 1 AND 2
DESIGN ASSESMENT REPORT

LINEAR PRESSURES
ABNORMAL CONDITION

FIGURE 7.1-15 REV. 2, 03/83

7.2 DESIGN CAPABILITY MARGINS

This section describes the design margins for structures, piping, and equipment resulting from the LGS design assessment which uses the methods of Section 7.1

7.2.1 STRESS MARGINS

Stresses at the critical sections for all of the structures, piping, and equipment described in Section 7.1 are evaluated for the loading combinations presented in Chapter 5.

The stress margin (SM) in percent is defined as follows:

$$SM = (1 - SR) \times 100$$

where SR represents the stress ratio. SR is calculated by dividing the factored stress ($C_n f_n$) by the associated stress allowable (F_n) or, mathematically,

$$SR = \Sigma (C_n f_n / F_n)$$

7.2.1.1 Containment Structure

The detailed results from the structural assessment of the containment structure are summarized in Appendix D.1. Figure D.1-1 shows the design sections in the basemat, shield walls, containment walls, reactor pedestal, and the diaphragm slab that were considered in the structural assessment. Figures D.1-2 through D.1-25 give the calculated maximum design stresses for the load combinations listed in Table 5.2-1.

Both rebar stresses and concrete stresses are calculated based on the applicable load combination equations. The stresses in the drywell wall are calculated at design sections 1 to 5 and are tabulated in Figures D.1-2 through D.1-5. The stresses in the wetwell wall are calculated at design sections 6 to 11 and are tabulated in Figures D.1-6 through D.1-9. The stresses in the shield wall are calculated at design sections 12 and 13 and are tabulated in Figures D.1-10 and D.1-11, respectively. The RPV pedestal stresses are calculated at design sections 14 to 20 and are tabulated in Figures D.1-12 through D.1-16. The stresses in

the diaphgram slab are calculated at design sections 21 to 25 and are tabulated in Figures D.1-17 through D.1-20. The stresses in the basemat are calculated at design sections 26 to 30 and are tabulated in Figures D.1-21 through D.1-25.

The containment assessment is summarized as follows:

a. The calculated stress level is very low for load combination equation 1 (an operating condition), i.e., rebar stresses are far less than 20 ksi.

b. The maximum rebar stress is predicted as 53.9 ksi at design sections 6 and 11, located in the wetwell vertical direction. The magnitude is within the rebar stress allowable (0.9 Fy = 54 ksi).

c. In general, rebar stresses and concrete compressive stresses are within stress allowables.

7.2.1.2 Reactor Enclosure and Control Structure

Results of the structural assessment of the reactor enclosure and control structure are summarized in Appendix E. Figures E.1-1 through E.1-21 show the selected structural elements and sections where stresses were calculated.

Appendix E contains tabulations of predicted stresses, stress allowables, and design margins for critical loading combinations considered. The sections selected for assessment were considered to be the most critical based on previous seismic calculations.

The critical load combinations are tabulated considering critical locations/sections related to reactor enclosure and control structure shear walls, foundations, floor slabs and supporting steel, steel platforms, and floor support columns.

Emphasis is placed on margins of principal resisting structural elements, with reinforcing bar stresses for reinforced concrete structures and axial and/or bending stresses for steel structures.

Also included in Appendix E are diagrams of axial forces, N-S shear forces, N-S overturning moments, E-W shear forces, E-W overturning moments for reactor enclosure and control structure as shown in Figures E.1-22 through E.1-31.

The reactor enclosure floor system stress margins were calculated for both slabs and floor support steel beams, including floors at El. 201, 217, 253, 283, 313, 333, and 352 ft. Calculated slab stress levels were generally governed by either Equation 1 or 7a of Table 5.2-1. The highest reinforcing bar stress was found at the floor of El. 253 ft, having a stress intensity of 51.26 ksi and an associated stress margin of approximately 5 percent. Figure E.1-32 shows rebar stresses and related stress margins of the aforementioned floors. In addition, the stresses and related stress margins of floor support steel beams are presented in Figure E.1-33. The governing equations were Equations 1 and 7 of Table 5.3-1. Stress levels were generally low.

In the case of reactor enclosure support columns, load combination 7 of Table 5.3-1 governs the column stress interaction. Stress interaction calculations were performed and show that columns were generally understressed (Figure E.1-34). The column at column lines 30.5 and E of El. 217 to 253 ft has a fully stressed situation.

The reactor enclosure shear wall sections close to the base (El. 177 ft) were assessed as shown in Figure E.1-35. The highest stress conditions occurred in the walls of column lines 14.1 (west wall) and 31.9 (east wall) due to shearing effect at the base. The corresponding stress margin was approximately 1 percent.

The floor system of the control structure, including the concrete slabs and their supporting steel beams, are shown in Figure E.1-9 through E.1-17, while the stress margins are listed in Figures E.1-36 and E.1-37.

In general, none of those selected critical sections were found overstressed in the control structure. All concrete floors were assessed. The concrete slabs are governed by the normal load conditions, Equation 1 of Table 5.2-1. The steel floor beams supporting the concrete slabs are governed by the abnormal extreme environmental load conditions, Equation 7 of Table 5.2-1. Generally, the concrete slabs have a higher stress margin than the supporting steel beams.

For the control structure shear walls, the stress levels are critical in the walls close to the base due to seismic loads. The stress margins for the shear walls at column lines 19.4 and 26.6, as shown in Figure E.1-38, were found most critical under the abnormal extreme environmental load condition including DBE and seismic torsional effects.

The steel platforms at El. 313, 322, 340, and 350 ft were also assessed. The dynamic loads applied on the steel frames which support the platforms were found less significant than the normal loads. All the steel frames are governed by the normal load condition, Equation 2 of Table 5.3-1, with its associated allowable stresses. Those assessed steel members are shown in Figures E.1-18 through E.1-21. As demonstrated in Figure E.1-39, steel frames are generally understressed.

7.2.1.3 Suppression Chamber Columns

The column vibration mode shapes are calculated using computer program BSAP. The mode shapes are shown in Appendix D, Figure D.2-1. The equivalent water mass is equal to the column volume.

The stresses at the top and bottom of the suppression chamber columns were calculated and combined in accordance with the load combinations shown in Table 5.3-1. The maximum stresses in the column are governed by load combination Equation 7. The maximum stresses in the column (42-inch diameter pipe), top anchorage, and bottom anchorage are shown in Figure D.2-2. The lowest stress margin in the column structure is 10 percent.

7.2.1.4 Downcomer Bracing

The bracing member forces and the corresponding design margins due to the governing load combinations are given in Figure D.2-11 for the critical bracing members.

7.2.1.5 Liner Plate

For the normal and abnormal conditions, the liner plate system does not experience any net negative pressures as demonstrated in Figures 7.1-12 and 7.1-13. There is a large stress margin because the liner plate is designed for resisting a large suction (i.e., 5 psi negative).

7.2.1.6 Downcomers

The downcomer vibration mode shapes are calculated for the modal analyses using computer program BSAP. The mode shapes are shown in Appendix D, Figures D.2-3 through D.2-5, for the three representative bracing system spring stiffnesses. The equivalent water mass included in the model is equal to the downcomer volume.

The downcomers were assessed in accordance with ASME Section III, Division 1, subsection NB-3652, using load combinations in Table 5.5-1. Stresses and design margins are given in Appendix D, Figure D.2-6.

Downcomer fatigue at three critical locations were also checked. Loads are combined by the absolute sum method. Figure D.2-7 shows the fatigue usage factors at these critical locations, computed in accordance with ASME Section III, Division 1, subsection NB-3650 (1979 Summer Addenda). Downcomers are adequate for fatigue considerations.

7.2.1.7 Electrical Raceway System

The electrical raceway system was analyzed using the load combinations in Table 5.8-1 in accordance with the methodology described in Section 7.1.8. The stress margins were found to be most critical under the abnormal/extreme load condition. Stresses are below allowable stress levels for all members of the electrical raceway system.

7.2.1.8 HVAC Duct System

The HVAC duct system was analyzed using the load combinations in Table 5.9-1 in accordance with the methodology described in Section 7.1.9. The stress margins were found to be most critical under the abnormal/extreme load condition. Stresses are below allowable stress levels for all members of the HVAC duct system.

7.2.1.9 ASME Class MC Steel Components Margins

To be provided later.

7.2.1.10 BOP Piping and MSRV Systems Margins

As described in Section 7.1.5, all Seismic Category I BOP piping systems located inside the containment, reactor enclosure, and control structure are analyzed for seismic and hydrodynamic loads. The loads from the analyses are combined as described in Table 5.6-1. Additional supports and modification of existing supports are required at selected locations to accommodate the hydrodynamic and seismic loads for some piping systems. Stresses and stress margins for selected BOP piping systems are summarized in Appendix F. The stress reports for the evaluation of the BOP piping will be available for NRC review.

7.2.1.11 BOP Equipment Margins

All Seismic Category I BOP equipment is re-assessed for hydrodynamic and seismic loads (Section 7.1.7) via the Limerick Seismic Qualification Review Team (SQRT) program. For each piece of BOP equipment, a five-page SQRT summary form has been prepared documenting the re-evaluation of the equipment.

7.2.2 ACCELERATION RESPONSE SPECTRA

7.2.2.1 Containment Structure

The method of analysis and load description for the acceleration response spectrum generation are outlined in Section 7.1.1.1.1.6.1. From a review of the acceleration response spectra curves for the containment structure, the maximum spectral accelerations are tabulated for 1 percent damping of critical. For SRV and LOCA loads, the maximum spectral accelerations are presented in Table 7.2-1.

The hydrodynamic acceleration response spectra of the containment structure are presented in Appendix A.2.

7.2.2.2 Reactor Enclosure and Control Structure

The method of analysis and load applications for the computation of the hydrodynamic acceleration response spectrum in the reactor enclosure and the control structure are described in Section 7.1.1.2. The response spectra of the reactor enclosure and the control structure are shown in Appendix B.

QUESTION 220.17 (DAR Section 7.2)

In Section 7.2, Design Capacity Margins, it is stated that you are going to provide the pertinent information on margins of various structures at a later date. Indicate when ou will be able to provide the necessary information.

RESPONSE

DAR Sections 7.2.1.1, 7.2.1.2, 7.2.1.3, 7.2.1.6, 7.2.1.7, and 7.2.1.8 have been added to provide pertinent information on the design capacity margins of the containment structure, reactor enclosure and control structure, suppression chamber columns, downcomers, electrical raceway system, and HVAC duct system, respectively.

QUESTION 220.18

The combination of dynamic load responses or effects appears to be different for different structures, some by ABS and others by SRSS. This is deduced from your statements made in Sections 7.1.1.1.4, 7.1.2.1.2.5 and 7.1.2.2.3. A clarification of these statements is requested. Indicate how the responses due to condensation and oscillation are combined with those due to chugging. Identify the combination method, ABS or SRSS for each of the structures inside or outside the containment as well as the structures comprising the containment itself.

RESPONSE

The Limerick containment structure, reactor enclosure, and control structure are assessed for the inclusion of Mark II hydrodynamic loads in accordance with Section 7.1. The use of the square root of the sum of the squares (SRSS) combination method for combining hydrodynamic and seismic dynamic load events (i.e.,

$\sqrt{SRV^2 + LOCA^2 + SEISMIC^2}$) is justified in Reference 7.1-4.

In general, for structural assessment, the combination of these dynamic load events is accomplished by conservatively summing the peak dynamic responses by the absolute sum method (ABS) (i.e., SRV + LOCA + SEISMIC). SRSS combination of the hydrodynamic and seismic loads is used only for the suppression chamber columns and the downcomer bracing system.

Sections 7.1.1.1.4, 7.1.2.1.2.5, and 7.1.2.2.3 have been changed to clarify the combination method used for seismic and hydrodynamic load effects.

Section 7.1.1.1.1.5.2 has been changed to clarify the consideration of the dynamic responses due to condensation oscillation in conjunction with those due to chugging.

QUESTION 220.19

In Section 7.1.1.1.1.6.1 on Page 7.1-7, it is stated that the enveloped response-spectra furnished in two sets of damping values, the low and the high. Explain the condition under which each of the two sets is used. Note that in the DAR only the response-spectra for the low damping is given in Appendix A.

RESPONSE

For Mark II hydrodynamic load assessment, enveloped floor response spectra were generated for eight damping values between 0.5 to 20 percent of critical. For clarity, these eight enveloped floor spectra are grouped into two separate plot sets of four damping values each.

Application of these spectra to various components and systems attached to the floor slabs are in accordance with the appropriate component and system damping values as shown, for example, in Table 5.8-1. Floor response spectra of larger damping values (i.e., greater than 7 percent of critical) are generated for application to systems and components where larger system or material damping values are justified.

Section 7.1.1.1.1.6.1 has been changed to provide the above clarifications.

QUESTION 220.20 (DAR Section 7.1.3)

In Section 7.1.3, the liner plate under negative pressure should be designed in accordance with Section 111, Division 1 criteria. The liner plate should also be investigated for fatigue. The liner system design requirements are specified in Section 5.6 of the DFFR. In the fatigue analysis the number of cycles to be considered should be specified. The results of the analysis should be included in the DAR.

RESPONSE

Section 7.1.3 presently states that for the normal condition, a maximum net negative pressure of 1.27 psi exists on the wetwell liner plate due to the combination of SRV actuation and hydrostatic pressure. This value is incorrect and should equal 2.6 psi (positive) for the following reasons.

A maximum SRV dynamic negative pressure of 7.8 psi exists on the liner plate based on a consideration of all KWU pressure traces. The pressure is derived from KWU pressure trace No. 76 (Figure 4.1-26) multiplied by a 1.5 pressure multiplier to account for the difference in pool geometries and quencher constructions between Limerick and Brunsbuttel as described in Section 4.1.4.1. This SRV dynamic negative pressure was incorrectly provided in Section 7.1.3 as 11.67 psi and should be corrected to reflect 7.8 psi. When combined with the positive hydrostatic pressure of 10.4 psi, a net positive pressure of 2.6 psi exists on the liner plate.

Based on the discussion above, it is concluded that the liner plate will not be subjected to dynamic cyclic negative pressure load under both normal and abnormal conditions. Therefore, the fatigue evaluations of the Limerick concrete-backed liner plate due to cyclic dynamic negative pressure need not be considered.

Sections 7.1.3 and 7.2.1.5 and Figures 7.1-12 and 7.1-13 changed to reflect the impact of the corrected SRV maximum dynamic pressure value for both the normal and abnormal conditions.

QUESTION 480.63

Although FSAR Section 6.2.2.2 states that the RHR intake strainers are designed to withstand all hydrodynamic loads postulated to occur in the suppression pool, concerns arise due to the close proximity of the downcomer discharges to the intake strainers. Provide a list of all loads used in the design of the strainers and also provide additional information on your analyses that demonstrate the capability of the strainers to accommodate the hydrodynamic loads from downcomer discharges.

RESPONSE

A dynamic loading analysis has been performed for the ECCS suction strainers and demonstrates their capability to adequately accommodate inertial loads (resulting from a design basis earthquake, SRV discharge, and LOCA condensation oscillation and chugging), operational loads (pressure and temperature), dead weight loads, and direct hydrodynamic loads. The latter loads are due to direct hydrodynamic SRV discharge (SRV air bubble loads) and downcomer discharges (LOCA air bubble, CO, chugging, water jet, and poolswell loads). All of the mentioned loads are combined in accordance with Table 5.8-1. Figure 5.6-1 presents elevations, dimensions, and orientations of the piping systems inside containment that are associated with the ECCS suction strainers. A Seismic Qualification Review Team (SQRT) form summarizes the ECCS suction strainers' loading assessment and will be available for review.

QUESTION 480.68

Chapter 8 of the Design Assessment Report (DAR) that addresses the T-quencher verification test (proprietary) has not been submitted. We request that a copy of this chapter be submitted for our review.

RESPONSE

Volume 3 (proprietary) of the Design Assessment Report containing Chapter 8 was submitted to the NRC with Amendment 35 to the Limerick License Application by letter from E. J. Bradley to H. R. Denton, dated June 30, 1982.

QUESTION 480.69

Provide the pool temperature analysis for the transient involving the actuation of one or more SRV's. For additional guidance, your attention is directed to NUREG-0873, "Pool Temperature Transients for BWR."

RESPONSE

The requested information will be provided by May 1983.

QUESTION 480.70

Table 1.3-2 of the DAR indicates that the quencher arm loads, the total quencher loads during SRV opening, and loads during irregular condensation are under evaluation. Provide these load specifications.

RESPONSE

The quencher load specifications are provided in DAR Volume 3 (Proprietary), Section 4.1. DAR Volume 3 was submitted to the NRC with Amendment 35 to the Limerick License Application by letter from E.J. Bradley to H.R. Denton, dated June 30, 1982.

QUESTION 480.71

Concerns regarding the capability of the vacuum breaker to perform its function during the pool swell and chugging phases of LOCA have been raised. Provide the design changes, if any, that have been implemented to resolve this concern.

RESPONSE

A redesign and requalification program that considers the effects of the poolswell and chugging events has been initiated by the vendor, Anderson Greenwood & Co., and is being funded by three utilities: Philadelphia Electric Co., Pennsylvania Power and Light, and Long Island Lighting Co. The design changes will be implemented on Limerick during the second and third quarter of 1983 and will be provided in the DAR at that time.

APPENDIX F

PIPING DESIGN ASSESSMENT

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APPENDIX F

F.1 BOP PIPING DESIGN ASSESSMENT

Table F.1-1 provides maximum cumulative fatigue usage factors for the MSRV discharge lines in the wetwell airspace. Table F.1-2 summarizes the stresses and stress margins for selected BOP piping systems.

The stress reports for the evaluation of the BOP piping will be available for NRC review.

TABLE F.1-1

MAXIMUM CUMULATIVE USAGE FACTORS
FOR MSRV DISCHARGE LINES IN WETWELL AIR SPACE

Component	Calculated Cumulative Usage Factors	Code Allowable Cumulative Usage Factors
Flued head	0.401	1.0
Flush weld (weld between process pipe and flued head)	0.059	1.0
Short radius elbow	0.110	1.0
Long radius elbow	0.179	1.0
Tapered transition (thin end)	0.868	1.0
Tapered transition (thick end)	0.084	1.0
Tee	0.106	1.0
Flush weld for pipe anchor	0.870	1.0