LIMERICK GENERATING STATION UNITS 1 & 2

DESIGN ASSESSMENT REPORT

REVISION 5 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 Volume 1.

REMOVE	INSERT
VOLUME 1	
Pages S-i, -v	Pages S-i, -v
Page 2-i	Page 2-i
Pages 2.2-1 thru -3	Pages 2.2-1 thru -4
Pages 3.1-1 & -2	Pages 3.1-1 & -2
Page 5-ii	Page 5-ii
Table 5.3-1 (pg 1)	Table 5.3-1 (pg 1)
Table 5.3-2 (pg 1)	Table 5.3-2 (pg 1)
Table 5.6-1 (pg 1)	Table 5.6-1 (pg 1)
Page 5.7-1	Page 5.7-1 thru Table 5.7-1
Page 6.7-1	Page 6.7-1
Pages 7-ii, -iii	Pages 7-ii, -iii
Pages 7.1-9 & -10	Pages 7.1-9 & -10
Pages 7.1-21 thru -26	Pages 7.1-21 thru -26f
Page 7.1-35	Page 7.1-35
Pages 7.2-5 & -6	Pages 7.2-5 thru -7
----	Page 220.22-1 thru Figure 220.22-1
VOLUME 2	
Page F-i	Page F-i
----	Table F.1-2

THIS DAR SET HAS BEEN UPDATED TO INCLUDE REVISIONS THROUGH 5 **DATED** 08/83.

SUMMARY TABLE OF CONTENTS

CHAPTER 2

SUMMARY

TABLE OF CONTENTS

2.2 DESIGN ASSESSMENT SUMMARY

Design assessment of the LGS structures and components is achieved by analyzing the response of the structures and components to the load combinations explained in Chapter 5. In Chapter 7, predicted stresses and responses (from the loads defined in Chapter 4 and combined as described in Chapter 5) are compared with the applicable code allowable values identified in Chapter 6.

2.2.1 CONTAINMENT STRUCTURE, REACTOR ENCLOSURE, AND CONTROL STRUCTURE ASSESSMENT SUMMARY

2.2.1.1 Containment Structure Assessment Summary

The primary containment walls, base slab, diaphragm slab, reactor pedestal and reactor shield are analyzed for the effects of SRV and LOCA in accordance with Table 5.2-1. The ANSYS finite element program is used for the dynamic analysis of structures.

Response spectra curves are developed at various locations within the containment structure to assess the adequacy of components. Stress resultants due to dynamic loads are combined with other loads in accordance with Table 5.2-1 to evaluate rebar and concrete stresses. Design safety margins are defined by comparing the actual concrete and rebar stresses at critical sections with the code allowable values. The assessment methodology of the containment structure is given in Section 7.1.1.1.

The containment mode shapes, modal frequencies, and hydrodynamic response spectra are given in Appendix A.

The results of the structural assessment of the containment structure are given in Appendix D.

2.2.1.2 Reactor Enclosure and Control Structure Assessment Summary

The reactor enclosure and control structure are assessed for the effects of SRV and LOCA loads in accordance with Table 5.2-1 and Table 5.3-1.

Pressure time histories in the wetwell are used to investigate the reactor enclosure and control structure response to SRV and LOCA loads. Maximum time history force responses and broadened response spectra curves are approximately used to assess the adequacy of associated structural components. The assessment methodology of the reactor enclosure and control structure is presented in Section 7.1.1.2.

The mode shapes, modal frequencies, and hydrodynamic response spectra of the reactor enclosure and control structure are presented in Appendix B.

The results of the structural assessment are summarized in Appendix E.

2.2.2 CONTAINMENT SUBMERGED STRUCTURES ASSESSMENT SUMMARY

Load combinations for the downcomer bracing and suppression chamber columns are presented in Table 5.3-1. Load combinations for the downcomers are presented in Table 5.5-1. The hydrodynamic design assessment methodology for the downcomers, bracing, and columns is presented in Sections 7.1.2 and 7.1.4. The results of the analysis are presented in Appendix D.

The suppression pool liner plate loads are combined in accordance with Table 5.2-1. Results from the analysis indicate that no structural modification is required (see Sections 7.1.3 and 7.2.1.5).

2.2.3 BOP PIPING SYSTEMS ASSESSMENT SUMMARY

Containment and reactor enclosure BOP piping systems are being analyzed by the methods presented in Section 7.1.5. The load combinations for piping are described in Table 5.6-1. The results of the analysis are presented in Appendix F.

2.2.4 NSSS ASSESSMENT SUMMARY

2.2.4.1 Introduction

General Electric Company performed a design assessment of Limerick Unit 1 to demonstrate that the NSSS piping and safety-

related equipment have sufficient capability to accommodate combinations of seismic and hydrodynamic loadings. The scope of the evaluation included the reactor pressure vessel (RPV), RPV internals and associated equipment, main steam and recirculation piping, and GE-supplied floor mounted equipment, pipe mounted equipment, and control and instrumentation equipment.

The methodologies described in Section 7.1.6 were used to perform the evaluation. Load combinations and acceptance criteria listed in Table 5-7.1 were used for the evaluation of ASME Class 1, 2 and 3 piping, equipment, and supports.

2.2.4.2 Design Assessment Results

The results of the assessment have demonstrated that the NSSS piping and safety-related equipment have sufficient capability to accommodate combinations of seismic and hydrodynamic loadings for the normal, upset, emergency and faulted conditions.

Detailed results of the NSSS piping and major safety-related equipment evaluations will be given in FSAR Sections 3.9 and 3.10.

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 ASSESSMENT SUMMARY

Suppression pool temperature monitoring system (SPTMS) adequacy assessment and analysis of suppression pool temperature response to SRV discharge are presented in Appendix I.

CHAPTER 3

SRV DISCHARGE AND LOCA TRANSIENT DESCRIPTION

3.1 DESCRIPTION OF SAFETY RELIEF VALVE DISCHARGE

Limerick Generating Station is equipped with a safety relief system that condenses reactor steam in a suppression chamber pool. By this arrangement, reactor steam is conducted to the wetwell via fast-acting safety relief valves and quencher-equipped discharge lines. This section discusses the causes of SRV discharge, describes the SRV discharge process, and identifies the resultant SRV discharge actuation cases. Section 4.1 presents a quantitative description of specific SRV-related loads.

3.1.1 CAUSES OF SRV DISCHARGE

During certain reactor operating transients, the SRVs may be actuated (by pressure, by electrical signal, or by operator action) for rapid relief of pressure in the reactor pressure vessel. The following reactor operating transients have been identified as those which may result in SRV actuation:

a. Turbine generator trip (with bypass or without)

b. Main steam line isolation valve (MSIV) closure

c. Loss of condenser vacuum

d. Feedwater controller failure - maximum demand

e. Pressure regulator failure - closed

f. Generator load rejection (with and without bypass)

g. Loss of ac or auxiliary power

h. Loss of feedwater flow

i. Trip of two recirculation pumps

j. Recirculation flow control failure - decreasing flow

k. Inadvertent safety relief valve opening

l. Control rod withdrawal error

m. Anticipated transient without scram (ATWS)

n. Failure of shutdown cooling

A description of these transients is provided in Chapter 15 of the FSAR.

3.1.2 DESCRIPTION OF THE SRV DISCHARGE PHENOMENA AND SRV LOADING CASES

Before an individual safety relief valve opens, the water level in the discharge line is approximately equal to the water level in the pool. As a valve opens, steam flows into the discharge line air space between the valve and the water column and mixes with the air. Because the downstream portion of the discharge line contains a water slug, the pressure inside the line increases. The increased pressure expels the water slug from the SRV discharge line and quencher. The magnitude of the water clearing pressure is primarily influenced by the steam flow rate through the valve, the degree to which entering steam is condensed along the discharge line walls, the volume of the discharge line airspace, and the volume of the water slug to be accelerated.

The clearing of water is followed by an expulsion of the enclosed air-steam. The exhausted gas forms an oscillating system with the surrounding water, where the gas acts as the spring and the water acts as the mass. This oscillating system is the source of short-term air clearing loads.

As the air-steam mixture oscillates in the pool, it also rises because of buoyancy and eventually breaks through the pool water surface, at which time air clearing loads cease. When all the air leaves the safety relief system, steam flows into the suppression pool through the quencher holes and condenses. The Limerick quencher design ensures stable condensation even with elevated pool water temperature.

CHAPTER 5

TABLES

TABLE 5.3-1 (Page 1 of 2)

LOAD COMBINATIONS AND ALLOWABLE STRESSES FOR STRUCTURAL STEEL COMPONENTS (Suppression Chamber Columns, Downcomer Bracing, and Reactor Building Structural Steel)

Equation	Condition	Load Combination	Allowable Stress
1	Normal w/o Temp.	$D+L+P_o+SRV$	F_s
2	Normal w/Temp.	$D+L+P_o+T_o+SRV$	F_s
3	Normal/ Severe	$D+L+P_o+T_o+E+SRV$	$1.25\ F_s$
4	Normal/ Extreme	$D+L+P_o+T_o+E'+SRV$	(1)
5	Abnormal	$D+L+P+(T_o+T_a)+R$ $+SRV+LOCA$	(1)
6	Abnormal/ Severe	$D+L+P+(T_o+T_a)+R+E$ $+SRV+LOCA$	(1)
7	Abnormal/ Extreme	$D+L+P+(T_o+T_a)+R+E'$ $+SRV+LOCA$	(1)

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(1) In no case shall the allowable stress exceed 0.90 Fy in bending, 0.85 Fy in axial tension or compression, and 0.50 Fy in shear. Where the design is governed by requirements of stability (local or lateral buckling), the actual stress shall not exceed $1.5F_s$.

TABLE 5.3-2 (Page 1 of 2)

LOAD COMBINATIONS AND ALLOWABLE STRESSES FOR ASME CLASS MC COMPONENTS

The drywell head assembly, equipment hatches, personnel lock suppression chamber access hatches, CRD removal hatch, and piping and electrical penetrations are designed for the following loading combinations and allowable stresses:

Equation	Condition	Load Combination	Stress Limits
1	Normal	D+L+1.15P	1.15 times ASME Section III, Class B
2	Normal	$D+L+T_A+P$	ASME Section III, Class B
3	Emergency	$D+L+T_A+P+H_A+R+E$	ASME Section III, Summer 1970 Addenda, Figure N-414
4	Faulted	$D+L+T_A+P+H_A+R+E'$	ASME Section III, Summer 1970 Addenda, Figure N-414
5	Normal w/Temp.	$D+L+T_o+SRV$	ASME Section III, Class MC Components
6	Abnormal/ Severe	$D+L+T_A+P+H_A+R+E$ +SRV+LOCA	ASME Section III, Fig. NB-3224-1 for "Emergency Conditions"
7	Abnormal/ Extreme	$D+L+T_A+P+H_A+R+E$ +SRV+LOCA	ASME Section III, Fig. NB-3225-1 for "Faulted Conditions"

Definitions

D = Dead load

L = Live Load

T_o = Thermal effects due to temperature gradient through the wall, under operating conditions

T_A = Thermal effects due to temperature gradient through the wall, under accident conditions

P = Design basis accident pressure load

TABLE 5.6-1

LOAD COMBINATIONS AND STRESS LIMITS FOR BOP PIPING SYSTEMS

Equation	Condition	Load Combination	Stress Limit
1	Design	PD	NB-3652, NC-3600, ND-3600
2	Normal	PD + DW	NB-3654, NC-3600, ND-3600
3	Upset	(a) $PO+DW+(OBE^2+SRV^2)^{1/2}$ (b) $PO+DW+(RVC^2+OBE^2)^{1/2}$ (c) PO+DW+FV (d) PO+DW+OBE+RVO	NB-3654, NC-3600, ND-3600
4	Emergency	(a) $PO+DW+(OBE^2+SRV_{ADS}^2+SBA^2)^{1/2}$ (b) $PO+DW+(FV^2+OBE^2)^{1/2}$	NB-3655, NC-3600, ND-3600
5	Faulted	(a) $PO+DW+(OBE^2+SRV_{ADS}^2+IBA^2)^{1/2}$ (b) $PO+DW+(SSE^2+SRV_{ADS}^2+IBA^2)^{1/2}$ (c) $PO+DW+(SSE^2+DBA^2)^{1/2}$	NB-3656, ASME Code Case 1606

Notations:

PD = Design pressure
PO = Operating pressure
DW = Dead weight
OBE = Operating basis earthquake (inertia portion)
SSE = Safe shutdown earthquake (inertia portion)
SRV_x = Loads due to safety relief valve blow, axisymmetric or asymmetric
SRV_{ADS} = Load due to automatic depressurization SRV blow, axisymmetric
SBA = Small break accident
IBA = Intermediate break accident
DBA = Design basis accident
FV = Transient response of the piping system associated with fast valve closure (transients associated with valve closure times less than 5 seconds are considered)
RVC = Transient response of the piping system associated with relief valve opening in a closed system
RVO = Sustained load or response of the piping system associated with relief valve opening in an open system or last segment of the closed system with steady state load

5.7 NSSS LOAD COMBINATIONS

Load combinations and acceptance criteria for ASME Class 1, 2, and 3 NSSS piping, equipment, and supports are provided in Table 5.7-1.

TABLE 5.7-1 (Page 1 of 2)

LOAD COMBINATIONS AND ACCEPTANCE CRITERIA FOR ASME CLASS 1, 2 AND 3 NSSS PIPING, EQUIPMENT, AND SUPPORTS

LOAD COMBINATION	DESIGN BASIS	EVALUATION[3] BASIS	SERVICE LEVEL
N + $SRV_{(ALL)}$	Upset	Upset	(B)
N + OBE	Upset	Upset	(B)
N + OBE + $SRV_{(ALL)}$	Emergency	Upset	(B)
N + SSE + $SRV_{(ALL)}$	Faulted	Faulted	(D)[1]
N + SBA + SRV	Emergency	Emergency	(C)[1]
N + SBA + $SRV_{(ADS)}$	Emergency	Emergency	(C)[1]
N + SBA/IBA + OBE + $SRV_{(ADS)}$	Emergency	Emergency	(C)[1]
N + SBA/IBA + SSE + $SRV_{(ADS)}$	Faulted	Faulted	(D)[1]
N + LOCA[2] + SSE	Faulted	Faulted	(D)[1]

LOAD DEFINITION LEGEND

N - Normal loads (e.g., weight, pressure, temperature, etc)

OBE - Operating basis earthquake loads

SSE - Safe shutdown earthquake loads

SRV - Safety/relief valve discharge induced loads from two adjacent valves (one valve actuated when adjacent valve is cycling)

TABLE 5.7-1 (cont'd) (Page 2 of 2)

SRV_{ALL}	-	Loads induced by actuation of all 14 safety/relief valves that activate within milliseconds of each other (e.g., turbine trip operational transient)
SRV_{ADS}	-	Loads induced by the actuation of all 5 safety/relief valves associated with automatic depressurization system that actuate within milliseconds of each other during the postulated small or intermediate size pipe rupture.
LOCA	-	Loss-of-coolant accident associated with the postulated pipe rupture of large pipes (e.g., main steam, feedwater, recirculation piping)
$LOCA_1$	-	Poolswell drag/fallback loads on piping and components located between the main vent discharge outlet and the suppression pool water upper surface
$LOCA_2$	-	Poolswell impact loads on piping and components located above the suppression pool water upper surface
$LOCA_3$	-	Oscillating pressure induced loads on submerged piping and components during condensation oscillations
$LOCA_4$	-	Building motion induced loads from chugging
$LOCA_5$	-	Building motion induced loads from main vent air clearing
$LOCA_6$	-	Vertical and horizontal loads on main vent piping
$LOCA_7$	-	Annulus pressurization loads
SBA	-	Abnormal transients associated with a small break accident
IBE	-	Abnormal transients associated with an intermediate break accident.

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(1) All ASME Class 1, 2 and 3 piping that are required to function for safe shutdown under the postulated events are designed to meet the requirements described in NEDO-21985 (Sept. 1978).
(2) The most limiting case of load combinations among $LOCA_1$ through $LOCA_7$.
(3) Evaluation basis in accordance with NRC requirements.

6.7 NSSS CAPABILITY ASSESSMENT CRITERIA

The capability assessment criteria used for the evaluation of NSSS piping systems, reactor pressure vessel (RPV), RPV supports, RPV internals and floor mounted equipment are shown in Table 5-7.1. Table 5-7.1 is in agreement with a conservative general interpretation of the NRC technical position, "Stress Limits for ASME Class 1, 2 and 3 Components and Component Supports of Safety-Related Systems and Core Support (CS) Structures Under Specific Service Loading Combinations".

Peak response due to related dynamic loads postulated to occur in the same time frame but from different events are combined by the square-root-of-the-sum-of-the-squares method (SRSS). A discussion of this load combination technique is given in Reference 7.1-4.

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

sections. CECAP uses an iterative technique to obtain stresses considering redistribution of forces due to cracking and, in the process, it reduces the thermal stresses due to the relieving effect of concrete cracking. The program is also capable of describing the spiral and transverse reinforcement stresses directly. The input data for the program consists of the uncracked forces, moments and shears calculated by FINEL, ANSYS, and seismic analysis. The loads are then combined in accordance with Table 5.2-1 with appropriate load factors. The stress margins are calculated in Section 7.2.

7.1.1.2 Reactor Enclosure and Control Structure

7.1.1.2.1 Hydrodynamic Loads

7.1.1.2.1.1 Load Definitions

The reactor enclosure and control structure were analyzed for both the SRV discharge load and the LOCA condensation oscillation and chugging loads. Description of the different load cases are presented in Section 7.1.1.1.1.5.

7.1.1.2.1.2 Hydrodynamic Analysis Models

For the hydrodynamic loads described in Section 7.1.1.2.1.1, different mathematical models are constructed for the determination of the reactor enclosure and control structure hydrodynamic responses. The mathematical models are presented in detail in the following sections and are summarized in Table 7.1-1.

7.1.1.2.1.2.1 SRV Analysis Models

The reactor enclosure and control structure were modeled to simulate global structural response during SRV actuation. Included in the analyses were an axisymmetric model for axisymmetric SRV loads and flexible base vertical, N-S, and E-W stick models for the asymmetric SRV loads. The latter uses the ANSYS containment finite element model response as input. The mathematical models and analysis procedures are described below.

7.1.1.2.1.2.1.1 Axisymmetric SRV Analysis Model

An axisymmetric model, based on Bechtel proprietary code CE971-FESS, was created to generate vertical response data for the NSSS new loads' structure and equipment adequacy assessment. The axisymmetric model has been closely correlated with in-plant test data (Reference 7.1-5).

The model represents a containment system, adjacent structure (including reactor enclosure and control structure), and the soil medium as shown in Figure 7.1-3. Figure 7.1-8 shows a mass-proportional and stiffness-proportional damping simulation. The containment system and soil medium were modeled as FESS axisymmetric finite elements, whereas the adjacent structure was simulated by a coupled stick model. Altogether, the model has a combination of 673 dynamic degrees of freedom.

The model was modified to simulate as-built conditions (i.e., concrete aging effect, etc) and normal plant operating conditions (i.e., RPV mass, etc) for generation of response data used for associated equipment adequacy evaluation. The analytical elements have the material properties as shown below:

Element Material Type	Young's Modulus, E Kip/ft²	Material Density, ρ Kip.s²/ft⁴	Poisson's Ratio	Shear Wave, Vs (Ft/s)
Concrete	0.0936E+6*	0.00446	0.22	-
Steel	0.4176E+7	0.01524	0.33	-
Soil Medium	0.432E+6	0.00481	0.30	5950**

*The modulus represents a dynamic modulus of elasticity.
**The shear wave velocity, Vs, is used to simulate a soil shear modulus ($G=Vs^2\rho$), equal to 0.166 E+6 Kip/ft^2.

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 ASME Class MC steel components include suppression chamber access hatch, equipment hatch, equipment hatch-personnel airlock, refueling head and CRD removal hatch. Details of these components are shown in FSAR Figures 3.8-31 through 3.8-34. All of these components were reevaluated for additional loads due to Mark II hydrodynamic effects (SRV and LOCA) by Chicago Bridge and Iron Company under subcontract from Bechtel. The refueling head and the equipment hatch-personnel airlock were analyzed using CBI computer program E0781. This computer program calculates the stresses and displacements in thin wall elastic shells of revolution when subjected to static edge, surface, and/or temperature loads with an arbitrary distribution over the surface of the shell. The other components (CRD removal hatch, suppression chamber access hatch, and equipment hatch) were reassessed using manual computations in accordance with the load combinations and allowable stresses shown in Table 5.3-2.

7.1.2.3.1 Loads

Loads considered in the assessment of the components included dead load, live load, design accident pressure and thermal load, external pressure load, and jet load resulting from postulated pipe rupture as discussed in FSAR Section 3.8.2.3. Equivalent static loads were considered for the seismic load and Mark II hydrodynamic loads using appropriate peak spectral accelerations.

7.1.2.3.2 Load Combinations

Load combinations and allowable stresses used in the reassessment are given in Table 5.3-2. Loads due to SRV, seismic, and LOCA events were combined using the SRSS technique.

7.1.2.3.3 Design Assessment

The resultant membrane stresses, surface stresses, shear stresses and stress in welds were evaluated against allowable stresses given in Table 5.3-2 for all components. The preloads and maximum stresses in connecting bolts were also assessed. Relative deflections and rotations were examined at locations where leaktightness is required. The assessment results for the components are discussed in Section 7.2.

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 liner plate is contained in Section 7.2.1.5.

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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 BOP 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

Safety-related NSSS piping and equipment located within the containment, reactor enclosure, and control structure are subjected to hydrodynamic loads due to SRV and LOCA discharge effects principally originating in the suppression pool of the containment structure. The NSSS piping and equipment 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 5.7-1.

The structural system responses for the SRV and LOCA suppression pool hydrodynamic phenomena are generated by Bechtel Power Corporation using defined forcing functions. These structural system responses are transmitted to General Electric in the form of (1) broadened response spectra and (2) acceleration time-histories at the pedestal to diaphragm floor intersection and at the stabilizer elevation.

The response spectra for piping attachment points on the reactor pressure vessel, shield wall and pedestal complex (above the pool area) are generated by General Electric, based on the acceleration time-histories supplied by Bechtel Power Corporation, using a detailed lumped mass beam model for the reactor pressure vessel internals, including a representation of the structure. For the assessment of the NSSS primary piping (main steam and recirculation), a combination of General Electric and Bechtel developed response spectra are used as input responses for all attachment points of each piping system. For the assessment of the NSSS floor mounted equipment, except the reactor pressure vessel, the broadened response spectra supplied directly by Bechtel are used.

The acceleration time-histories and the detailed reactor pressure vessel and structure lumped mass beam model are used to generate the forces and moments acting on the reactor pressure vessel supports and internal components. These forces and moments are used for the GE assessment of reactor pressure vessel supports and internals.

The structural system response to the LOCA-induced annulus pressurization transient asymmetric pressure buildup in the annular region between the biological shield wall and reactor pressure vessel is based on pressure time-histories supplied by Bechtel. These pressure time-histories are combined with jet reaction, jet impingement, and pipe whip restraint loads for the assessment. A time-history analysis is performed resulting in accelerations, forces and moment time- histories as well as response spectra at the piping attachment points on the reactor pressure vessel, shield wall, pedestal, pressure vessel supports, and external components.

7.1.6.1 NSSS QUALIFICATION METHODS

7.1.6.1.1 NSSS Piping

The NSSS piping stress analyses are conducted to consider the secondary dynamic responses from: (1) the original design-basis loads including seismic vibratory motions, (2) the structural system feedback loads from the suppression pool hydrodynamic events, and (3) the structural system loads from the LOCA-induced annulus pressurization from postulated feedwater and recirculation pipe breaks.

Lumped mass models are developed by General Electric for the NSSS primary piping systems, main steam, and recirculation. These lumped mass models include the snubbers, hangers, and pipe mounted valves and represent the major BOP branch piping connected to the main steam and recirculation systems. Amplified response spectra for all attachment points within the piping system are applied; i.e., distinct acceleration excitations are specified at each piping support and anchor point. The detailed models are analyzed independently to determine the piping system resulting loads (shear and moments) for:

a. Each design-basis load which includes pressure, temperature, weight, seismic events, etc

b. Bounding suppression pool hydrodynamic event

c. Annulus pressurization dynamic effects on the unbroken piping system.

In addition, the end reaction forces and/or accelerations for the pipe mounted/connected equipment (valves and nozzles) are simultaneously calculated.

The piping stresses from the resulting loads (shears and moments) for each load event are determined and combined in accordance with the load combinations given in Table 5.7-1. These stresses are calculated at geometrical discontinuities and compared to ASME code allowable determined stresses (ASME Section III-NB-3650) for the appropriate loading condition to ensure design adequacy. Fatigue usage is calculated for the range of stress between all operating and upset events and summed to ensure that the fatigue usage factor is less than one.

7.1.6.1.2 Valves

The reaction forces and/or accelerations acting on the pipe mounted equipment when combined in accordance with the required load combinations are compared to the valve allowables to assure design adequacy. The reactor coolant pressure boundary (RCPB) valves are qualified for operability during seismic and hydrodynamic loading events by both analysis and test.

7.1.6.1.3 Reactor Pressure Vessel, Supports, and Internal Components

The bounding load combinations for seismic, hydrodynamic, and annulus pressurization forces are established within each service condition category (upset, emergency, and faulted).

The loads for these bounding load combinations are compared to the design basis loads originally used to establish the component design. When the calculated bounding loads are less than the design basis loads, the component design is deemed adequate. When the calculated loads are greater than the design basis loads, the new stresses are calculated and are compared to the code allowable stresses. When the calculated stresses are below the code allowable stresses, the design is deemed adequate. If the increased stresses are above the code allowable stresses, the specific load combination is identified and a more refined stress analysis is performed, if possible, to demonstrate the component design adequacy.

In certain cases, component test results are combined with analyses to assess component adequacy. Fatigue evaluations of

the reactor pressure vessel, supports, and internal components are also conducted for SRV cyclic duty loads. The equipment is analyzed for fatigue usage due to SRV load cycles based on the loading during the SRV events. SRV fatigue usage factors are calculated and combined with all other upset condition usage factors to obtain a cumulative fatigue usage factor.

7.1.6.1.4 Floor Mounted Equipment

7.1.6.1.4.1 Qualification Methods

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

a. Dynamic analysis

b. Testing

c. Combination of testing and analysis

The choice depends on function, type, size, shape, and complexity of the equipment and the reliability of the qualification method.

In general, the requirements outlined in IEEE-344-1975 are followed for the qualification of equipment.

7.1.6.1.4.1.1 Dynamic Analysis

7.1.6.1.4.1.1.1 Methods and Procedures

The dyanamic 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 - comprises equipment that can be adequately represented by frame-type structures consisting of members physically similar to beams and columns.

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

1. Greater than 33 Hz for the consideration of seismic loads

2. Greater than the zero period acceleration (ZPA) frequency of the suppression pool hydrodynamic load required response spectra (RRS).

c. Structurally complex equipment - Comprises equipment that cannot be classified as structurally simple or structurally rigid.

The appropriate response spectra for specific equipment are obtained from the response spectra for the floor 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 selected from the appropriate response spectrum. The acceleration selected corresponds to the equipment natural frequency, if the equipment natural frequency is known. If the equipment natural frequency is not known, the acceleration selected corresponds to the maximum value of the response spectra, which is multiplied by a static coefficient of 1.5 to take into account the effects of both multifrequency excitation and multimode response.

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. The hydrodynamic loading consists of a static load corresponding to the equipment weight times the acceleration at the ZPA, selected from the appropriate response spectrum.

The analysis of structurally complex equipment uses an idealized mathematical model which predicts the dynamic properties of the equipment. A dynamic analysis is performed using any standard analysis procedure. An acceptable alternative method of analysis is by static coefficient analysis for verifying structural integrity of frame type structures 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. This response is multiplied by a static

coefficient to take into account the effects of both multifrequency excitation and multimode response. The static coefficient used for structurally complex equivalent is justified and is consistent with Regulatory Guide 1.100 guidelines.

7.1.6.1.4.1.2 Testing

Dynamic adequacy for some equipment is established by providing dynamic test data instead of performing dynamic analysis. Such data must conform to one of the following:

a. Performance data of equipment that has been subjected to equal of 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.

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.

7.1.6.1.4.1.3 Combined Analysis and Testing

This method has not been used in the NSSS piping and safety-related equipment adequacy evaluations.

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.

7.1-2 Wilson, E. L, "A Computer Program for the Dynamic Stress Analysis of Underground Structures," USAEWES, Control Report 1-175, January 1968.

7.1-3 Desai and Abel, "Introduction to the Finite Element Method," Van Nostroid Reinold Co., 1972

7.1-4 "Technical Bases for the Use of SRSS Method for Combining Dynamic Loads for Mark II Plants," NEDE-24010-P, General Electric Co, July 1977.

7.1-5 Caldwell, M.K. and Whittle, J.J. "In-Plant Test Report for Adjacent Structure Response to Hydrodynamic (Mark II) Loads", Philadelphia Electric Company - Limerick Generating Station, July 28, 1982.

7.1-6 Davis, W. M., "MK II Main Vent Lateral Loads Summary Report," NEDE-23806-P, General Electric Co., October 1978.

7.1-7 T. E. Johnson, et al., "Containment Building Liner Plate Design Report," BC-TOP-1, Bechtel Corporation, San Francisco, December 1972.

7.1-8 "Seismic Analysis of Piping Systems," BP-TOP-1, Revision 2, Bechtel Power Corporation, San Francisco, January 1975.

7.1-9 IEEE Standard 344-1975, "Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations."

7.1-10 American Institute of Steel Construction, Manual of Steel Construction, 7th Edition, 1970.

7.1-11 "Cable Tray and Conduit Raceway Seismic Test Program-Release 4", Test Report #1053-21.1-4, Volumes 1 and 2, ANCo Engineers, Inc., December 15, 1978.

7.1-12 "Development of Analysis and Design Techniques from Dynamic Testing of Electrical Raceway Support Systems", Technical Report, Bechtel Power Corporation, July 1979.

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

7.2.1.9.1 Refueling Head And Flange

The refueling head and flange were found to have no stresses exceeding the specified allowable limits.

The leaktightness of the flanged joint is investigated for the combined effect of temperature, pressure, seismic, SRV, LOCA and jet forces. Vertical separation at the flange faces is prevented by providing sufficient bolt preload to offset uplift due to the applied loads. Similarly, relative horizontal movement between the flange faces is prevented by the bolt preload induced frictional forces. A preload of 157K per bolt is required to maintain leaktightness at the flange joints.

7.2.1.9.2 Suppression Chamber Access Hatch, CRD Removal Hatch, and Equipment Hatch

For these components, CBI's analysis indicated that there are no stresses in excess of the specified allowable limits when considering the additional hydrodynamic loading.

7.2.1.9.3 Equipment Hatch-Personnel Airlock

The equipment hatch with personnel airlock has been assessed for hydrodynamic and seismic loads. Modifications to some cap screws of the attachment brackets are required to accommodate the additional hydrodynamic loading. The equipment hatch with personnel airlock and all related components are within the specified allowable limits.

7.2.1.10 <u>BOP Piping and MSRV Systems Margins</u>

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.

7.2.1.12 NSSS Margins

NSSS piping and safety-related equipment have been assessed for hydrodynamic and seismic loads. Detailed results of the evaluation will be given in FSAR Sections 3.9 and 3.10. In addition, General Electric Co. has prepared Seismic Qualification Review Team (SQRT) summary forms, NSSS Loads Adequacy Evaluation (NLAE) Program Summary reports, and design stress reports to document the assessment of seismic and hydrodynamic loads on NSSS piping and safety-related equipment. These forms and reports will be available for NRC review.

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 220.22 (DAR Sections 7.1 and 7.2)

The following concerns are related to your responses in relation to questions 220.17 and 220.19.

a) In response to question 220.17 you indicated the DAR sections where stress margins for various structures or structural components can be found. A review of the values provided indicates in some of the cases there is little margin left. In your response to question 220.20, it is observed that some incorrect pressure values have been used in the investigation of liner fatigue. In view of this latter observation provide your assurance that the actual stress does not extend beyond the margin in those cases where there is barely any margin.

b) In response to question 220.19 you indicated that damping values greater than 7% of critical are used. In Section 7.1.8.1 it is stated that in the analysis and design of electrical raceway system, different damping values are used for different support systems and different loading conditions. In addition it is stated that the damping ratios used for the electrical raceway assessment are in accordance with Reference 7.1-12. Provide the justification for using different damping values for different support systems and for different loading conditions and state clearly what damping values are used for electrical raceway assessment. The use of damping values greater than those specified in Regulatory Guide 1.61 should be justified.

RESPONSE

a) All load bearing structures, systems, and components were assessed for the Mark II hydrodynamic loads using dynamic time history analysis methods, as discussed in Section 7.1. The input pool-structure interface pressure time history traces, used for the above analysis, include appropriate amplitude and frequency modifiers.

For the assessment of the containment liner plate, which is backed by concrete and is nonload bearing, the peak negative SRV pressure is obtained from the digitized pressure time history used as input for the dynamic analysis described above. This digitized SRV pressure included a 1.5 pressure multiplier, as discussed in Section 4.1.4.1. An additional multiplier of 1.5 was inadvertently applied to this digitized SRV pressure and resulted in the incorrect pressure values originally used for the liner plate assessment.

Because load bearing and nonload bearing items (structures, systems, and components) are assessed independently of each other, there was no carryover of the liner plate assessment error to the other items. In addition, an independent third party review of the technical basis used for the Mark II hydrodynamic load assessment has provided assurance of the adequacy of the design assessment presented in the DAR.

b) For the normal load condition, involving SRV discharge loading, a damping value equal to 3% of critical is used for all raceway systems. The SRV load is considered similar to an operating basis earthquake (OBE) load; therefore, a 3% damping value is considered conservative because 4% damping is recommended by Regulatory Guide 1.61 for bolted steel structures for the OBE loading.

For the abnormal/extreme load condition, the following damping values are used: 10% of critical for cable tray support system design; 7% damping for conduit and wireway gutter trapeze type support systems; and 5% damping for conduit and wireway gutter non-trapeze type support systems. These damping values are based on the results of the Cable Tray and and Conduit Raceway Seismic Test Program (Ref. 7.1-11).

The cable tray system damping is substantially greater than that of bolted steel structures due to the cable motion within the trays. The test program demonstrated that cable tray system damping is, in general, much higher than 10%, and damping values up to 50% were reported. The damping values recommended in Reference 7.1-12 and shown in Figure 220.22-1, are based on the lower bound values developed from the test program. An unloaded tray will have an associated lower bound damping value of about 7% as shown in Figure 220.22-1.

Analysis using 10% damping for a fully loaded tray system under the abnormal/extreme load conditions is conservative and will envelop an analysis of an unloaded tray with a 7% damping ratio for the following reason:

> The frequency shift resulting from reduced mass in a relatively unloaded tray may result in either higher or lower response, depending on the individual response spectrum. However, when the combined effects of frequency shift, reduced damping, and lower weights are considered, the result will be a more conservative

design. For example, consider the comparison of accelerations, weights, and resulting seismic forces for fully loaded and unloaded trays shown in Table 220.22-1. A fully loaded tray typically weighs approximately eight times more than an empty tray. The maximum acceleration for the unloaded tray case (at 7% damping) is four times that for the fully loaded tray case (at 10% damping) assuming that frequency shift, due to the reduced mass of the unloaded tray, results in the maximum increase in acceleration. In calculating the resulting seismic forces for both cases, it is apparent that the loaded tray case yields the higher seismic load.

In addition, based on a random sampling of cable tray supports and conservatively assuming a fully loaded tray and peak acceleration, approximately 75% of the sampled members have a stress margin of 30% or more. The remaining 25% of the members are within allowable stress limits.

Limerick cable tray systems are similar to those tested in Reference 7.1-12, i.e., the trays are of the same material and of similar construction, and the hangers and installation are similar in construction and design. Therefore, the dynamic behavior of Limerick tray systems will parallel the dynamic behavior of the tested tray systems.

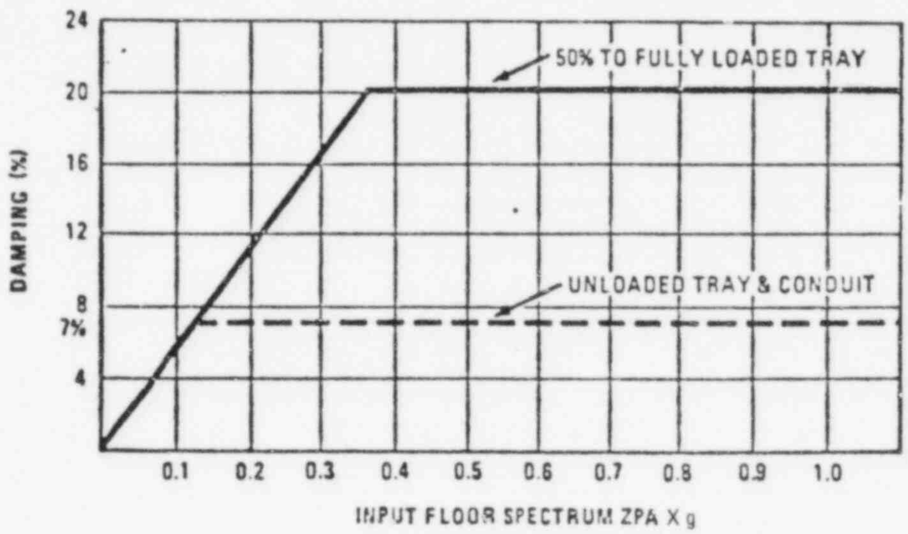
For conduit systems, the test program demonstrates that, at the abnormal/extreme load condition, the damping value equals 7% of critical. This damping value is consistent with Regulatory Guide 1.61 recommended values for bolted steel structures. Therefore, 7% damping is used for conduit with trapeze-type support systems, and a more conservative 5% damping is used for conduit with nontrapeze-type support systems.

Wireway gutters were not tested; however, the manner in which they are constructed (with more bolted connections and more cables than conduit) provides more damping mechanisms than those present in conduit systems. Therefore, it is conservative to use the conduit system damping value.

TABLE 220.22-1

EXAMPLE COMPARISON OF SEISMIC FORCES ACTING ON FULLY LOADED AND EMPTY CABLE TRAYS

	Fully Loaded Tray (10% Damping)	Empty Tray (7% Damping)
Acceleration	a	4a
Weight	8w	w
Seismic Force (= Acceleration X Weight)	8aw	4aw



(SOURCE: DAR REF. 7.1-12)

LIMERICK GENERATING STATION
UNITS 1 AND 2
DESIGN ASSESSMENT REPORT

ALLOWABLE DAMPING VALUES FOR ELECTRICAL RACEWAY SYSTEM DESIGN

FIGURE 220.22-1 REV. 5, 08/83

APPENDIX F

BOP PIPING DESIGN ASSESSMENT

TABLE OF CONTENTS

Piping System	I.C./(2) O.C.	Maximu Normal Upset
Reactor Water Cleanup	I.C.	10073
	O.C	10904
	O.C	9712
Residual Heat Removal	I.C	11698
	O.C.	12074
	O.C.	17123
Core Spray	I.C.	11246
	O.C.	12200
	O.C.	15041
Fuel Pool Cooling and Cleanup	I.C.	6019
	I.C.	13505
	O.C.	6577
High Pressure Coolant Injection	I.C.	11438
	O.C.	14646

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(1) Design Margin = 1 - $\frac{\text{Max. Stress}}{\text{Allowable Stress}}$

(2) I.C. = Inside Containment
O.C. = Outside Containment

PRC APERTURE CARD

TABLE F.1-2

SUMMARY OF BOP PIPING STRESSES

Stress Ratio(1) = Maximum Stress / Allowable Stress

m Calculated Stress (PSI)						
/ Emergency	Faulted	Normal/ Upset	Emergency	Faulted	Reference Stress Calculation
23054	27081	.615	.938	.826	1-10-11B Rev. 2
15121	20698	.571	.528	.542	P1-37-52 Rev. 3
9712	9712	.509	.339	.255	R1-37-53 Rev. 0
11323	16282	.697	.450	.485	1-10-05 Rev. 3
19597	23241	.671	.726	.646	1-10-65B Rev. 1
17413	19928	.951	.645	.554	P1-10-75 Rev. 2
10190	14942	.670	.405	.397	1-20-02 Rev. 4
13343	14573	.678	.494	.405	P1-20-54 Rev. 3
17070	17415	.836	.632	.484	P1-20-56 Rev. 1
5046	16996	.334	.187	.472	1-33-01 Rev. 3
8298	21389	.750	.307	.594	1-33-02 Rev. 5
7015	10232	.299	.213	.233	1-33-62 Rev. 1
11052	17089	.635	.409	.479	1-01-03 Rev. 4
16928	20304	.814	.627	.564	P1-10-72 Rev. 1

Also Available On Aperture Card

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