LIMERICK GENERATING STATION UNITS 1 & 2

DESIGN ASSESSMENT REPORT

REVISION 8 PAGE CHANGES

The attached pages and tables 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 have been inserted, place the page that follows these instructions in the front of Volume 1.

REMOVE	INSERT
VOLUME 1	
Table 1.3-2 (pg 11)	Table 1.3-2 (pg 11)
Page 2-i	Page 2-i
Pages 2.2-3 & -4	Pages 2.2-3 & -4
Pages 4.2-15 thru -18	Pages 4.2-15 thru -18
Table 4.2-10	Table 4.2-10
Pages 7.1-23 & -24	Pages 7.1-23 & -24
Pages 7.2-5 thru -7	Pages 7.2-5 thru -7
Page 640.29-1	Page 640.29-1

THIS DAR SET HAS BEEN UPDATED TO INCLUDE REVISIONS THROUGH 8 **DATED** 4/84.

TABLE

Load or Phenomenon	NRC
8. Seismic Slosh Load	Meth ing seis eval basi
V. Confirmatory In-plant Tests of SRV Discharge	
A. SRV Load Specification	In t cann sati of t crit NURE conf to d of t indi if p guid
B. Pool Temperature Specification (Thermal Mixing)	The reli test conf spec 8 of appl to p just foll in S

Acceptance Criteria	Criteria Source	LGS Position
odology for establish- loads resulting from mic slosh to be uated on a plant unique s.	NUREG-0487	Load is negligible when compared to design basis loads (Section 4.2.3.7)
he event that an applicant ot demonstrate, to the staff's sfaction, equivalence in any he areas cited in acceptance eria A.1.1 through A.1.7 of G-0802, Appendix A, in-plant irmatory testing may be employed emonstrate the applicability he acceptance criteria for vidual plants. Such testing, roposed, should conform to the elines set down in NUREG-0763.	NUREG-0802, Appendix A	Acceptable. No in-plant test is required. DAR Section 4.1.1.1 demonstrates the acceptability of using the SSES SRV load specification for LGS.
acceptability of the safety ef valve in-plant confirmatory program shall be based on ormance with the guidelines ified in Sections 6, 7, and NUREG-0763. If the icant/licensee elects not erform the SRV in-plant tests, ification should be provided owing the guidelines specified ection 4 of NUREG-0763.	NUREG-0763	Acceptable. The LGS pool thermal mixing capability has been adequately demonstrated by in-plant testing at LaSalle and analysis (Appendix I, Sections I.1.2 and I.3).

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CHAPTER 2

SUMMARY

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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 are 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) design criteria and adequacy assessment, analysis of suppression pool temperature response to SRV discharge, and analysis of the suppression pool local-to-bulk temperature difference (ΔT) are presented in Appendix I.

2.2.9 WETWELL-TO-DRYWELL VACUUM BREAKER AND DOWNCOMER CAPPING ASSESSMENT SUMMARY

The assessment of the wetwell-to-drywell vacuum breakers to adequately withstand the dynamic effects of poolswell and chugging is summarized in Appendix J. The design assessment of the downcomer capping arrangement is also summarized in Appendix J.

the structural loading conditions in the containment because they are the basis for other containment hydrodynamic phenomena. The response must be determined for a range of parameters such as break size, reactor pressure, and containment initial conditions.

4.2.4.1 Design Basis Accident (DBA) Transients

The DBA LOCA for LGS is conservatively estimated to be a 3.538 ft^2 break of the recirculation line. This transient results in the maximum drywell pressure and therefore governs the LOCA hydrodynamic loads. The LGS-unique assumptions and input for the analysis are given in FSAR Section 6.2.1. Drywell and wetwell pressure and temperature reponses are shown in Figures 4.2-11 and 4.2-12. This description of the transient does not include the effect of reactor subcooling.

4.2.4.2 Intermediate Break Accident (IBA) Transients

The worst-case intermediate break for LGS is a 0.1 ft^2 break of a liquid line. The drywell and wetwell pressure and temperature responses are shown in Figures 4.2-13 and 4.2-14. This description of the transient does not include the effect of reactor subcooling.

4.2.4.3 Small Break Accident (SBA) Transients

Plant-unique SBA data for LGS is not available. The wetwell and drywell pressure and temperature transients for a typical Mark II containment are used to estimate the LGS containment response to these accidents. These curves are shown in Figure 4.2-15 (extracted from Reference 4.2-6).

4.2.5 LOCA LOADING HISTORIES FOR LGS CONTAINMENT COMPONENTS

The various components directly affected by LOCA loads are shown schematically in Figure 4.2-16. These components may in turn load other components as they respond to the LOCA loads. For example, lateral loads on the downcomer vents produce minor reaction loads in the drywell floor from which the downcomers are supported. The reaction load in the drywell floor is an indirect load resulting from the LOCA and is defined by the appropriate structural model of the downcomer/drywell floor system. Only the direct loading situations are described in detail here.
Table 4.2-11 is a LOCA load chart for LGS. This chart shows

which LOCA loads directly affect the various structures. Details of the loading time histories are discussed below.

4.2.5.1 LOCA Loads on the Containment Wall and Pedestal

Figure 4.2-17 shows the LOCA loading history for the LGS containment wall and the RPV pedestal. The wetwell pressure loads apply to the unwetted elevations in the wetwell; addition of the appropriate hydrostatic pressure is made for loads on the wetted elevations. Condensation oscillation and chugging loads are applied to the wetted elevations in the wetwell only. The poolswell air bubble load applies to the wetwell boundaries as shown in Figures 4.2-8 and 4.2-9.

4.2.5.2 LOCA Loads on the Basemat and Liner Plate

Figure 4.2-18 shows the LOCA loading history for the LGS basemat and liner plate. Wetwell pressures are applied to the wetted and unwetted portions of the liner plate as discussed in Section 4.2.5.1. The downcomer water jet impacts the basemat liner plate as does the poolswell air bubble load. Chugging and condensation oscillation loads are applied to the wetted portion of the liner plate.

4.2.5.3 LOCA Loads on the Drywell and Drywell Floor

Figure 4.2-19 shows the LOCA loading history for the LGS drywell and drywell floor. The drywell floor undergoes a vertically applied, continuously varying differential pressure, the upward component of which is especially prominent during poolswell when the wetwell airspace is highly compressed.

4.2.5.4 LOCA Loads on the Columns

Figure 4.2-20 shows the LOCA loading history for the LGS columns. Poolswell drag and fallback loads are minor because the column surface is oriented parallel to the poolswell and fallback velocities. The poolswell air bubble, condensation oscillations, and chugging will provide loads on the submerged (wetted) portion of the columns.

4.2.5.5 LOCA Loads on the Downcomers

Figure 4.2-21 shows the LOCA loading history for the LGS downcomers. The downcomer clearing load is a lateral load applied at the downcomer exit (in the same manner as the chugging lateral load) plus a vertical thrust load. Poolswell drag and fallback loads are minor because the downcomer surfaces are oriented parallel to the poolswell and fallback velocities. The poolswell air bubble load is applied to the submerged portion of the downcomer as are the chugging and condensation oscillation loads.

4.2.5.6 LOCA Loads on the Downcomer Bracing

Figure 4.2-22 shows the LOCA loading history for the LGS downcomer bracing system. This system is not subject to impact loads because it is submerged at elevation 203 feet, 5 inches. As a submerged structure, it is subject to poolswell drag, fallback, and air bubble loads. Condensation oscillations and chugging at the vent exit will also load the bracing system both through downcomer reaction (indirect load) and directly through the hydrodynamic loading in the suppression pool.

4.2.5.7 LOCA Loads on Wetwell Piping

Figure 4.2-23 shows the LOCA loading history for piping in the LGS wetwell. Because the wetwell piping occurs at a variety of elevations in the LGS wetwell, sections may be completely submerged, partially submerged, or initially uncovered. Piping may occur parallel to poolswell and fallback velocities, as with the main steam safety relief piping. For these reasons, there are a number of potential loading situations that arise, as shown in Table 4.2-12. In addition, the poolswell air bubble load applies to the submerged portion of the wetwell piping as do the condensation oscillation and chugging loads.

4.2.7 REFERENCES

4.2-1 A.J. James, "The General Electric Pressure Suppression Containment Analytical Model", General Electric Co, July 1971.

4.2-2 Ernst, "Mark II Pressure Suppression Containment Systems: An Analytical Model of the Pool Swell Phenomenon", NEDE 21544-P, December 1976.

4.2-3 Letter MFN-080-79, L.J. Sobon (General Electric Co.) to J.F. Stolz (NRC), Subject: Vent Clearing Pool Boundary Loads for Mark II Plants, March 20, 1979.

4.2-4 F.J. Moody, "Analytical Model for Liquid Jet Properties for Predicting Forces on Rigid Submerged Structures," NEDE-21472, General Electric Co., September 1977.

4.2-5 R. J. Ernst, et al, "Mark II Pressure Suppression Containment Systems: Loads on Submerged Structures - An Application Memorandum," NEDE-21730, General Electric Co., September 1977.

4.2-6 "Dynamic Forcing Function Information Report (DFFR)," Rev. 3, NEDO-21061, General Electric Co. and Sargent and Lundy Engineers, June 1978.

4.2-7 "Generic Condensation Oscillation Load Definition Report," NEDE-24288-P, General Electric Co., November 1980.

4.2-8 "Mark II Improved Chugging Methodology," General Electric Co., NEDE-24822-P, May 1980.

4.2-9 "4T Condensation Oscillation Test Program Final Test Report," NEDE-24811-P, General Electric Co. May 1980.

4.2-10 "Generic Chugging Load Definition," NEDE-24302-P, General Electric Co., April 1981.

4.2-11 R.L. Kian and B.J. Grossi, "Dynamic Modeling of a Mark II Pressure Suppression System," EPRI NP-441, Palo Alto, April 1977.

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	41.0
Bracer	0.8	10.2
Core spray discharge line	0.22	6.6
HPCI discharge line	22.0	22.0
RHR discharge line	2.2	16.0
Column	51.6	190.0

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

BOP piping and SRV systems were 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. Hydrodynamic load considerations are provided in Section 5.6. 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.

7.2.1.6 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 5.9-1 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 5.10-1 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 are given in FSAR Sections 3.9 and 3.10. In addition, General Electric Co. has prepared Seismic Qualification Reevaluation (SQR) Program 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 640.29

Provide a test description for any Confirmatory Inplant Tests of Safety-Relief Valve Discharges to be performed in compliance with NUREG-0763.

RESPONSE

NUREG-0763 provides guidelines to determine if in-plant tests are required on the basis of plant-unique parameters in order to confirm generically established specifications for SRV loads and maximum suppression pool temperature.

Limerick Specification for SRV Loads

Confirmatory in-plant tests of SRV discharges to verify the adequacy of the Limerick SRV hydrodynamic load specification are not required. Limerick uses the generic Mark II T-Quencher load specification developed by Kraftwerk Union (KWU) for Susquehanna (SSES) due to similarities in key operating parameters between SSES and LGS (DAR Table 4.1-1 and Section 4.1.1.1). To verify this load specification and to further verify the quencher's steam condensing characteristics, full-scale single cell tests were conducted at the KWU laboratories in Karlstein, West Germany. The generic load specification used for Limerick is described in DAR Section 4.1, while the Mark II T-Quencher verification test is described in DAR Chapter 8.

The acceptability of the Limerick SRV load specification conforms with NUREG-0763 and NUREG-0802 acceptance criteria. General NRC acceptance criteria are provided in Section 4 of NUREG-0763, while specific acceptance criteria for plants using the SSES SRV load specification are provided in Appendix A of NUREG-0802. These specific criteria have been addressed in DAR Section 4.1.1.1 and demonstrate the acceptability of using the SSES SRV hydrodynamic load specification for Limerick.

Limerick Specification for Suppression Pool Temperature

The Limerick suppression pool thermal mixing capability has been adequately assessed through in-plant testing at LaSalle and analysis in conformance with NUREG-0763. DAR Appendix I, Sections I.1.2 and I.3 have been added to provide the suppression pool thermal mixing capability assessment.

DAR Table 1.3-2, Parts II.D and V, have been added to clarify our position on NUREG-0763 guidelines for in-plant tests of SRV discharges and NUREG-0802 SRV load acceptance criteria.