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March 31, 1983

Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U. S. Nuclear Regulatory Commission

Docket Nos. 50-352
50-353

Subject: Limerick Generating Station (LGS)-Units 1 & 2
Qualification of Safety Related Equipment for
Hydrodynamic Loads

References: (1) Letter from A. Schwencer to E. G. Bauer, Jr., dated August 12, 1982

(2) NEDO-24010, "Technical Bases for the Use of the SRSS Method for Combining Dynamic Loads for Mark II Plants", July, 1972, Supplement 1 issued October, 1978, Supplement 2 issued December, 1978, and Supplement 3 issued August, 1979

(3) NUREG-0484, Revision 1

(4) NEDO-21061, "Mark II Containment Dynamic Forcing Functions Report", Rev. 4, issued November, 1981

Dear Mr. Schwencer:

We are pleased to provide our response to concerns expressed by the NRC staff in Enclosure 1 to the reference (1) letter.

The Limerick dynamic qualification program ensures that safety related equipment are qualified appropriately for applicable combinations of seismic and hydrodynamic loads. Dynamic qualification criteria, methodology, and program description are provided in the LGS DAR. Dynamic testing and analysis are addressed in the LGS FSAR.

The program has been assessed as being fully responsive to each of the referenced concerns identified by the NRC staff. The LGS DAR and FSAR are being appropriately revised to reflect the results of this assessment. The applicable revisions will be completed by the Fourth Quarter of 1983.

The following specific responses summarize the Limerick program with regard to your concerns:

<u>NRC Item (a)</u> A description of the method used to account for the uncertainty in the frequency and amplitude in the hydrodynamic load spectra.

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Response: To account for uncertainties in the dynamic model (frequencies), the peaks of the hydrodynamic load spectra are broadened by ±15%. Other regions of the spectra are appropriately increased to achieve a relatively smooth curve. This method is consistent with the Regulatory Guide 1.122 for seismic loading, although this regulatory guide was not the design basis requirement for Limerick.

Hydrodynamic load amplitudes were conservatively developed through the use of methods which account for any uncertainties in amplitude. The methods used to define the loads are identified in ref. 4.

NRC Item (b) A discussion of what loads are being combined and the basis for combining the input spectra.

Response: A discussion and definition of seismic, LOCA, SRV, and AP loads and their load combinations and acceptance criteria are described below.

1) Dynamic Load Definition

Dynamic forcing functions considered for Limerick dynamic loads evaluation are defined below:

a) Seismic-Induced Loads (Primary and Secondary)
The operating basis earthquake (OBE) and the safe shutdown earthquake (SSE) induce dynamic loads (primary and secondary) on structures and equipment.

The design basis horizontal ground motions are 0.075g (OBE) and 0.15g (SSE). The design basis vertical ground motions are two-thirds of the horizontal values. Structural responses to seismic loads are evaluated through the use of state-of-the-art technology (e.g. finite element, continuum modeling of soil, or compliance spring).

b) Loss-of-Coolant Accident (LOCA) Loads
The various low-probability LOCA conditions postulated to occur are small-break accident (SBA), intermediate-break accident (IBA) and design/basis LOCA (DBA). The various loads considered with these accident conditions are as follows:

Main Vent Clearing (MVC)
Main vent air clearing loads are induced during IBA and DBA by purging drywell air through the main vent and into the suppression pool. The suppression pool boundary pressures may cause dynamic excitations of the structure and the contained equipment.

Pool Swell (PS)

Pool swell loads are induced during DBA by the continued injection of drywell air into the suppression pool during the LOCA and the subsequent expansion of the air bubble which results in the rise of suppression pool surface. Structures above the pool surface may experience loads. In addition to the initial impact loads, these structures may experience drag loads as water flows past them.

Condensation Oscillation (CO)

Condensation oscillation loads are induced during IBA and DBA following vent air clearing and pool swell. There is a period of high steam flow rate through the vent system where the steam is condensed in a region near the vent exit resulting in oscillation. The resulting hydrodynamic pressure oscillations may cause dynamic excitation of the structures and contained equipment.

Main Vent Chugging

Main vent chugging loads are induced during SBA, IBA, and DBA where there is insufficient steam flow to maintain a steady steam jet at the vent exit. A random formation of steam bubbles, which alternately form and collapse at the vent exit, produces hydrodynamic pressure oscillations on the suppression pool boundary. These pressure oscillations may cause dynamic excitations of the structure and the contained equipment.

c) Safety/Relief Valve (SRV)

Safety/relief valve air clearing loads are induced by safety/relief valve actuations which produce a rapid compression of the air mass in the interior of the safety/relief valve discharge pipes. The internal pipe pressure drives the water out of the submerged safety/relief valve discharge device (quencher) and ejects a high-pressure air bubble into the suppression pool below the water surface, causing oscillating pressures on the suppression pool boundary. The oscillating pressures may cause dynamic excitations of the structure and contained equipment.

d) Annulus Pressurization (AP)

Dynamic loads (annulus pressurization, jet reaction, jet impingement, and pipe whip restraint) may be induced on the Limerick equipment and piping by time-varying pressure differentials within the annular subcompartment between the reactor vessel and biological shield wall as a consequence of a postulated pipe rupture at the reactor vessel nozzle safe end to pipe connection (i.e., recirculation, feedwater, etc.).

2) Load combinations and Acceptance Criteria for ASME Code Class 1, 2, and 3 Piping and Equipment are listed below:

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

LOAD DEFINITION LEGEND

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

SRV_{ALL} - The loads induced by actuation of all 14 safety/relief valves which activate within milliseconds of each other (e.g., turbine trip operational transient).

SRV_{ADS} - The loads induced by actuation of the 5 safety/relief valves associated with Automatic Depressurization System which actuate within milliseconds of each other during the postulated small or intermediate size pipe rupture.

LOCA - The loss of coolant accident associated with the postulated pipe rupture of large pipes (e.g., main steam, feedwater, recirculation piping).

$LOCA_1$ - Pool swell drag/fallback loads on piping and components located between the main vent discharge outlet and the suppression pool water upper surface.

$LOCA_2$ - Pool swell impact loads on piping and components located above the suppression pool water upper surface.

$LOCA_3$ - Oscillating pressure induced loads on structures and equipment during condensation oscillations.

$LOCA_4$ - Oscillating pressure induced loads on structures and equipment during chugging.

$LOCA_5$ - Building motion induced loads from main vent air clearing.

$LOCA_6$ - Vertical and horizontal loads on main vent piping from chugging and pool swell.

$LOCA_7$ - Annulus pressurization loads.

SBA - The abnormal transients associated with a Small Break Accident.

IBA - The abnormal transients associated with an Intermediate Break Accident.

* The most limiting case of load combinations among $LOCA_1$ through $LOCA_7$.

** Evaluation basis per NRC requirements.

NRC Item (c) A confirmation that individual spectra were developed by time history analysis, including a clear definition of each dynamic load considered.

Response: All response spectra generated to date for Limerick have been generated from time history analyses. For clear definition of each dynamic load, see response to NRC item (b) above.

NRC Item (d) A description of the approach used to develop enveloped spectra, if such an approach is used to limit the number of tests for equipment qualified by tests, or the number of analyses for equipment qualified by analysis.

Response: Seismic and non-seismic response spectra are combined by SRSS in accordance with Reference 3, and as described in Reference 2, for the load combinations provided in response to NRC item (b) above. For the same equipment located at different locations, the combined response spectra, from each of the different locations, are enveloped for each of the N-S, E-W, and vertical directions. The enveloped spectra are then used as the basis for testing and/or analysis.

NRC Item (e) A description of the method used to account for hydrodynamic load cycles using typical examples.

Response: Equipment designed to ASME Code Class 1 requirements are qualified by analysis. The approach taken in addressing the normal and upset loads is considered to yield a conservative evaluation of fatigue effects since SRV and OBE loads together are considered along with thermal and pressure cycles. This Class 1 analysis method is extended to selected ASME Code Class 2 piping and components (e.g., SRV downcomers, quenchers,...) where required by the NRC.

Furthermore, we have reviewed fatigue effects analyses performed, to date, by other utilities, and have reviewed loads at LGS due to SRV actuations. These reviews indicate that fatigue failures due to normal plant loads, including SRV actuation loads, are not a concern.

However, in order to address the fatigue issue on a plant specific basis, the following actions are being taken:

(1) As discussed in our meeting with your Equipment Qualification Branch on March 4, 1983, we are pursuing extended duration testing of equipment which have yet to be qualified; included are components of the ATWS/SDV (Anticipated Transient Without Scram/Scram Discharge Volume) modifications package.

(2) As a result of the meeting discussions, an analysis will be performed on one piece of equipment each in the Reactor Building and Containment structures to further demonstrate that for LGS fatigue usage factors are less than 1.0.

The above actions will demonstrate that fatigue, due to SRV actuations over the life of the plant, is not a concern.

NRC Item (f) A detailed justification of approach used to qualify equipment with potential for non-linear behavior where full scale testing is not used.

Response: To date, it has not been necessary for us to perform non-linear analyses. For non-linear analysis which may be necessary to account for non-linear material properties or geometry-related non-linearities, the analysis would include a detailed justification for the approach used for the qualification. Alternatively, the testing method of qualification would be used where the effects of non-linearities are to be considered.

We trust that the above responses provide acceptable descriptions as requested. If you have any questions, do not hesitate to call us.

Very truly yours,

John S Kemper

Copy to: See attached Service List.