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Mr. William J. Cahill, Jr.
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River Bend Nuclear Group
Gulf States Utilities
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Beaumont, Texas 77704
ATTN: Mr. J. E. Booker

Dear Mr. Cahill:

Subject: Qualification of Safety Related Equipment for Hydrodynamics Loads

Recent discussions and meetings on BWR plants indicate that the effects of a large number of cycles of dynamic loading due to suppression pool hydrodynamic loading are not being adequately accounted for. When qualification is performed by analysis, it is necessary to demonstrate that, for aging consideration, the accumulated fatigue "damage factor" is less than one. For qualification performed by testing, it is necessary to ensure that the input motion used to test the equipment simulates the expected loading environment including the number of cycles of loading.

Concerns of the Equipment Qualification Branch staff are summarized in Enclosure 1. If you have any questions regarding this matter, please contact R. Perch, NRC Project Manager.

Sincerely,

A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing

Enclosure: As stated

cc: See next page

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nsideration of Suppression Pool Hydro amic Loading In Boiling Water Reactors For Qualification of Safety Related Equipment

Background

Hydrodynamic loads associated with the suppression pool is global in nature, in that it excites the whole reactor building. Such excitation, in turn, subjects the equipment supported within the reactor building to a vibratory motion which is transmitted through the building floors and walls.

Many simplifying assumptions are made in the process of arriving at the hydrodynamic load, for equipment qualification, from the analysis of the reactor building. The reactor building is generally represented by axi-symmetric geometry and the asymmetric nature of the loading is accounted for by Fourier decomposition. It was evident from tests at the Kuosheng reactor that correlation between the test and the prediction was reasonably good for vertical motion, but not so for horizontal motion. The implication is that there is some uncertainty associated with the structural response calculation under the effects of the hydrodynamic load.

The effect of the hydrodynamic load in equipment qualification is considered in terms of a response spectrum plot much the same way that earthquake loading is charactarized. However, there are important differences between the earthquake motion and the hydrodynamic load. In case of earthquakes the effective number of cycles of motion may be several tens, whereas the hydrodynamic load cycles are at least two orders of magnitude higher. The objective here is to ensure that equipment qualification for hydrodynamic loads addresses these concerns adequately.

Uncertainty in Hydrodynamic Loads

The use of axisymmetric model, variations in the properties of the structure and its foundation, inability of analytical models to accurately predict higher natural frequencies of the structure may cause uncertainty in the frequency and amplitude of the response spectrum characterizing the hydrodynamic loading. The method of accounting for the uncertainty in hydrodynamic load amplitude and frequency should be clearly defined and appropriately accounted for.

Input Load For Equipment

The input load for equipment which is either supported by a structure or a mechanical system is the response of the structure or the mechanical system. Equipment loads from the seismic and hydrodynamic effect of the suppression pool are thus responses of the support points and are combined before their use in qualification of equipment. NUREG-0484, Revision 1, "Methodology For Combining Dynamic Responses," studied this issue, and provides generic guidance for combining responses from any two dynamic loads. Provisions of NUREG-0484, Revision 1 are based on the premise that the individual responses are obtained from time history analyses. Results of such time history analyses may then be used to establish individual response spectra

for input to equipment. These individual response spectra should be modified to account for the uncertainty in the frequency and amplitude of the hydrodynamic load spectra and for the uncertainty in the seismic response spectra. The modified response spectra can then be combined using the criteria approved in NUREG-0484, Revision 1.

Hydrodynamic loads induced by various accident and transient conditions vary in their amplitude and frequency content. Various hydrodynamic loads then combine with either the SSE or the OBE. These combined hydrodynamic and seismic input for equipment qualification must be clearly defined and the justification for each combination used should be indicated. If the equipment is to be qualified for only a few enveloped spectra to reduce the number of tests to be performed, the bases for establishing the enveloped spectra should be discussed.

Many equipment, electric and mechanical, behave nonlinearly and testing should be the preferred method of qualification for such equipment. Where equipment susceptible to nonlinear behavior is to be qualified by methods other than full scale testing, a detailed discussion of the acceptability of the proposed approach should be provided.

Effect of Number of Cycles

When input for equipment qualification is defined in terms of response spectra for the combined earthquake and hydrodynamic loading, it is necessary to consider the large number of cycles expected from the hydrodynamic load. If qualification is done by analysis, all stress cycles on critical sections from plant normal, abnormal, and accident conditions including the effect of thermal cycles and hydrodynamic and earthquake load cycles should be considered. If qualification is performed by testing, shake table using random motion is compatible with the required response spectra per IEEE Std. 344-1975 is preferred. Prior to the operating basis and safe shutdown earthquake tesing, shake tests simulating the hydrodynamic load cycles should be performed as a part of the equipment aging process. The approach to be used should be described using typical examples.

Remarks

Sections of the FSAR dealing with qualification of safety related mechanical and electrical equipment for seismic and dynamic loads should be revised to address the subject concerns. Thus the revised FSAR should include the following:

(a) a description of the method used to account for the uncertainty in the frequency and amplitude in the hydrodynamic load spectra,

(b) a discussion of what loads are being combined and the basis for combining the input spectra,

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

(d) a description of the approach used to develope 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,

(e) a description of the method used to account for hydrodynamic load cycles using typical examples,

(f) a detailed justification of approach need to qualify equipment with potential for nonlinear behavior where full scale testing if not used.