STRUCTURAL DYNAMIC ANALYSIS ON THE BWR CONTAINMENT SYSTEM SUBJECT TO POOL DYNAMIC LOADS

H. C. HAN, Y. S. HUANG
Gilbert Associates, Inc., Reading, Pennsylvania 19603, U.S.A.

SUMMARY

Pool dynamic load has been one of the most important considerations among the complex loading combinations in the design of the BWR containment structures since General Electric Company introduced the Mark III containment for its large size boiling water reactor (BWR-6) in 1972. The Mark III containment system employs a suppression pool whose function is to condense any steam released from various reactor system upsets.

This paper describes the phenomena and characteristics of the pool dynamic loads in the event of loss-of-coolant accident (LOCA) and main steam safety relief valve (MSRV) actuation. These accidents initiate expulsion of the highly compressed air into the pool and cause dynamic loads on the containment structures. These pool dynamic loads are a result of a complicated thermal-hydraulic dynamic phenomenon. These loads and their interactions are still being verified. One of the most important phenomena is the air bubble pressure load associated with the MSRV actuation, which is an oscillatory dynamic load having the sequence of repeated expansion and contraction with an identifiable frequency until the bubbles reach the pool surface. Other unique loads associated with the pool swell phenomena are also described, such as jet load, bubble expansion load, impact load, drag load, and pressurization load.

This paper then evaluates the dynamic structural responses of the containment structures subject to the pool dynamic loads described above. Three conceptual arrangements of the interior structure inside the containment to encounter the pool dynamic load are presented in terms of dynamic analysis and engineering design. In the event of LOCA, the significance of structural response is dependent upon the arrangement of the structures. In the case of MSRV actuation, the vertical structural response is found significant and more or less of the same order as seismic induced vertical accelerations. The impact of the MSRV on vertical structural response may not be significant to structural design but is important to the nuclear steam supply system (NSSS) equipment. Typical response spectra at various locations were generated for the NSSS equipment. By superimposing these response spectra curves on those generated from seismic analysis, a final evaluation of the equipment can be made. The effect on these curves due to the variation of soil properties such as shear modulus and damping is also presented. Finally, a few sets of typical response spectrum family curves were generated over a range of soil properties of those sites usually selected for nuclear power plants. These curves are useful in preliminary evaluation of the NSSS equipment and can be extended for use in detail design.