SEISMIC ANALYSIS OF EQUIPMENT IN NUCLEAR POWER PLANTS

C.-W. LIN,

Westinghouse Electric Corporation,
Power Systems, Pittsburgh, Pennsylvania, U.S.A.

In the past, seismic resistant design of equipment has been performed by using static percentage g loading approach. Since what the component truly experienced in an earthquake motion is its reverse effective force which depends on its dynamic characteristics such as the frequencies, the damping ratios and the modal participation factors of the contributing modes, such an analysis tends to underestimate the coupling effect of the members consistent in the component. Hence, it is not necessarily conservative and cannot be used without justification.

For remedy, a dynamic analysis based on a discrete mass mathematical model can be carried out. In particular, when damping ratio can be assumed proportional either to the mass or to the stiffness, the standard normal mode decomposition and the response spectrum curve technique may be used. A sophisticated computer code such as WESTDYN can then be utilized to obtain useful information like the frequencies, mode shapes, absolute and relative displacements, absolute accelerations, internal resisting forces, and the stresses. Confidence level cannot only be determined from the safety margin over the stresses as compared to the code allowable, but also insured by limiting the displacements to be within the operating tolerance.

In this paper, the mathematical modeling techniques are first established and discussed for the safety injection charging pump of a typical four loop nuclear power plant. The mathematical background of the adopted computer code WESTDYN is then introduced followed by the discussion of the response spectrum curve used. Numerical examples are presented for some tanks, valves, and pumps. The important conclusion is that the majority of the equipment is either controlled by their fundamental modes in the response or responding only as rigid bodies. As a result, these conclusions enable one to choose an artificial response spectrum for all the analyses, and the results are readily convertable to other spectral inputs if the artificial response spectrum possesses the following characteristics:

(1) High acceleration values. The curve has a maximum DBE value which is higher than most, if not all, of the existing plant at the equipment support elevation.

(2) Broad band distribution of the peak. The peak of the curve extends from a "rigid" frequency down to existing low frequencies. Due to the filtering effect, the actual response spectrum curve of the supporting structure would have limited sharp peaks. In reality, the time response of a component will not see the peak value unless it falls into resonant range with the structure. However, for a fictitious response spectrum curve as indicated, there is no way for the component to avoid the peak.