POST–EARTHQUAKE EVALUATION OF NUCLEAR PIPING SYSTEMS

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SUMMARY

To date the latest developments in engineering research, related to nuclear power plants, have been to ensure the highest possible level of safety of a plant in the event of a natural disaster. This work has of necessity been in the form of preventative engineering.

The next major step, which fortunately has not yet been required, is in the area of evaluation of structural integrity following a natural disaster such as an earthquake. The Nuclear Regulatory Commission, the owner of a plant, and the public at large will want to know the extent of damage after an earthquake. This post earthquake evaluation forms the basis of this paper.

Two of the most critical components of a nuclear plant are the primary and secondary core cooling piping systems. Although every effort is made to ensure that no significant inelastic deformation occurs in these systems during an earthquake, assurance of this after the fact would be most desirable. Assurance will only come when a knowledge of the stress and strain levels have been ascertained, for a complete piping system. Such information could be obtained if the entire system were extensively instrumented. Such instrumentation would be prohibitively expensive.

An alternative that appears to be feasible is to use recorded data from only a few carefully selected locations in conjunction with mathematical models. With this approach it would be possible to determine shortly after the event the stress and strain levels, and hence the degree of damage, suffered by the piping system during the earthquake.

The process of creating mathematical models from measured data is system identification. In this process, a preliminary mathematical model is formulated and then data recorded during an earthquake are used to systematically adjust some or all of the parameters in the model until the best possible correlation is achieved between the measured and computed response quantities. As a result of this process, the stress and strain levels in the complete system can be determined.

The first step in this process is to evaluate the application of the system identification procedure to a single degree of freedom system. The paper describes an extensive research program that was performed on a simple steel frame. The mathematical model used for the force-deflection relationship of the columns was the Ramberg-Osgood non-linear model. Shaking table tests were performed on the frame and the parameters of the non-linear model were determined. The mathematical model was then used to compare the computed and experimental results and the agreement was very good.

The paper further describes the steps that are currently being taken to extend the system identification procedure to multi-degree of freedom systems and specifically to nuclear piping systems.