A GENERAL PURPOSE COMPUTER PROGRAM FOR ANALYSIS OF NUCLEAR POWER PLANT PIPING SYSTEMS

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SUMMARY

This paper discusses SUPERPIPE, a new general prupose program which performs comprehensive structural analysis of piping systems for deadweight, thermal expansion, seismic time history or spectra and other loading conditions. Analyses are performed to ASME requirements for Class 1, 2 and 3 systems.

The program has various features for user ease in defining the piping system. These include automatic generation of node coordinates and curved segments or elbows, automatic cartesian/polar coordinate transformation (translation/rotation), built-in data (including stress indices) for standard pipe components such as tees, elbows, reducers and valves, and built-in standard material properties and piping schedules. Various plotting capabilities and extensive diagnostic error and warning messages aid in checking the model.

For ease in review of results, the output of SUPERPIPE is arranged in stress report form with special summaries for support loads, break location evaluation, maximum stresses, welded attachments point stresses, flexible connection, displacements, etc.

Recognizing the need for computational efficiency in the analysis of large and complex piping systems, SUPERPIPE uses equation solvers, eigenvalue routines and storage optimizers that represent the state of the art in numerical methods in finite element analysis.

The standard capabilities that are found in most piping analysis programs currently in use in the U.S. Nuclear industry include the ability to perform deadweight, thermal expansion, and seismic response spectrum analysis. In addition to these basic capabilities, SUPERPIPE offers a number of more sophisticated analysis features for specialized piping analysis applications. These include:

(a) analysis with multiple response spectra for piping supported at numerous levels within a building and, therefore, subject to independent loadings (different spectra) at each level;
(b) modal superposition or direct integration techniques of time history analysis for shock loads associated with steamhammer and waterhammer effects in piping systems, and;
(c) analysis with multiple earthquake records for situations in which a piping system is subjected to independent motions at each support, and the effect of phase relationships between these motions is important.

To provide an overview of the capabilities of the program, the paper presents results of a sample analysis for a typical PWR piping system for the conventional deadweight, thermal, seismic loadings and typical ASME design compliance checks. Additional practical analysis cases are presented to illustrate the refinements that may be obtained by using the special program options. Alternative analytical approaches to the analysis of a PWR Pressurizer Relief Line for steamhammer loads are compared. Comparisons are made between an analysis using multiple response spectra versus the more conventional approach of using a single envelope spectrum to illustrate conservatisms involved. Response of a typical piping system subjected to multiple earthquake motions is studied to illustrate the importance of so called "pseudo static" effects in stress evaluations. It is concluded that refined, efficient designs can be achieved through the use of sophisticated automated analytical tools. Such a tool is now available in the form of program SUPERPIPE.