FLOW-INDUCED VIBRATION BENCH TESTING OF REACTOR COMPONENTS

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SUMMARY

The absence of a clear understanding of flow-induced vibration (FIV) mechanisms for the complex flow conditions and structural geometry of each new generation of reactors requires elaborate design verification scale model testing of complete systems. Also, during the design process, bench testing of greatly idealized models are employed to provide an early warning of design features which are highly suspect of being associated with a particular FIV mechanism. Because bench testing often includes severe distortion in scaling, model design and test parameter definition must focus on simulation of the character of the particular FIV mechanism and suspect design feature. General scale modeling guidelines exist, but each bench test is unique. The pertinent design considerations and test results are summarized here for three example bench tests performed in support of the Clinch River Breeder Reactor upper internals design, which is intended to serve as a baseline for future U.S. liquid metal breeder reactors.

For each bench test, the rationale behind the expected existence of a dominant FIV mechanism (fluidelastic excitation, vortex shedding, or turbulent flow excitation) is presented. This includes statements on the state of the art knowledge on each FIV mechanism and the circumstances requiring model testing. Conditions are illustrated for which testing of portions of large structures or isolated small components produce conservative test results. Specific model designs are described to make apparent the geometric detail necessary to simulate flow paths. Also, discussion of the model design includes enumeration of the similitude parameters for each excitation mechanism. This provides a basis for showing how model distortions are circumvented to yield conservative test results, or how the sensitivity of the response to distortions in modeling is determined.

Because of the complexity of the fluid/structure interaction response predictions were not made. But comparison of free vibration predictions with shaker test results demonstrates the large mass and damping effects associated with structures immersed in dense fluids, especially those having small clearance gaps typical of the boundary conditions of components designed to allow for thermal expansion. Finally the data from each test is summarized for comparison to expectations. Reasons for discrepancies are proposed.

In cases where expected FIV mechanisms (e.g., vortex shedding) did not materialize, additional confidence is gained to forego expensive testing of similar designs in the future. Dependence of a fluidelastic mechanism (galloping) on details of the geometry was unexpected. The smaller fluid damping provided by thermal expansions boundary conditions was found to be very pervasive and possibly could be considered as a design feature to avoid FIV. In all, the bench testing described provides guidelines for future FIV investigations of similar reactor designs and directions for design of components.