ELASTIC-PLASTIC RESPONSE OF PWR COOLANT PIPES CONTAINING POSTULATED CIRCUMFERENTIAL FLAWS

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To meet the regulatory requirements on the pipe break accident condition evaluation of Nuclear Power Plants, double-ended fully circumferential breaks are postulated in the primary coolant pipe. There is a growing awareness in the industry that the assumption of full circumferential break is physically impossible and therefore efforts are made to convince the regulatory authorities the need for a more realistic break postulation. The primary objective of this paper is to show that a conservatively assumed initial circumferential flaw in the primary coolant pipe of the W Pressurized Water Reactor System does not become unstable. The specific geometry and loading chosen for this study represents typical plant conditions in the hot leg.

The pipe length was chosen to be 94 inches long and its internal and external diameters were 29 and 34 inches, respectively. The pipe was subjected to the operating pressure of 2250 psi and external axial and moment loadings due to the combined effects of pressure, thermal and safe shut down earthquake loadings. In the absence of probabilistic data associated with the non-detection of a given size flaw, two conservative assumptions were made in the selection of initial flaw. First, the flaw was assumed to be through-wall which will result in a detection probability of unity. Second, the flaw length was assumed to be larger than or equal to one and a half times the wall thickness. This assumption is based on the flaw size used in the ASME Boiler and Pressure Vessel Code, Section 3, Appendix G, Brittle Fracture Evaluation of Reactor Vessels subjected to normal and upset condition loading.

Static elastic-plastic response of the pipe was computed by performing finite element analyses using ADINA, a non-linear incremental computer program developed at Massachusetts Institute of Technology. The values of J integral were computed. The moment-curvature relationship was obtained from finite element results. The local crack stability was examined by comparing J_I versus J_{IC}, as a conservative criteria. Whenever, J_{IC} was exceeded local stability was examined by a more realistic criteria based on tearing Modulus. The global stability was examined by considering the post-elastic slope of the moment-curvature relationship.

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