Reliability Analysis of Welds in Nuclear Power Plant Reactor Vessels

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ABSTRACT

In this report, a methodology has been suggested to calculate the reliability of nuclear power plant weld components using a combination of fracture mechanics, non-destructive evaluation techniques and Monte Carlo simulations. Initial crack size distribution data are as provided by manufacturers/ existing literature. The probability of detection (POD) curve is developed from non-destructive test data. This characteristic POD curve is then used for Bayesian updating of current estimated crack size distribution by incorporating single/multiple measurements from the in-service inspection results. The updated current crack size distribution along with fracture mechanics based crack growth law parameters and loading history is then used for estimating the crack size at the required future instant of time. From available loading time history, the power spectral density is calculated by taking the Fourier transform of the autocorrelation function. The power spectral density is then used to generate multiple loading histories. Each simulated loading history is filtered and converted into simple stress reversals using rain flow counting algorithm. The filtered stress history is used to estimate the future crack size by integrating the randomized Paris Law. Repeated simulation yields crack size distribution at a desired time instant in the future. Reliability of the weld component as a function of time corresponding to a critical crack size is estimated from the time dependent crack size distribution thus obtained.