A PROCEDURE FOR ESTIMATING THE PROBABILITY OF FLAW NONDETECTION

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SUMMARY

In previous efforts to quantify the probability of a nuclear accident due to brittle fracture of the pressure vessel, it is assumed that a flaw of some size is present and the conditional (on the presence of the flaw) probability of failure is calculated. Such a result is incomplete in the sense that the probability of the postulated flaw being present is generally extremely small and that small probability isn't reflected in the estimated conditional probability. To remedy this we must multiply the conditional probability by the probability that flaws of the postulated size exist in the vessel. In this paper we present a mathematical expression for estimating the probability that such flaws remain in the vessel even after the completion of the sequence of inspections, which are carried out during and after fabrication (e.g., ultrasonic, magnetic particle, dye penetrant, etc.).

Specifically we have obtained a mathematical expression for estimating the probability that at least one flaw of length a or greater remains in the pressure vessel after the required sequence of inspections has been completed. This solution involves accounting for i) the number of flaws initially present in the vessel, ii) the sizes of these flaws and iii) the detection capability of each of the inspection procedures in the sequence. In order to be realistic and reflect the variability known to exist, we have treated these three quantities as random variables and have suggested some general forms for their distributions. In addition to providing an estimate of flaw nondetection, the expression obtained can be used to compare various inspection procedures using a sensitivity type analysis. It is also interesting to note that with the present formulation and solution we can handle as a special case, the simpler and more commonly posed problem of estimating the probability of missing a flaw given one of a specified size is present. The expression is general enough to handle any number of inspection steps and can reflect the different sensitivity of each inspection procedure to different types of flaws.

In summary, this work will allow estimates of unconditional probability of brittle fracture to be obtained, by multiplying the estimated probability that flaws of various sizes remain in the vessel even after inspections, by the estimates of the conditional probability of brittle fracture. Also using the mathematical expression provided we can assess the effect including or excluding various inspection procedures will have on the size distributions of undetected flaws. This will provide a quantitative way to evaluate an inspection program.