LMFBR STEAM GENERATOR TUBING DESIGN SELECTION THROUGH FAULT TREE ANALYSIS

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SUMMARY

Reliability could be defined as the probability that an item will perform its assigned function for the time intended under expected conditions of operation. In the quality-conscious market of the present day, and especially in the safety-conscious nuclear power industry, reliability has become a most important parameter associated with any device or system. However, unlike other design parameters such as power, efficiency, strength and others, reliability has not been long used as a decision parameter. No doubt the basic reason for this is the relative unfamiliarity of design engineers with the complex techniques of measuring, predicting, and using reliability.

The theory of reliability can be divided into two broad categories: qualitative analysis and quantitative analysis. In general, the qualitative analysis is already familiar to most designers of safety-related equipment through the use of single failure analysis. In addition, other methods of systematic qualitative analysis, specifically Failure Mode and Effects Analysis and Fault Tree Analysis, can be used to identify strong and weak points of a design, to document the type and safety implications of various failures anticipated, to spot possibilities for common-mode failure of a system, or as is used in this report, as a preliminary step in the overall reliability analysis of the system.

Quantitative reliability methods, which consist in the application of statistics to a structural model, is considerably less familiar to design engineers than qualitative reliability techniques. The terms "reliable" and "unreliable" are used with great abandon and imprecision often without any quantified evidence of the accuracy of such statement.

In this paper, techniques are presented to quantify the parameters "reliability" which would give the design engineer a statistical basis in which to justify the soundness of his design. The problem of how to statistically treat variables for which little data is available, is addressed.

Through the application of quantitative fault tree analysis, the reliabilities of three possible tube designs for application in sodium heated steam generators for application in a Liquid Metal Fast Breeder Reactor plant are investigated and the optimum design identified. The three tubing designs, single walled, double walled, and double walled with leak detection are considered in terms of the probability of the occurrence of a major sodium water reaction. This constitutes a pioneering effort in applying a statistical/probabilistic approach in the selection of a major component for a significant engineering project.

The analysis indicates:

1. The duplex tube without leak detection represents the best design.
2. There exists a high probability that a single wall tube bundle steam generator will experience a major sodium-water reaction during the design life of a LMFBR plant.