OPTIMIZATION AND COMMON CAUSE ANALYSIS
OF A PROTOTYPE LARGE BREEDER REACTOR SAFETY SYSTEM

by

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SUMMARY

The prototype large breeder reactor (PLBR) is a 1000 MWe sodium cooled fast breeder reactor designed to succeed the Clinch Breeder Reactor and verify scaling laws. Several conceptual PLBR designs have been presented for consideration. A procedure is needed for the conceptualization of, evaluation of, and selection between such designs. This paper presents a method that can be effectively used to:

1. allocate optimal component redundancy,
2. evaluate design trade-offs, and
3. help in design finalization.

The procedure is applied to three diverse design options for a shutdown heat removal system (SHRS). The selected configuration is analyzed for potential common cause failures.

The method is an extension of ideas developed by the authors [1]. Briefly, the method consists of the following steps:

1. Construct a fault tree for each basic design option.
2. Identify the optimization variables and associated constraints.
3. Construct the appropriate cost and unavailability functions in terms of the optimization variables.
4. Develop any additional constraints.
5. Generate Monte Carlo cost versus unavailability plots for each basic design option.
6. Determine an approximation to the minimum cost-unavailability functional relationship by identifying the optimization variables that reduce unavailability the greatest with minimum cost increase.
7. Select the candidate configurations for each option using the Monte Carlo plots and the minimum cost-unavailability function approximation.
(8) Select the optimal design configuration from all candidates using engineering judgment, cost effectiveness considerations, etc.

(9) Perform a common cause failure analysis on the selected design.

The above steps were used to determine the optimal configuration from three diverse PLBR SHRS options. Each design option consisted of several million configurations that had to be considered. The optimum, of course, depends upon the assumptions made.

The minimum cost-unavailability relationship for each option is shown in Figure 1. The configuration from Option A with no component redundancy was selected as the optimal design based upon the assumptions made. This design was then analyzed for potential common cause failures using COMCAN II [2].

In this study the assumptions, such as loss of offsite power, no natural circulation in the primary heat transport system, etc., were found to be the strongest contributor to the optimum configuration. If the assumptions were changed, sometimes other design options yielded the optimal configuration. Cost data and failure data also contributed to the optimal configuration.

In conclusion, the authors found that this method is an efficient, inexpensive tool that can be used to assist the designer in making the final selection. The method can be used in component redundancy allocation, in design trade-off studies, in the evaluation of designs, and in the assessment of the sensitivity to assumptions made.
REFERENCES


Fig. 1 Lower bounding curves for the three options.