PREFACE

CRITICALITY ARRAY DATA AND CALCULATIONAL METHODS

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This series of papers reviews criticality array data and the calculational techniques developed to extend the usefulness of these data in formulating rules for handling fissile material in processing and storage facilities. The object of this review is to give a presentation of this information in a way that will be useful to a criticality engineer in solving plant problems. The calculational techniques are explained and compared so that the criticality engineer can select the most applicable technique for a specific job.

Prior to 1960, experimental data were the only reliable source of information on which to base criteria for the handling of fissile materials in process plants, storage areas, and during transportation of nuclear components. The requirement to store quantities of fissile materials within vaults and processing facilities brought about the need for criticality data on arrays of such material.

The purpose of the first paper, "History of Fissile Array Measurements in the United States," is to review the history of these experiments in the U.S. and to supply a collection of usable experimental data. A list of primary references, many of which have not been widely distributed, is also included.

The second paper, "A Review of Criticality Safety Models Used in Evaluating Arrays of Fissile Materials," describes and critically evaluates calculational models and techniques used to extend the usefulness of the existing array criticality data. In most cases, these models were based on a few specific sets of array data and are normalized to these data sets. The density analog method, for instance, was based on a series of early weapon component array measurements in which the array critical mass is plotted versus array density for different array unit sizes or shapes and for different array reflector materials.

Two general classes of models are considered. The first is semi-empirical models in which equations are written that describe the data on either critical or "safe" arrays in terms of some selected set of array parameters. The second is array unit interaction models in which equations describing the neutron exchange between units are written and used to evaluate the array. The historical background plus the development and subsequent evolution of each method is outlined, together with a review of the equations, rules, and assumptions constituting the model. A description of how these methods apply to typical array problems is given. A critical evaluation of each method is given that attempts to point out areas where the models work well and where they do not apply. The method assumptions, together with possible extensions of the several models, are discussed.

The third paper in this series, "The Monte Carlo Method for Array Criticality Calculations," describes the Monte Carlo method for calculating the multiplication factor of arrays of fissile material and discusses some of the difficulties that can arise. The Monte Carlo method is the only means for evaluating arrays without making the several simplifying assumptions necessary in the models described in the second paper. Monte Carlo calculations are presently used in many different ways in criticality safety studies. They are used directly to determine the safety of a particular storage configuration, to generate data on which to base a simplified calculational model, or to check the results of a calculational model. Monte Carlo calculations also have a dual role in regard to critical experiments. Calculations are used in the selection and design of experiments, and later the experimental data provide checkpoints for the validation of the computer codes and cross-section sets.

Many of the calculational models are difficult to use in practice. The final paper in this series, "Comparative Calculational Evaluation of Array Criticality Models," shows the application of the calculational methods described in the second and third papers to actual arrays. Indeed, one of the purposes of the examples is to show the limitations of each method. The examples have been done in the way that a criticality engineer might use them in his every day work. Necessary constants are, where possible, taken from experiments or published data that are readily available. The results of the calculational comparisons and areas where models disagree or are significantly nonconservative are discussed. Lessons learned in the applications of the several methods are mentioned for the purpose of sparing the reader some of these pitfalls.