Calculational Methods for Interacting Arrays of Fissile Materials. By A. F. Thomas and F. Abbey. Pergamon Press (1973). 127 pp. $13.50.

Nuclear criticality safety in a processing plant depends on avoiding the formation of critical configurations of fissile material. Methods are therefore required for determining *a priori* whether particular configurations will be subcritical. Although experimental measurements are often useful, the number of configurations requiring consideration is usually too great for such measurements to be generally practical. Moreover, the sort of abnormal configuration that must be considered in any safety analysis may be difficult to create in a controlled manner. Criticality safety evaluations therefore rely extensively on calculational methods.

An acceptable method need not yield accurate estimates of reactivity provided it errs on the conservative side by predicting values that are too high. Excessive conservatism, however, may prove expensive in terms of operating and storage costs.

Despite the complexity of the problem, reasonable approximations can be made or empirical relationships developed that lead to fairly simple calculational methods with satisfactory accuracy or conservatism. A configuration of fissile material may be regarded as a large complex reactor containing various types of regions, including voids. Its reactivity clearly depends on the average density of fissile material and on the size of local accumulations. This viewpoint has led to the development of the Density Analog and Surface Density methods. Alternatively, the configuration may be regarded as a collection of interacting reactors, each of which would generally be subcritical by a substantial margin with the others absent. The probability of neutrons leaving one unit and entering another must depend in some manner on the average solid angle subtended by the latter at the former, and for each unit there is a critical ratio of neutrons being received to neutrons being emitted which depends on the composition of the unit and which varies inversely with its size. This latter viewpoint has led to several other methods. Most of these simple methods were developed before recent improvements in computing machinery made Monte Carlo calculations practical. Even today, however, where the number of configurations to be analyzed is large or where computing machinery suitable for Monte Carlo is not available, the simple methods have an important role to play.

Following two brief introductory chapters describing the interaction problem in general terms, the monograph by Thomas and Abbey treats three simple methods, which consider a configuration as an array of interacting units, in a 99-page chapter entitled "Simple Hand Methods." (The appropriateness of "Hand" is debatable; certainly tedium and hence computational errors are minimized, particularly in the determination of the maximum eigenvalue of a matrix of more than third or fourth order, if a computer is used where feasible.) Graphs and tables are included to aid the reader in solving interaction problems. The final chapter (12 pages) is devoted to Monte Carlo but only in terms of a particular computer code.

The first of the simple methods is called the Oak Ridge method. This method, commonly termed the solid angle method in the U.S., was largely developed by Henry, Knight, and Newlon at the Oak Ridge Gaseous Diffusion Plant. The probability of transfer of neutrons from one unit to another is given by the average solid angle subtended by the latter at the former, or approximations thereto. The effect of unit size is characterized by k_{eff} for the bare unit with the other units absent. In the 15 pages devoted to this method the authors seem to do it justice.

The second of the simple methods, to which the authors devote 71 pages, they term the Interaction Parameter Method. Since this method is one which the authors have developed and worked with, it is understandable that they emphasize it. Obviously, they have found it to be a useful method that is easily applied. It also equates the probability of neutron transfer to the average solid angle, but expresses the effect of unit size in terms of surface multiplication (neutrons emitted by a unit per neutron entering its surface). The method is treated quite comprehensively, but the novice would have to gain considerable experience with it before having confidence in the estimates and judgments it requires him to make. A deficiency of the monograph is its failure to give direct comparisons between results predicted by the method and critical experiments. Many critical arrays of units containing ^{235}U and ^{239}Pu have been built by Callihan's group at the Oak Ridge Critical Experiments Facility and at Lawrence Radiation Laboratory with which comparison could be made in terms of predicted values of k_{eff} or predicted safe spacings.

The third simple method is termed the PQR method and was originally developed to accompany the GEM Monte Carlo computer code, which is discussed in the final chapter.

The statement on the jacket that "Reactor safety experts and criticality specialists now have the main calculational methods for assessing the safety of interacting arrays of fissile materials in one volume" is certainly debatable unless it is interpreted to include other important methods that are merely cited in the monograph. The list of references is quite comprehensive.

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About the Reviewer: Hugh Clark has contributed significantly to nuclear reactor physics, particularly as applicable to nuclear critical safety, for a decade and more while associated with the Reactor Physics Division of the Savannah River Laboratory. He has also been instrumental in preparing American National Standards and Recommendations of the International Organization for Standardization on the subject of criticality safety. Dr. Clark completed his graduate studies at Cornell following his undergraduate work at Oberlin.