Book Reviews

Small-Sample Reactivity Measurements in Nuclear Reactors. By Wesley K. Foell. American Nuclear Society (1972). 260 pp. $23.50.

Small-Sample Reactivity Measurements in Nuclear Reactors is the twelfth in a series of monographs sponsored jointly by the American Nuclear Society and the U.S. Atomic Energy Commission to present a unified treatment of very specific areas of nuclear science and technology, primarily for the working scientist or engineer but also for the nuclear engineering student. In this monograph, the scope has been limited to a consideration of the methods used, their limitations, and the analytical basis for interpretation in the measurement of the effect of a physically small sample of material on the reactivity of a nuclear reactor. In the selection of measurements discussed, emphasis has been given to those which seek to determine material parameters, at the expense of determinations of reactivity coefficients and reactor characteristics.

Within the defined scope, the subject is treated in a systematic, comprehensive, and objective manner. Following a brief introduction (Chap. 1), the static and dynamic methods for measuring reactivities in the range from 10^{-3} to 10^{-8} $\Delta k/k$ are described (Chap. 2). Period, power history, and the variety of local and pile oscillator techniques are described in sufficient detail to reveal the merits and limitations of each. Problems of precision achievable and reactor drift are considered in Chap. 2, but the other aspects of the design and interpretation of small-sample reactivity measurements are treated in Chap. 3. There the treatment is presented in a manner relatively independent of the specific reactor system or parameter being investigated therein. The determination of the properties of various types of materials is described subsequently, in Chap. 4 for thermal reactors and Chap. 5 for fast reactors.

The text is noteworthy for its clarity in the discussion of complex effects encountered in small-sample reactivity measurements. An adequate analytical basis is provided, but it is supplemented by explanations of the physical significance of the complex mathematical expressions. There are a few typographical, grammatical, and technical errors, but they are of minor consequence. For example, it is stated (p. 22) that, in the determination of reactivity by the period technique, negative reactivities in absolute magnitude less than ~0.3 dollars are to be avoided because of potential inaccuracies arising from the very rapid variation of reactivity with period in this region; however, the discussion which follows makes it clear that such problems are encountered for negative reactivities greater than that amount of reactivity.

The convenience of using "pick-up" artwork is understood, but insufficient effort was made to delete material extraneous to the point to be illustrated by the figures introduced. Of course, the interested reader will be able to determine the meaning of unidentified symbols, etc., since the source is always indicated.

The author has been an active participant in the subject field for over a decade at various universities and national laboratories, so he writes with first-hand knowledge and indisputable authority on many of the specific aspects. Some controversial statements are made, but they serve to add interest and stimulate the reader. Some of the debatable statements are as follows:

1. It is certainly *safe to predict* that thousands more (small-sample reactivity measurements) will be performed in the coming decade (Preface).
2. There is a *rapidly growing* application of small-sample measurements in fast reactor research and development (Preface).
3. Adequate flux-measurement techniques are *just now* becoming available for fast reactors (p. 197).
4. The nuclear cross-section compiler is a *new* breed of specialist (p. 199).
5. Reactivity effects due to samples inserted into fast-neutron spectra *often* result from absorption or scattering effects over a broad range of the energy spectrum (p. 201).

All pertinent material is covered, but at times the detail provided seems to be disproportionate to its usefulness. For example, the inhour equation which is the basis for the asymptotic-period reactivity-measurement technique must be evaluated for the specific reactor in which measurements are made, yet ten pages are devoted to tables and graphs of the periods and corresponding reactivities for three fissile species and a range of neutron lifetimes, using 1957 data. Similarly, six pages are used to describe a study of scattering effects in the thermal Advanced Reactivity Measurement Facilities (ARMF-I and -II). In view of the author's comment that the bulk of the pioneering small-sample reactivity measurements in thermal systems may already have been performed, and the phenomenological nature of most measurements in fast spectra, one questions his decision (p. 85) to emphasize the measurement of material parameters. Fortunately, the measurement of reactivity coefficients and reactor characteristics are given more than the promised "discussion in passing."

While there is no question that this monograph fills a gap in the unified coverage of important subject areas in reactor physics, a consideration of its timeliness is pertinent. The only other comprehensive coverage of this subject appeared at the end of the first decade of such measurements (1953). In passing, it is of interest to note that the first application was in quality assurance procedures for reactor materials, and that the first pile oscillator, after a decade of productive use, is now in the Smithsonian Institution. The second decade witnessed extensive applications in thermal reactors, and the third decade has been the transitional period to a dominance of small-sample reactivity measurements in fast reactors over those in thermal reactors. Over 60% of the approximately 200 references cited in the monograph were published between 1963 and 1968, while only 9% (18 references) are more recent. The last of these appeared in mid-1970, more than two years before publication of the monograph. Thus, the monograph is more useful in providing an historical perspective and a basic understanding rather than an awareness of current activities.

On balance, in spite of the above emphasis on shortcomings, the book is a valuable addition to the bookshelf on reactor physics. It accomplishes well its objective of providing a unified, systematic treatment of the fragmented literature on the subject of small-sample reactivity measurements. Current problem areas, such as the complexity of scattering contributions to the observed reactivity and the systematic discrepancy between measured and calculated reactivity coefficients in plutonium-fueled fast reactors, are discussed, and suggestions for further studies made, where appropriate. The book deserves to be studied, rather than just read, by those who are working or interested in the subject area.

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About the Reviewer: Charles Redman has been with the Argonne National Laboratory since 1944 and was associate director of its Applied Physics Division for nine years. Dr. Redman, who did his graduate studies at Yale, has research interests in the physics of neutrons and of nuclear reactors.

The Elements of Nuclear Power. By D. J. Bennett. Longman Group Limited, London (1972). 206 pp. £3.50.

The Elements of Nuclear Power, a small paperback book, should find a useful and convenient niche in the literature somewhere between the voluminous Glasstone and Sesonske's *Nuclear Reactor Engineering* and the soon to be revised *Introduction to Nuclear Engineering* by Raymond Murray. Several unique features recommend this text: its modest size (201 pages); reasonable price of 3 pounds 50; its readability; and a slight bias toward natural uranium reactor systems.

The text begins with the traditional review of atomic and nuclear physics, then covers some of the more simple aspects of chain reaction theory and homogeneous reactor theory. Modest corrections are given for two-group analysis, heterogeneity, fast-neutron escape probabilities and fission. Other considerations include heat transfer and fluid flow, thermodynamics of power plant systems, the elements of reactor kinetics, and reactivity effects and reactor control. The closing chapter briefly introduces radiation hazards and simple shielding concepts.

Hardly discussed are radiation damage to material, nuclear fuel cycles, enrichment plants, or reactor technology. Several drawbacks to the text include the lack of any student exercise problems at the end of the chapters and, slightly more serious, the lack of any significant number of illustrative examples worked into the body of the text. Such omissions render the book somewhat less useful for self-study and for classroom application if other sets of exercises and examples are not readily available.

The text is only meagerly supplemented with tables of typical values of atomic masses, gamma-ray energies, decay constants, delayed-neutron fractions, thermal-neutron cross sections, Westcott g factors, neutrons per fission, etc. The reviewer has found that such a consistent set of numerical values presented throughout the text can be very useful in introducing the student to sample calculations and practical problems.

Data are limited on typical values for such derived or calculated parameters as Fermi age, resonance escape probabilities, temperature ranges, pressures, flow rates, plutonium concentrations, enrichments, xenon and samarium poisoning effects, fission product buildup, and control requirements in typical reactor situations. A consistent and accurate set of such numbers can be of great use to the student who is in no position to either derive, calculate, or select and evaluate such parameters from the literature.

All things considered, this book should be useful as an introductory textbook for engineering students wishing a reasonably broad but not too detailed technical introduction to nuclear power reactors. It should also serve as a rather brief and completely self-consistent introductory course for undergraduate-level nuclear engineering students.

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About the Reviewer: G. R. Dalton graduated from the University of Michigan with a BS in mechanical engineering and a PhD in nuclear engineering. He attended the Oak Ridge School of Reactor Technology and has taught nuclear engineering at the University of Florida since 1960. During the year 1965-66 he was involved in reactor fuel management and criticality calculations at the Westinghouse Pressurized Water Reactor Division. Since 1966 Dr. Dalton has been teaching undergraduate nuclear engineering courses, and has a continuing interest in graduate education in the fields of reactor analysis, transport theory calculations, and fuel management.