BOOK REVIEWS

Selection of books for review is based on the editors' opinions regarding possible reader interest and on the availability of the book to the editors. Occasional selections may include books on topics somewhat peripheral to the subject matter ordinarily considered acceptable.

Nuclear Reactor Instrumentation (In-Core)

Author James F. Boland

Publisher Gordon and Breach Science Publishers

Pages 229

Price $12.50

Reviewer Charles N. Jackson, Jr.

Because the nuclear industry and in-core instruments in particular have advanced gradually and irregularly for many years, this book serves a very useful purpose of identifying progress achieved. The 11 chapters treat a broad range of parameters and disciplines associated with measurement of nuclear flux, temperature, pressure, flow, etc. The initial chapters introduce the general problems encountered in the extremely hostile environment of the in-core instrument. The subject treatment employs a vigorous systematic analysis of each instrument type, one of the strong features in the author's presentation. The description and development of theory, accompanied by identification of specific components, and assessment of strengths and weakness provide valuable information to the designer or developer. Each chapter includes an excellent bibliography for those desiring to delve further into specific areas.

An in-core instrument presents an extremely challenging problem. Success for a measurement system requires ambitious, skillful effort. Mr. Bolan brings these circumstances into sharp focus after initially acquainting the reader with the effects of nuclear radiation on materials and broadly characterizing the problem areas.

The book helps bridge an important gap in this field between the initial beginning and the eventual time when sufficient information would be available for documentation in a handbook. It points out important limitations and characteristics gleaned from review, evaluation, and projection based on information that is widely scattered in the available literature. His summarization of performance data in some cases from several sources provides solid, efficient use of available information. Comparison between various measurement techniques very effectively brings the various methods into focus. The information should save needless expense for installing costly inadequate in-core components.

The book makes a valuable documentation and thought-provoking presentation of in-core instrumentation, augmented by an excellent bibliography. Workers in the nuclear field from the transducer manufacturer to the plant manager and especially the instrumentation and control engineer will find this book extremely valuable.

Charles N. Jackson, Jr. (MS, nuclear engineering, University of Cincinnati, 1959; BS electrical engineering, Clarkson College of Technology, 1948) has engaged in instrumentation research and development as a principal investigator in neutron radiography and neutron detectors. A regenerative coating development, employing a fertile-fissile mixture increased the useful life of an in-core fission detector by a factor of 10. He has published or presented 14 technical papers describing his present work and prior efforts with nuclear nondestructive testing equipment. Other work involved development of radiation-hardened electronic circuits and student engineering assignments in electric meters, steam turbines, and electrical switch gear. Professional affiliations include membership in the American Nuclear Society, the Institute of Electrical and Electronics Engineers, and registration as a professional engineer. He presently works for WADCO Corporation, a subsidiary of Westinghouse, as a senior development engineer.

Techniques in Fast Reactor Critical Experiments

Authors W. G. Davey and W. C. Redman

Publisher Gordon and Breach, Science Publishers, Inc.

Pages 320

Price $20.40

Reviewer R. J. Neuhold

This book discusses principally

1. the design of fast reactor critical facilities
2. measurements made and techniques used in fast reactor critical facilities

3. capabilities and future trends related to items 1 and 2.

These items have been discussed in Chaps. 2 through 7, 9, 11, and 12. In general, this reviewer found these chapters satisfactory. The material presented, however, is not self contained and needs to be supplemented by referenced information. Frequently, calculated and experimental results are compared with virtually no explanation of calculational methods. Such results are often obtained from the list of conference proceedings and reviews presented on p. 1. Typical in this respect is Fig. 6-4 (comparison of calculated and experimental sodium-void reactivity values for various intracell plate configurations in ZPR-6 Assembly 3). The claim is made that the figure shows (among other things) the ability to calculate the results. The figure also appears in referenced conference proceedings. The proceedings need to be examined to find out when the calculations were made, what methods were used, and the source of cross sections. This information is certainly pertinent to the claim. Often, old sources of data are used to demonstrate a point without reference to current sources or a warning that better data may be available. Table 4-1, for example, gives delayed neutron fraction data for several isotopes. The reviewer would caution the reader particularly about the use of the ^{241}Pu and ^{242}Pu data.

Chapter 1 presents an elementary review of some fast reactor physics aspects. The source of cross sections used in this chapter is not given. Some of the data appear again in Chap. 10 and are referenced in Chap. 10. Certain statements made in Chap. 1 require further explanation. On p. 11, e.g., the authors state: "'Pancaking' the core also reduces the reactivity associated with axial fuel expansion."

Chapter 8 presents a discussion of kinetics and control. Evidently, this chapter was included to give the reader an understanding of some of the measurements. Generally, derivations are lacking, and the results presented are based on point kinetics with physical interpretations for reactivity and the kinetics parameters. "Point kinetics" equations can be derived from the Boltzmann equation [see, e.g., A. F. Henry, *Nucl. Sci. Eng.*, **3**, 52 (1958)]. Such derivations lead to a consistent set of mathematical definitions for the kinetics parameters which can only be "loosely" related to physical quantities. Such an approach may well lead to improved measurements and methods of analysis.

Chapter 10 presents several tables which need further explanation. Table 10-1, e.g., presents calculated and measured reactivities in units of millibarns! What is actually measured and calculated? The source references 3 and 13 do not shed any further light on the calculations except that they are related to the equations given on p. 63. What appears to be calculated is (see p. 63):

$$(1)\ \frac{(\phi^*\, A\, \phi)}{(\phi^*\, \phi)}$$ (operator and inner product notation is used).

With this expression and the data supplied in Ref. 13, the reviewer obtained 913 mb for ^{10}B in Assembly 33. Reference 13, however, refers to further experimental and calculated normalizations based on equating the calculated ^{239}Pu reactivity change to the calculated value of $(\nu\text{-}1\text{-}\alpha)\sigma_f$ for ^{239}Pu. This normalization probably explains the difference between the 913 mb and the reported 975 mb. This means that the measured reactivity (not cross section) had to be adjusted by quite a few calculated terms [comp., e.g., Eq. (1) with a first-order perturbation expression for reactivity] in order to obtain the pseudo cross sections given in Table 10-1.

Table 10-3 presents calculated and measured lifetimes. The prompt neutron lifetime is not measured (this is stated on p. 257). If the conditions for time separability are satisfied, a constant commonly referred to as α is measured. This constant can be related to mathematically defined quantities usually referred to as generation time $\Lambda(\Lambda = kl)$ and β. The values of β used to obtain l from the measured α are not given in the book nor in the source references (3 and 13). The value of β used should be consistently defined with l. An equation for l is given on p. 266; note that v_i should possibly be the reciprocal of the average of $1/v$ in group i. The reader is, therefore, led to believe that the calculated lifetime was obtained from this equation. The same data are presented in Ref. 3. In Ref. 3 it is stated that the lifetime was calculated by an α search in an S_n program; thus,

$$(2)\ l = \frac{k - 1}{\alpha}$$ (the eigenvalue for one of the two states is 1.0).

The authors apparently believe that the above equation and the equation reported on p. 266 are equivalent. An exact perturbation expression (for simplicity, let us assume that all the calculations are done in zero dimensions) relating the eigenvalues of two off-critical states where one state is achieved by adding α/v to the absorption cross section is

$$(3)\ \frac{k_0 - k_1}{k_1 k_0} = \frac{(\phi_0^*\, \alpha/v\, \phi_1)}{(\phi_0^*\, F_0\, \phi_1)}$$ (operator and inner product notation is used),

where F_0 = source operator and $1/v$ is a diagonal matrix of reciprocal group velocities.

If the eigenvalue of one of the states is 1.0, we obtain

$$(4)\ \frac{k - 1}{\alpha} = \frac{k(\phi_0^*\, 1/v\, \phi_1)}{(\phi_0^*\, F_0\, \phi_1)} \quad .$$

Equation (4) shows that Eq. (2) differs from the equation on p. 266 principally because the perturbed spectrum is, in essence, used in the calculation. The data in Ref. 3 show that some of the perturbed states were supercritical by as much as 1%. The resulting difference in the perturbed and unperturbed spectra may or may not (depending on spectrum hardness) be sufficient to cause Eq. (2) and the equation on p. 266 to give different results.

In summary, fast reactor critical facilities and related measurements are generally well described. The major shortcoming of the book is the lack of a unified treatment relating the measurements, analysis of the experiments, and the theoretical foundation. The review of this book points out a need for an examination of measurements and methods of analysis using current fast reactor technology. The book as a source reference should be useful to experienced reactor physicists and educators capable of supplementing its theoretical weaknesses. A course, e.g., on fast reactor measurements and analysis would require such a theoretical supplement.

R. J. Neuhold (BS, physics, Marquette University, 1953; MS, physics, University of Minnesota, 1956; PhD, nuclear engineering, Purdue University, 1969) worked on thermal reactor critical facilities and associated experiments from 1956 to 1959. Since 1959 he has been engaged in thermal and fast reactor design, methods development, and implementation. He has been a member of the American Nuclear Society since 1957. His current interests are in fast reactor physics, kinetics, safety, and related computer applications.

Peaceful Nuclear Explosions

Author International Atomic Energy Agency, Vienna 1970

Publishers Unipub, Inc.

Pages 454

Price $12.00

Reviewer Paul Kruger

Peaceful Nuclear Explosions is the proceedings of an international panel held March 2-6, 1970 in Vienna by the International Atomic Energy Agency. It presents the first formal across-the-table discussions by representatives from the several countries which have either the capability for or the interest in the use of nuclear explosions for peaceful uses. In the Foreword, the IAEA notes that although nuclear explosions for industrial applications have been under active consideration as part of the atomic energy programs of several countries for nearly two decades, it is only in the last five years that the science and technology has advanced sufficiently to attract international interest as a truly feasible engineering technique. The panel consisted of 60 participants and observers from 29 member states of the IAEA and 3 international organizations.

The first 45 pages of the 454-page proceedings give the "official statements" on the national programs in peaceful nuclear explosions of the 9 official panel countries. These include Australia, France, India, Japan, South Africa, Sweden, USSR, UK, and USA. Four of these statements were from countries considered as "have" countries under the international treaty on the nonproliferation of nuclear weapons. The statement from France (in French) announced the APEX program of the CEA; the statement from the UK summarized its efforts as an independent evaluation of the USA and USSR efforts and listed some potential projects that might be feasible for nations of high density populations. The statement from the USSR (in Russian) summarized the current status of their national program. The prior status was reviewed in a set of three reports given to the IAEA in September 1969. The review covered the experimental results of the mechanical and radioactivity aspects of both contained and excavation explosions and a summary of the applications being considered for the USSR national economy. This and the other USSR papers in the proceedings have been translated by the USAEC. (UCRL-tr-10475, 10476, 10477 and AEC-tr-7120, available from the Clearinghouse for Federal & Scientific Information, Soringfield, Virginia 22151.) The USA paper was a review of the Plowshare program. Appendixes listed the Plowshare chronology and the executed and proposed experiments for industrial and scientific applications.

A feature of the proceedings is a 58-page review paper by Milo Nordyke of the Lawrence Radiation Laboratory who together with V. N. Rodianov of the USSR were the technical consultants to the Panel. The paper, commissioned by the IAEA, is an excellent review, compiling for the first time the collected contributions from the experimental data of the French, USSR, and USA programs and the full range of applications proposed by most of the nations represented.

The 16 technical papers presented by the four "have" countries constitute the major portion of the proceedings. Six of these, from France, summarize the experimental data from a series of some 13 contained nuclear explosions in a granite massif medium in the Sahara. From these data, numerical codes of the geonuclear effects were developed. The one British paper describes a theoretical model of the early phases of the explosion.

The set of five technical papers from the USSR amplifies the details of the earlier set of papers given to the IAEA. They include two papers on the respective industrial applications of contained and cratering explosions. Among the details of the former are included the increased production following an oil stimulation experiment involving three nuclear explosives. Plans for specific oil and gas stimulation and storage projects and for mining are described. For the latter, details were given of the 1.1-kt excavation in siltstone involving infiltration by groundwater. Plans for specific civil construction of a large water reservoir project in Central Asia and for a water diversion canal to the Caspian Sea are considered.

The four USA contributions contain the experimental results of Plowshare cratering experiments and a description of the numerical codes developed for the simulation of stress wave propagation from explosions and the dynamics of cratering. A 50-page FORTRAN listing of the SOC code used for such calculations is appended.

A four-page summary of the Panel meeting by the scientific secretary completes the proceedings. In it, the secretary suggests some eight technical areas where further research is required to develop the technology and some possible roles the IAEA might play in developing the international aspects of peaceful nuclear explosions.

With the highlights of the national programs of the countries pursuing the development of peaceful nuclear explosions adequately covered in these proceedings, it is apparent that the proceedings will be of value to any reader wishing to acquaint himself with the status of this technology. The proceedings of the First Panel on Peaceful Nuclear Explosions thus constitutes a major reference work in this subject.

Paul Kruger (PhD, nuclear chemistry, University of Chicago) is director of the Nuclear Civil Engineering program at Stanford University where he is active in the application of nuclear techniques to civil engineering practices. He has been active in nuclear explosives engineering for many years and instituted one of the first courses in this subject. He was instrumental in organizing the Technical Group for Nuclear Explosion Engineering of the American Nuclear Society.