NUCLEAR SCIENCE AND ENGINEERING: 31, 170-172 (1968)

Book Reviews

Proceedings of Symposium on Criticality Control of Fissile Materials. International Atomic Energy Agency, November (1965). 746 pp. $7.50.

This volume is an account of the Second International Symposium on the Criticality Control of Fissile Materials which was held in Stockholm under IAEA auspices in November 1965. The first symposium was held $4\frac{1}{2}$ years earlier by the European Nuclear Energy Agency at Karlsruhe. A comparison of the two sets of proceedings shows the considerable progress that has been made in the intervening years.

Both meetings were dominated by contributions from France, the United Kingdom, and the United States of America, and divide broadly into four subjects: theoretical and experimental studies; criticality data; application to plant design; and safety in operations. It proved possible at Karlsruhe to keep these subjects together, but the organizers at Stockholm were not as successful and it is difficult to find any pattern in the allocation of papers to the first four sessions on "Basic Data," "Theoretical Studies," "Experimental Studies," and "Special Problems," which jointly contain the information on criticality data and on theoretical and experimental work. The remaining sessions on "Plant Design and Operation," "Current Practice in Criticality Control," and "Detection and Prevention of Criticality Accidents," do, however, conform to the titles.

In 1961 an outstanding theoretical problem was the understanding of the factors affecting the criticality safety of systems of interacting fissile units, a problem that had been brought to the fore by the work being undertaken at that time to devise a set of IAEA transport regulations for fissile materials. At Stockholm there were no less than eight papers that dealt wholly or in part with theoretical and experimental studies of this problem, from the USA, the UK, France, the USSR, and Japan. Noteworthy are the papers by J. T. Thomas who describes experimental measurements of critical parameters for a series of arrays in clean geometry and by F. Abbey who gives a comprehensive theoretical account of the interaction problems. It can now safely be said that the criticality of interacting arrays is well understood.

One of the striking developments in techniques of calculation brought out at the Symposium was the more widespread application of the Monte Carlo method. This method received only a brief mention at Karlsruhe but since that time has undergone considerable development and a number of very sophisticated machine codes are in use to determine criticality parameters for quite complex plant items and other equipment.

More than half the volume describes experience and techniques for ensuring criticality safety in the design and operation of chemical and fabrication plants and in transport. The trend has been away from the ultra-safe philosophy of several years ago when safety was demonstrated by showing that the system was safer than some reference assembly that had been shown experimentally to be subcritical. Economic pressures now demand a more accurate knowledge of the precise critical configuration as the basis of design so that realistic safety factors can be applied. This requires an elaborate and detailed machine calculation backed up by suitable experiments. The role of experiment is thus becoming more to check calculational methods than to directly give criticality clearance. There is also much interest in the use of neutron poisons, typically boron in Pyrex glass, as a means of enabling larger processing vessels to be used in chemical plants, and a number of papers refer to this concept.

A steady change of viewpoint is noticeable, away from the concept that the results of an accidental nuclear chain reaction can be so disastrous that every effort must be made for its prevention, to a realization that such an accident will nearly always be very limited in the damage it can cause and that provision can be made for protection. Consequently, criticality is ceasing to be glamourized and is gradually taking its place as just another industrial hazard against which sensible precautions must be taken.

This book, supplemented by the proceedings of the earlier Karlsruhe Symposium, forms an excellent and full account of the theory and practice of criticality control of fissile materials. It contains many diagrams giving criticality parameters for a variety of systems that have recently been evaluated either by experiment or calculation. The criticality specialist cannot really do without this book on his bookshelf.

E. R. Woodcock

United Kingdom Atomic Energy Authority
Risley, Warrington, Lancs., England

July 11, 1967

About the Reviewer: Ed Woodcock is Head of the Theoretical and Computing Section of the Health and Safety Branch of the United Kingdom Atomic Energy Authority with which he has been associated since 1954. His interests are primarily in radiation and neutron transport and in nuclear criticality safety. Prior to his position with the UKAEA, Mr. Woodcock was, successively, with the Meteorological Office, the Air Ministry, and the Ministry of Supply. His academic training was in mathematics at Cambridge.

Fast Reactor Technology: Plant Design. Ed. John G. Yevick. The MIT Press (1966).

In summary, this book is the first general reference for sodium-cooled fast-reactor technology to be published. It contains excellent bibliographies, outstanding illustrations, and provides an excellent source reference for the fast-reactor plant designer. Unfortunately, it is hampered more than usual by a severe delay between the time the material was prepared (1959-1963) and the time it was published and available (1967). There are an unusually high number of typographical errors and relatively minor technical errors for a book of this high cost.

The most outstanding treatment is clearly Chap. 8 on shielding. A comprehensive evaluation of the unique problems associated with shielding a fast reactor is accompanied by sufficient illustrative material and mathematical tables to provide the reader with the tools for undertaking a number of preliminary shield-design calculations. An excellent indication of the bases for a particular shield design precedes the detailed shield description. Taken as a whole, this chapter consolidates for the first time the necessary background information for guiding nuclear engineers in the design of a fast-reactor shield.

Chapter 7 provides an excellent consolidation of fuel-handling experience with in-depth discussions of system design as well as of specific hardware functions. The use of more schematic diagrams to describe certain operations of the illustrated equipment would have made this material more meaningful to a larger group of readers. Thermal hydraulics analyses are presented such that the fuel-handling decay heat-removal capacity can be estimated. The experimental results for gas cooling of an electrically heated EBR-II fuel subassembly using both air and argon are presented but these data are not compared to the theory.

A well-presented detailed description of sodium-cooled systems and the design and variations of the main system components are described in Chap. 4. The author has made extensive use of references with liberal inclusion of performance tabulations and illustrations. Many of the recommended practices show a dominant influence of the Fermi plant design practices. For example, there is a recommendation for double containment of the primary sodium piping, a controversial subject among reactor designers. Other means of assuring core coverage should have been discussed for completeness.

Chapter 9 devotes half its coverage to an extensive treatment of control- and safety-rod drive mechanisms contained in Fermi, EBR-II, and Dounreay. These descriptions are prefaced by general design considerations applicable to three methods of fast-reactor control: movement of 1) reflector, 2) fuel, and 3) poison assemblies. Curves showing reactivity and rod position vs time after scram will be of considerable value to the control system engineer. The authors should be commended on their obvious attempts to present the significant fast-reactor plant measurement and control needs and problems before discussing the current and expected problem solutions. Various methods of controlling the reactor as a function of steam power-plant operation and electrical load are well covered. It is unfortunate that the space allotted to the important area of sodium-cooled reactor plant measurements is relatively small. However, the 42 references will assist the reader in expanding his understanding. The important area of electrical power systems is included with emphasis on its application to control and safety system dependability. Fuel subassembly handling interlock systems and accountability techniques are also discussed.

The "Steam-Electric Plant" chapter is well presented, adequately referenced, and is understandably limited to a brief review of conventional feedwater/steam cycles for application in fast-breeder plants. Some minor design modifications are cited as unique reactor-plant requirements in areas of emergency steam dumping, turbine control systems, feedwater purity requirements, and surface condenser design.

Chapter 6 discusses site selection, containment design, and plant structures, and is highly oriented to the Fermi and EBR-II designs. The plant site selection is quite general but well presented and serves as an excellent introduction to siting criteria. A very comprehensive treatment of containment design and interfaces with the reactor systems and related structures is presented but unfortunately is limited to steel containment structures. Other thermal-reactor containment designs are discussed, tending to dilute the content of the chapter.

The discussion and references of the "Structural Analysis" chapter provide a solid framework for most areas of material stress design (fatigue, creep, plasticity). Included is a particularly outstanding section on the design of baffled walls. On the negative side is lack of identification of "criticality of service" and nuclear-structural interactions as governing considerations in fast-reactor design. For example, additional discussion is needed for 1) piping stress analysis, 2) earthquake-protection design, and 3) mechanical vibration and shock loads. Noticeable noncurrent areas are 1) creep and plasticity analysis (by computer codes), 2) materials data for irradiated steels at high temperature, 3) analytical techniques (particularly for perforated tube sheets) now in the ASME Section III Nuclear Code, and 4) strain gage technology.

A disappointing chapter is "Coolant Properties, Heat Transfer, and Fluid Flow of Liquid Metals." Roughly two-thirds of the chapter presents graphs and tables of properties of calcium, lithium, lead, potassium, and mercury for no apparent purpose since the rest of the book concentrates solely on sodium- or NaK-cooled fast reactors. Important areas of omission are considerations of 1) critical heat flux, 2) flow instabilities, and 3) superheating. Recent work by Dwyer on the Nusselt number vs Peclet number has outdated the text material. Also, experimental slip ratios for liquid metals have recently been shown to be an order of magnitude higher than the text's recommended ratios which are based on steam-water data.

The chapter on economics is not up to the standard of the rest of the book in that it does not attempt to cover the subject of fast-reactor economics. Rather, it is a discussion of the cost of building, starting up, and operating the Enrico Fermi plant. This information is of doubtful benefit to the reader in the year 1967.

All in all, the book is a fine contribution to the source literature on fast-reactor plant design.

Eugene R. Astley

Battelle Memorial Institute
Pacific Northwest Laboratory
Richland, Washington

June 9, 1967

About the Reviewer: Gene Astley received his MS Degree in Physics from Oregon State University and has 17 years' experience in the field of nuclear energy. From 1950 to 1954, at the General Electric Co. Advanced Technology Laboratory, he was engaged in a variety of development projects including sodium instrumentation, scintillation gamma counters, and gas thyratrons, as well as instrumentation for use in the ^{235}U *concentration cascades at Oak Ridge. From 1955 to 1965 his assignments at the Hanford Atomic Products Operation included Manager of the Reactor and Systems Design Analysis group for the New Production Reactor Project and Manager of Applied Reactor Engineering in direct support of eight production reactors. His present position is Manager of the sodium-cooled Fast Flux Test Facility Project (FFTF) at Pacific Northwest Laboratory (PNL).*