BOOK REVIEWS

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

Nuclear Reactor Safety

Editor F. R. Farmer

Publisher Academic Press, Inc. (1977)

Pages 216

Price $17.50

Reviewer George Yadigaroglu

This monograph brings together contributions from a number of United Kingdom Atomic Energy Authority (UKAEA) staff members, all specialists in the various fields of nuclear reactor safety. As stated in the introductory chapter, "one aim of this monograph is to put the nuclear hazard in perspective by an overall technical review of the field which will recognize the nature of the hazards, assess their gravity, and attempt to show that appropriate steps are being taken to ensure that the advantages to the community are commensurate with the inevitable risks." A deliberate attempt is made in many sections of the book to quantify probabilistically these risks.

Chapter 2 deals with radioactivity and radioactive releases from the fuel, the primary reactor system, and the containment following an accident. Starting from the very basic elements of radioactive decay (which *could* have been omitted), it progresses through a discussion of the chemical and physical forms of the fission products that are of importance in safety analyses. The most interesting sections in this chapter are those describing the behavior of these important fission products in the fuel, under both normal and accident conditions, their release in case of melting or a breach of cladding, and their subsequent behavior outside the core. A section is also devoted to the engineered safeguards used to remove fission products from the containment atmosphere.

Radiation hazards and environmental consequences of reactor accidents are discussed in Chap. 3, which starts with a general discussion of International Commission on Radiological Protection recommendations and their interpretation in the U.K. and in the U.S. Readers familiar with the very conservative present-day thinking on these matters in the U.S. and with the "as low as reasonably achievable" philosophy may find that some statements made in this chapter reflect "old-fashioned" opinions; more recent approaches such as those adopted regarding routine releases from nuclear power plants in the U.S. are, however, also discussed. A major part of the chapter is devoted to the evaluation of the consequences of an arbitrary (but commonly used in regulatory circles in the U.K.) release of gaseous and volatile fission products that include in their composition 1000 Ci of ^{131}I. An extrapolation is then made to the case of a release from a large power reactor that could conceivably be 10 000 times greater.

The philosophy behind the "accident-frequency-versus-release" limit line (Farmer plot) criterion used within the UKAEA for the safety assessment of prototype reactors is explained clearly and convincingly in Chap. 4. This simple criterion, based on ^{131}I releases only, has been useful in quantifying risks from the operation of nuclear power plants. It has been made obsolete, however, by the possibility of making detailed calculations of the probabilities and consequences of reactor accidents such as those of the *Reactor Safety Study* (RSS, WASH-1400). The chapter provides excellent background information on the advent of risk quantification criteria in the U.K. but suffers from ignoring almost completely recent work such as the RSS.

Chapters 5 and 6 are devoted to the quantitative approach to reliability with applications to control and instrumentation systems and shutdown heat removal systems, respectively. A very significant amount of work has been done in the U.K. on this topic. It is unfortunate that the authors restrict themselves to a simple mention of the methods that have been used to quantify the reliability of protective systems and do not attempt to describe some of these methods. System reliability analysis methods such as fault and event trees that are now being used fairly extensively in the U.S. are barely mentioned, but a number of pages are devoted to showing that quantitative reliability methods can be used with a fair degree of accuracy to predict the reliability of protective systems. Chapter 5 does, however, include a good presentation of the basic approach to the design of protective systems and discusses qualitatively the questions of redundancy, diversity, segregation in space, safe versus unsafe failure mode, etc.

Chapter 6 is essentially a detailed discussion of the reliability of the shutdown heat removal systems of the British Prototype Fast Reactor (PFR), with occasional references to the corresponding problems in gas-cooled reactors and in pressurized water reactors.

Chapter 7 sets reliability requirements for steel pressure vessels used for light water reactors (LWRs) and summarizes in a clear and useful manner the statistical information available on the integrity of similar vessels. It also discusses the reliability of various inspection techniques being used to reduce the probability of failure.

The last two chapters deal with generic safety concerns of thermal and fast reactors, respectively. Chapter 8 contains a very interesting comparative discussion of the physics of reactivity-addition, loss-of-flow accidents and loss-of-coolant accidents (LOCAs) or loss-of-pressure accidents in LWRs, gas-cooled reactors, and pressure-tube reactors. For U.S. readers, it is stimulating to see that less attention is paid to the LOCA in LWRs and that other safety concerns are given equal attention.

Chapter 9 reviews the safety concerns related to the liquid-metal fast breeder reactor, with frequent reference to the PFR. Differences between the safety aspects of thermal and fast reactors are emphasized, and excellent generic discussions of reactivity-addition, local loss-of-cooling and fuel-handling accidents, as well as of containment design bases and of sodium-water reactions and sodium fire protection are given. These last two chapters provide an excellent descriptive understanding of the physical processes expected or postulated to occur during the variety of accidents considered in the safety analysis of thermal and fast reactors. They are well written, very compact, and cover this vast topic in less than 40 pages. In a sense, it is unfortunate that they are not any longer and do not cover the subject in greater detail and depth.

The level of the book is introductory, and the almost total absence of mathematical formulations makes it accessible to a large audience. It also provides, however, in a very compact and readable form an excellent review of our understanding of physical phenomena such as those of fission product release from fuel and the primary system and of the situations arising during postulated reactor accidents, as noted above. This information is not, of course, novel, but an excellent synthesis has been made. It is understandable that the authors cannot get into their topics at great depth; we are left regretting this, however, since as an introduction the book is very good. We also regret that a more comprehensive list of references was not provided to guide the interested reader into further search in selected areas. In fact, many of the references cited are inaccessible, at least to the U.S. reader; they are often papers presented at various specialized meetings in Europe. Furthermore, the references are not always keyed to the topics under discussion, and they appear in uneven numbers in the various chapters of the book.

The book is clearly based on U.K. experience in reactor safety. As such, it often completely ignores or only briefly mentions some areas that have been of importance in the U.S. Most of the material seems to have been written three or four years ago and is uneven in depth of coverage and scope. In spite of these minor criticisms, most of the chapters are very good, and the book can be put in the category of recommended reading for the beginner interested in nuclear safety. Specialists in reactor safety will also find valuable material in some parts of the book and will certainly enjoy reading the remaining chapters.

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