Book Review

Nuclear Reactor Safety. By F. R. Farmer, Ed., Academic Press, Inc., New York (1977). 216 pp. $17.50.

This interesting book consists of nine chapters on various aspects of nuclear reactor safety:

1. "Introduction" by H. M. Nicholson
2. "Radioactivity and the Fission Products" by F. Abbey
3. "Radiation Hazards and Environmental Consequences of Reactor Accidents" by J. R. Beattie
4. "The Calculated Risk—A Safety Criterion" by G. D. Bell
5. "Quantitative Approach to Reliability of Control and Instrumentation Systems" by A. Aitken
6. "The Reliability of Heat Removal Systems" by F. M. Davis
7. "The Integrity of Pressure Vessels" by R. O'Neil
8. "Thermal Reactor Safety" by J. H. Bowen
9. "Safety of Fast Reactors" by H. J. Teague.

Nicholson adeptly summarizes the unifying theme of all the chapters: "The technical arguments will be concerned broadly with reactor accident conditions and will deal with both the arrangements necessary to prevent any dangerous diversion from normal operation and to ameliorate the consequences if such a diversion occurs . . . ." The chapters are written by quite knowledgeable individuals in the field, and hence the specific topics selected for inclusion in the text are well covered.

Chapters 2 and 3 review basic nuclear engineering properties of accident processes. Chapter 2 discusses the physical and chemical mechanisms by which fuel elements can release fission products. Fission product transport outside the core is also reviewed. Chapter 3 discusses dose limits and dose effects; fission product releases in reactor accidents are summarized, including the *Reactor Safety Study* (WASH-1400) calculations.

Chapter 4 discusses basic concepts involved in quantitative risk evaluations. Actuarial tables of probability of death per person per year are presented for various activities. The Farmer curve of acceptable frequencies for various levels of released ^{131}I is presented and is advocated as a means of systematizing safety assessments. In calculating actual probability-versus-consequence curves, the probability considerations involved are reviewed and categorized according to (a) accident probabilities, (b) weather condition probabilities, and (c) wind direction probabilities. The general need for quantitative, acceptability criteria is advocated.

Chapter 5 discusses basic concepts of quantitative reliability and availability analyses. Assumptions are explained that are usually made in reliability assessments. The theory is nicely balanced by presenting pieces of practical evaluations that have been made on protective systems. The analysis of independent hardware failures is principally addressed; however, the general concepts of redundancy and diversity are also covered.

In Chap. 6, quantitative reliability analyses of heat removal systems are discussed. As part of the discussion, considerations involved in setting quantitative reliability goals are identified. The general method of performing a quantitative system analysis is also described in some detail, including the construction of the logic diagram, determination of the component failure rates, model quantification, and interpretation of the significance of the results.

In Chap. 7, three categories of failure of steel pressure vessels are discussed:

1. catastrophic failure with severe containment damage possible
2. gross ductile rupture in which the containment is not at risk
3. limited leakage.

Probabilistic criteria are proposed for each of these failure modes. Available data on pressure vessel incidents are reviewed and are judged not to be inconsistent with the proposed criteria.

Chapter 8 reviews basic concepts of heat generation and heat removal. Reactivity faults (e.g., rod removal), loss-of-flow faults (e.g., loss-of-coolant accidents), and loss-of-pressure faults (e.g., steam line breaks) are all discussed in terms of associated phenomena that can occur. Factors are identified that enter in the probabilistic treatment of these events (i.e., definition of the initiating event, auxiliary systems that fail, etc.).

Chapter 9 concludes the presentations by addressing basic design and operation considerations involved in liquid-metal fast breeder reactors. The effects of delayed neutrons, peak power density effects, and reactivity feedback processes are discussed with regard to their safety implications. A review is then given of possible faults that can occur, including loss of cooling, fuel, handling faults, and containment incidents.

Nuclear Reactor Safety is a collection of applications, principles, and personal viewpoints that relate to safety and risk analyses. The book represents an overview of safety considerations, with no one area being developed in great depth; however, many different topics are usefully addressed. The subjective viewpoints are generally well separated from the objective facts. Certain topics are missing or are simply mentioned, such as common mode and common cause failures, human errors, and test and maintenance considerations. However, the text has sufficient material, presented in an easily readable form, to make it an important addition to the engineer's library.

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May 25, 1978

About the Reviewer: Saul Levine is director of the Office of Nuclear Regulatory Research in the U.S. Nuclear Regulatory Commission (NRC) and is responsible for all NRC confirmatory assessments of all nuclear facilities and nuclear materials licensed and regulated by the NRC. His experience in nuclear technology dates from association with Admiral Rickover in the Shippingport and U.S.S. Enterprise Projects. More recently, he participated in the Reactor Safety Study *with Professor Rasmussen. Mr. Levine received his academic training at the U.S. Naval Academy and at the Massachusetts Institute of Technology.*