Chapter 4 presents detailed guidelines for basic tasks of prediction of failure modes, critical component analysis, and design review. Utilizing these guidelines, the following chapter provides the reader with a background in the design process from a reliability standpoint to include attributes of equipment derating. The final chapter of this text emphasizes the need for detailed fault tree analysis of systems, continued reliability testing requirements for failure reporting, and the desirability of analysis of corrective actions. The body of this text is followed by Appendixes that provide the user with definitions, a listing of applicable standards and specifications, and a bibliography of other useful handbooks, and regulatory guidelines.

This book evolved from work performed by the authors for the U.S. Nuclear Regulatory Commission, the Federal Aviation Administration, the National Aeronautics and Space Administration, and industry. The authors provide a wealth of data to include hardware failure rates and human error statistics. This text can be utilized as a guide by management or design engineers to relate equipment reliability to specifications, cost trade-offs, and design and testing of equipment. It is also recommended as a text for upper level college instruction or as a training document for regulatory agencies.

After receiving his MS in nuclear engineering from the University of Missouri at Columbia in 1970, Gerald A. Schlapper joined the reactor operations staff of the University of Missouri Research Reactor Facility. Dr. Schlapper received his PhD in 1977 and remained on the staff of the Research Reactor Facility until January 1981, when he assumed his current position as a faculty member of the nuclear engineering department at Texas A&M University. During his career he has served as a consultant to various government and private organizations.

Thorium Dioxide: Properties and Nuclear Applications

Editors J. Belle and R. M. Berman

Publisher U.S. Department of Energy (August 1984)

Pages 573

Price $40.95

Reviewer Geoffrey G. Eichholz

After an interval of 25 years, this book has appeared as the latest in the series of *Naval Reactors Handbooks*. In their day those books included some of the most informative volumes on nuclear materials, and this tightly printed book is a worthy successor. In many ways this may be described as the obituary of the Shippingport Light Water Breeder Reactor (LWBR), because what the editors set out to do here is to collate and present most of the enormous amount of technical know-how that was generated during the design and operation of the LWBR, which was shut down in 1982 after operating without refueling for 5 years.

To some extent the treatment is parochial; there is only passing reference to the experience with other thorium-fueled reactors; Fort St. Vrain is barely mentioned and the German thorium breeder not at all. However, it is hard to cavil at the sheer wealth of detail, which is a tribute to the thoroughness of the naval program. After discussing the nuclear physics aspects of a thorium fuel cycle, several lengthy chapters deal with all significant properties of ThO_2 and ThO_2-UO_2 mixed oxides: physical, thermodynamic, mechanical properties, phase equilibria, and transport phenomena. Fuel fabrication is described for three types of fuel elements and a variety of preparation methods. One chapter reviews fuel irradiation behavior, including dimensional stability and fission product release. The final chapter discusses fuel reprocessing and waste handling. Each chapter is followed by an extensive bibliography, and there is an adequate index.

This book is a valuable and exhaustive reference for all nuclear engineers interested in fuel technology. The editors should be congratulated on preserving such a useful trove of irreplaceable data.

Geoffrey G. Eichholz is Regents' Professor of Nuclear Engineering at the Georgia Institute of Technology, which he joined in 1963. He obtained his PhD in physics at the University of Leeds, England, and was awarded the DSc degree in 1979. He edited the book Radioisotopes Engineering *and is the author of* Environmental Aspects of Nuclear Power *and* Principles of Nuclear Radiation Detection, *both published by Lewis Publishers. His research interests include the migration of radioactive wastes, environmental surveillance problems, radiation detector development, industrial radiation applications, nuclear materials technology, and the health physics of nonionizing radiations.*

Guidebook to Light Water Reactor Safety Analysis

Editor Paul B. Abramson

Publisher Hemisphere Publishing Corporation (1985)

Pages 393

Price $89.95

Reviewer Raymond L. Murray

The subject of reactor safety is important and challenging, especially in light of the Chernobyl accident. This book provides a great deal of information about potential events in light water reactors. It is described by the editor as an expanded version of a series of lectures given in 1981 at the International Centre for Heat and Mass Transfer in Yugoslavia.

Chapter 1, "Licensing and Safety Analysis Background," lists transient and accident types and gives risk values, discusses emergency procedures for operator action, and reviews multifailure events. Chapter 2, "PWR Systems Transient Analysis," reviews the event classifications that the U.S. Nuclear Regulatory Commission (NRC) uses in Chap. 15 of the standard review plan for preparing safety analysis reports, outlines the functions of computer codes such as RELAP and RETRAN, and describes pressurized water reactor (PWR) undercooling and overcooling transients. Chapter 3, "PWR Small Break LOCA," more than one-quarter of the book, gives a qualitative description of the phenomenon and then displays many graphs of responses in time of

temperatures, pressures, flow rates, void fractions and liquid level, mainly based on RELAP. One class of accidents—total loss of feedwater flow with concurrent loss of off-site power—was presented without any reference to the loss-of-fluid tests (LOFT) of Idaho National Engineering Laboratory. LOFT achieved successful reactor shutdown without operator intervention and a verification of RELAP. Chapter 4, "Boiling Water Reactor System Analysis," describes the system and subsystems in outline form and devotes one section to the basic theory of two-phase flow. It then shows a large number of responses based on computer programs RETRAN and RAMONA. Chapter 5, "BWR Small Break Loss of Coolant Accident Analysis," is a relatively brief discussion of calculation methods. The program TRAC is mentioned, but no results from it are provided. Instead, experimental tests are discussed. Chapter 6, "Boiling Water Containment," is the only chapter in the book that presents extensive theory and formulas (except for those noted for Chap. 4), and since the subject of the chapter is specialized, the material seems out of place. Alternatively, it may be that the rest of the chapters would be more useful to analysts if some theory were included, either as needed or in the early part of the book, as is common in many textbooks. Chapter 7, "Anticipated Transients Without Scram," is a logically organized and well-written tutorial on the phenomenon with the acronym ATWS, in which the control system fails to act when the core heats up, either by a power rise or by inadequate cooling. The long-term controversy about ATWS is mentioned but not explained. (For an excellent history of ATWS, *Nuclear Reactor Safety* by David Okrent is recommended.) Presented are the nature of calculations on various processes and graphs of typical results for both PWRs and boiling water reactors. The chapter was apparently written before the NRC issued its rule on required shutdown equipment to reduce the risk of ATWS. Chapter 8, "Containment of Degraded Core Accidents," indicates how Class 9 accidents, those resulting in core damage, can be initiated. A general scenario leading eventually to breach of containment is given, and the status of calculation methods is provided.

This reviewer has mixed reactions to the book. It clearly collects and consolidates useful information found only in many reports. The book is more expensive than one would expect, considering that it was printed from typed copy. Unfortunately, Chap. 8 was not proofread adequately, such that the typographical errors distract from the flow of ideas and give this reader an uneasy feeling about the accuracy of the subject material itself. The virtue of using word processing with a spelling checker is well demonstrated.

The authors have experience ranging from 10 to more than 20 years, and some are recognized authorities. There is some unnecessary repetition, partly because there are several authors, even within a single chapter, and partly because of the practice of presenting general trends, then more detailed response data. More thorough coordination and editing could have eliminated such deficiencies.

As noted earlier, theory is largely missing and none of the chapters describes the computer codes in any detail. The book relies on descriptive material, and thus assumes the reader is already very knowledgeable in reactor design and thermal-hydraulic principles. The editor notes in the preface that the material "grew out of an advanced course," and is intended to "provide guidance to practitioners." Much of the contents of the book can be found in Sec. 15 of a Final Safety Analysis Report for a nuclear station, written to meet requirements of Chap. 15 of the NRC *Standard Review Plan* (NUREG-0800). Many of the practitioners for whom the book is presumably written will already be familiar with such material. For the uninitiated, there is inadequate detail in the book about methods of analysis, the computer codes, and calculation methods.

Although the book was published in 1985, most of the references are dated 1981 and earlier, suggesting that a minimal updating was made for this publication. As such, it fails to reflect the major new efforts in "source term" analysis, calculation methods, and results. The final chapter gives the impression that the consequences of a meltdown are very poorly understood, in contrast with the more recent favorable state-of-the art information, for example as in NUREG-0956 (1985). There is only casual mention of NRC's interest in the degraded core topic, and no indication that the nuclear industry was investigating the subject in the IDCOR program, which was nearly completed by the time the book came out. Central to any relevant reactor safety analysis are topics such as chemical aspects of fission product release and retention, and radiation doses due to exposure to radioactive materials. These topics are covered in the *Reactor Safety Study* (WASH-1400) but are ignored or avoided in this book. The phrase "source term" does not appear in the index, and may not be in the book at all. In view of the keen interest in the consequences of major core damage on the part of the industry, the NRC, and the public, it might have been better for the editor and the authors to take the necessary time to update their material, postponing publication for as long as a year if necessary.

Raymond L. Murray received degrees in science education and physics at the University of Nebraska and the University of Tennessee, respectively. He was a researcher and supervisor in the Manhattan Project, and served as active faculty member in nuclear engineering at North Carolina State University for 30 years. He is a charter member and Fellow of the American Nuclear Society, and recipient of the Arthur Holly Compton Award. Dr. Murray is the author of a number of books in nuclear technology, including Nuclear Energy *(1980) and* Understanding Radioactive Waste *(1983). He is currently a consultant to Bechtel Power Corporation on criticality prevention at Three Mile Island Unit 2, is a member of the Institute of Nuclear Power Operations' Advisory Council, serves on the North Carolina Radiation Protection Commission, and is busy with writing and lecturing.*

Nuclear Energy—A Sensible Alternative

Editors	Karl O. Ott and Bernard I. Spinrad
Publisher	Plenum Publishing Corporation (1985)
Pages	386
Price	$25.00
Reviewer	Gerald A. Schlapper

As stated in the forward by E. L. Zebroski, the articles contained in this volume were written by professionals who are concerned that the myths associated with the use of