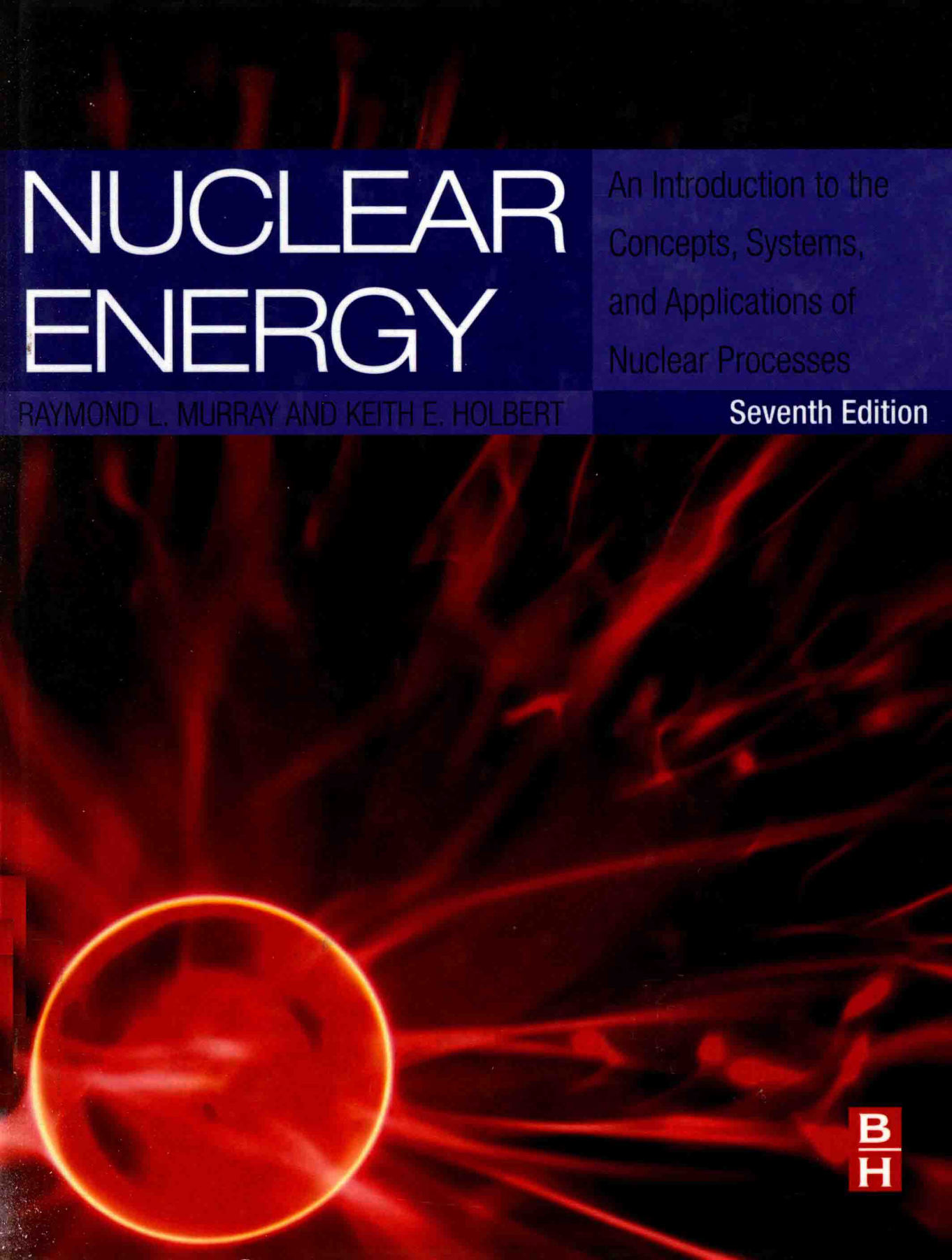
NUCLEAR ENERGY

An Introduction to the Concepts, Systems, and Applications of Nuclear Processes

RAYMOND L. MURRAY AND KEITH E. HOLBERT

Seventh Edition



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About the Authors

Raymond L. Murray (Ph.D., University of Tennessee, 1950) was a long-time faculty member in the Department of Nuclear Engineering of North Carolina State University. Professor Murray studied under J. Robert Oppenheimer at the University of California at Berkeley. In the Manhattan Project of World War II, he contributed to the uranium isotope separation process at Berkeley and Oak Ridge. In the early 1950s, he helped found the first university nuclear engineering program and the first university nuclear reactor. During his 30 years of teaching and research in reactor analysis at North Carolina State, he taught many of our leaders in universities and industry throughout the world. He was the author of textbooks in physics and nuclear technology and the recipient of a number of awards, including the Eugene P. Wigner Reactor Physicist Award of the American Nuclear Society in 1994. He was a Fellow of the American Physical Society, a Fellow of the American Nuclear Society, and a member of several honorary, scientific, and engineering societies. After retirement from the university, Dr. Murray was a consultant on criticality for the Three Mile Island Recovery Program, served as chairman of the North Carolina Radiation Protection Commission, and served as chairman of the North Carolina Low-Level Radioactive Waste Management Authority. He provided an annual lecture at MIT for the Institute of Nuclear Power Operations.

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Keith E. Holbert (Ph.D., University of Tennessee, 1989) is presently an Associate Professor in the School of Electrical, Computer and Energy Engineering at Arizona State University. His research expertise is in the area of instrumentation and system diagnostics including radiation effects on sensors. Dr. Holbert has performed tests on safety-related systems in more than a dozen nuclear power plants in the United States. He has published more than 100 journal and conference papers, a textbook, and holds one patent. Dr. Holbert is a registered professional (nuclear) engineer. He is a member of the American Nuclear Society and a Senior Member of the IEEE. Dr. Holbert holds a Guest Scientist affiliation with Los Alamos National Laboratory. As the Director of the Nuclear Power Generation Program at ASU, Professor Holbert teaches undergraduate and graduate engineering courses on electric power generation (from all forms of energy), nuclear reactor theory and design, nuclear power plant controls and diagnostics, reactor safety analysis, and health physics and radiation measurements. Dr. Holbert has been the recipient of multiple teaching awards. Keith is a Christian, who ascribes to the doctrine that God has entrusted humanity with good stewardship of His creation.

Preface

Professor Raymond L. Murray (1920–2011) authored six editions of this textbook until his death. Standing on the shoulders of his work, I have humbly attempted to expand the coverage and depth of the material while keeping with its original intent. As stated in the preface to the first edition (1975), the book "is designed for use by anyone who wishes to know about the role of nuclear energy in our society or to learn nuclear concepts for use in professional work." The continued hope is that the book will benefit both (future) nuclear professionals and interested members of the public.

For the first time in recent memory, the United States is projected to be energy independent by ~2040, largely due to increased domestic production of petroleum and natural gas. However, by many accounts, humanity stands at a crossroads, with self-inflicted stresses due to population growth and anthropogenic climate change. Simultaneously, the quality of life is enhanced through the availability of economic energy sources. Trends show electricity being increasingly tapped as the end-use energy form. Another challenge is the competitive collaboration between two critical resources—the energy-water nexus.

Nuclear reactors are planned that combat global warming, conserve nuclear fuel, support desalination, and produce hydrogen for transportation. The construction and plans for new nuclear power plants continue worldwide despite the events at Fukushima in 2011. In what is called a nuclear revival, many utilities in the United States have applied to the Nuclear Regulatory Commission for license extension and approval for new reactor construction.

Besides nuclear power generation, associated technologies are utilized in a variety of applications including nuclear medicine and smoke detectors. Furthermore, since the terrorist attacks of 2001, radiation detectors have been installed at ports of entry worldwide to intercept illicit shipments of nuclear materials.

Like politics and religion, the subject of nuclear energy generates heated debate in certain circles. Hence, a purpose of this book must be to bring factual information to the discussion. Topics that seem to generate the most concern inevitably include the persistent nuclear waste issue, nuclear power plant safety, radiation, and atomic weapons. Therefore, the authors are compelled to devote coverage to these (sometimes controversial) areas.

Those familiar with earlier editions will quickly realize that the ordering of chapters in the last two-thirds of the textbook has changed noticeably. Part I retains its focus on foundational nuclear concepts. Part II is now devoted to topics concerning radiation and its generation, effects, and utilization; whereas Part III is aligned to nuclear power generation. Besides changes to the organizational structure, significant amounts of up-to-date nuclear data have been added (e.g., see Appendix A), thereby increasing the utility of this book as a reference.

Student learning is enhanced by performing calculations and analyses on nuclear quantities. This edition provides Exercises, solvable by handheld calculator, with final answers given in Appendix B. In addition, MATLAB programs and Excel spreadsheets for the solution of computer exercises in the text can be downloaded from *http://booksite.elsevier.com/9780124166547/*.

Persons providing valuable ideas and information are recognized at appropriate places in the book. The author welcomes any constructive comments and corrections to the text (holbert@asu.edu).

Keith E. Holbert
Tempe, Arizona, 2013

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