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0521553059 - Practical Applications of Radioactivity and Nuclear Radiations: An Introductory Text for Engineers, Scientists, Teachers and Students - G. C. Lowenthal and P. L. Airey

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PRACTICAL APPLICATIONS OF RADIOACTIVITY AND NUCLEAR RADIATIONS

This book introduces selected examples from the numerous applications of radioisotopes and ionising radiations to engineering and environmental sciences and technologies. In addition, it serves teachers and students as an introductory course in nuclear sciences.

The early chapters introduce the properties of radionuclides, radioactive sources, ionising radiations, detectors and instrumentation, and how they are used. Also described are the methods for obtaining accurate count rate measurements allowing for the statistics of radioactive decays. Later chapters introduce applications to mining, mineral processing, petroleum refining, contaminant transport, borehole logging, fluid flow measurements and to the assessment of sites for radioactive waste disposal. The fact that different radiotracers can be used to separately label and study different components of complex systems is an outstanding example of their versatility.

This book will be of particular interest to scientists, technologists, teachers and students, helping them to work with radioisotopes safely, efficiently and reliably.

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Since the 1960s, Drs Lowenthal and Airey served on the research staff of the Australian Nuclear Science and Technology Organisation, ANSTO (formerly the Australian Atomic Energy Commission, AAEC), where Dr Airey continues to hold a senior position.

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PRACTICAL APPLICATIONS OF RADIOACTIVITY
AND NUCLEAR RADIATIONS

*An introductory text for engineers, scientists,
teachers and students*

G. C. LOWENTHAL
University of New South Wales

P. L. AIREY
Australian Nuclear Science and Technology Organisation



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Foreword

I welcome the publication of the book *Practical Applications of Radioactivity and Nuclear Radiations – An introductory text for engineers, scientists, teachers and students* by Drs Gerhart Lowenthal and Peter Airey.

This book aims to provide readily accessible information on the applications of nuclear science and technology to industry, the environment and scientific research. It is tailored to students and non-specialists who seek to be informed, and may eventually wish to contribute to this world-wide endeavour. Emphasis is placed on the science underpinning the applications.

An objective of international bodies such as the Forum for Nuclear Cooperation in Asia (FNCA) and the International Atomic Energy Agency (IAEA) is to extend the benefits of nuclear related technologies across national boundaries. One of the authors (P.A.) was involved for a number of years in this endeavour through the IAEA.

I am pleased to endorse this book as a further step in this on-going quest.

Dr Sueo Machi

FNCA Coordinator, Japan

Former Deputy Director General, Nuclear Science and Applications,
IAEA

The discovery of X rays and radioactivity in the 1890s had a profound effect on the century which was to follow. After more than one hundred years of endeavour which has been both marred by conflict and enriched by high achievement, we enter the new millennium with a more mature understanding of the benefits that nuclear technology can bring to mankind. These extend to medicine, agriculture, industry, the environment and the exploration for natural resources.

The potential for nuclear and isotope techniques to contribute to the

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advance of scientific knowledge appears unbounded. As shown by examples in the book, these techniques contribute to our understanding of the structure of modern materials, the dynamics of biological systems, the complexity of many ecosystems and the dating of terrestrial processes from the recent past back almost to the formation of the earth.

This book is written for students and non-specialist scientific workers and aims to raise the awareness of the practical application of isotopes and radiation to industry and the environment. I support its publication. I believe that people everywhere will continue to benefit from the safe applications of nuclear science and technology in the years ahead.

Professor Helen M. Garnett

Chief Executive

Australian Nuclear Science and Technology Organisation.

Preface

Radionuclides and the emitted radiations have long been applied routinely throughout all branches of engineering and the technologies to obtain useful results, many of which could not have been obtained by other means.

As with the application of any other tool or technique, problems can be encountered. Practitioners working with radioactivity face health risks but long-standing records show that, overall, risks in the nuclear industries have been consistently smaller than those faced by workers in most other industries. This is so not least thanks to easily followed, legally backed precautions, developed over the decades to ensure safe operating conditions during all nuclear radiation applications carried out within the common sense rules devised for that purpose.

This book was written for workers and students as yet largely unfamiliar with the nuclear sciences and with the advantages in numerous fields which quickly become apparent on employing nuclear radiations. The potential of nuclear science and engineering for enhancing, e.g. the effectiveness of nuclear power production and of radioactive tracers is far from exhausted. Today's beginners could have a highly rewarding way ahead of them.

A useful overview of the contents can be readily obtained by scanning the chapter and section headings in the table of Contents. The bibliography contains over 120 references to assist practitioners looking for more detailed and/or more specialised information than could be included here. The latest information about nuclear data and specialist techniques is available via the Internet, with web sites and other comments listed in Appendix 3.

One of us (P.A.) spent four years with the International Atomic Energy Agency (Vienna, Austria) involved with the applications of radioisotopes and radiation to industry, medicine, agriculture and the environment in Asia and the Pacific. The knowledge and dedication of many colleagues both at the

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IAEA and in its Member States experienced during these years and since has greatly benefited the writing of this book.

We gratefully acknowledge the contributions from many colleagues who read sections of this text, making constructive suggestions and pointing out inadequate explanations and errors. There is Dr D.D. Hoppes, formerly of the USA National Institute of Standards and Technology, Gaithersburg (NIST), USA and Dr J.S. Charlton, former General Manager, Tracerco (Australasia). To our regret we can no longer thank Dr A. Rytz, formerly of the International Bureau of Weights and Measures (BIPM), Paris, France, who died early in 1999 and is sadly missed. Overseas colleagues who helped us materially with abstracts from their publications were Dr W.B. Mann (NIST, USA), Dr K. Debertin (Germany), and Drs T. Genka, H. Miyahara, Y. Kawada, Y. Hino and Professor T. Watanabe (Japan).

We are deeply indebted to colleagues at the Australian Nuclear Science and Technology Organisation (ANSTO) of Lucas Heights, NSW, who have been engaged on applications of nuclear radiations for two and more decades and assisted us in numerous ways. In particular, advice on X and gamma ray spectroscopy came from Dr D. Alexiev and Mr A.A. Williams. Special thanks are due to the radiotracer team at ANSTO, including Mr T. Kluss, Dr C. Hughes and Mr G. Spelman. Assistance came also from Dr B. Perczuk, School of Physics, University of New South Wales.

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A very special “thank you” goes to the extremely helpful and valuable secretarial assistance from Mrs Diane Augee, also at the School of Mechanical and Manufacturing Engineering, UNSW. Mrs Augee could not protect us from our oversights though she did so in a good many cases. She always made sure that the text was throughout well arranged, clearly expressed and correctly spelled.

We acknowledge with most sincere gratitude support over the many years while writing this book from the Chief Executive, ANSTO (Professor H.M. Garnett) and the Director, Environmental Division, ANSTO (Professor A. Henderson-Sellers), and from the School of Mechanical and Manufacturing Engineering, UNSW (Professor B.E. Milton and later Professor K.P. Byrne)

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and the Dean of Engineering (Professor M.S. Wainwright). G.L. also received substantial support at the Department of Positron Emission Tomography and Nuclear Medicine, Royal Prince Alfred Hospital, Sydney (Professor M.J. Fulham and earlier Professor J. Morris). Finally, our apologies go to colleagues whom we failed to mention, to our readers who will have to put up with remaining errors, and to our wives who put up with the demands the book made on our time and assisted us in every way.