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This edition of *Fundamentals of Industrial Hygiene* presents original new chapters on Particulate Matter (Chapter 8), Ionizing Radiation (Chapter 11), Personal Protective Equipment (Chapter 23), Environmental Health and Safety (Chapter 28), Government Regulations (Chapter 30), and International Developments in Occupational Safety and Health (Chapter 31). All other chapters have been extensively updated and revised.

The primary purpose of this book is to provide a reference for those who have either an interest in or a direct responsibility for the recognition, evaluation, and control of occupational health hazards. Thus, it is intended to be of use to industrial hygienists, industrial hygiene students, physicians, nurses, safety personnel from labor and industry, labor organizations, public service groups, government agencies, and manufacturers. Others who may find this reference helpful include consultants, engineers, architects, lawyers, and allied professional personnel who work with those engaged in business, industry, and agriculture. It is hoped that this book will be of use to those responsible for planning and carrying out programs to minimize occupational health hazards.

*Fundamentals of Industrial Hygiene* is also intended to be used either as a self-instructional text or as a text for an industrial hygiene fundamentals course, such as the ones offered by the National Safety Council, various colleges and universities, and professional organizations.

The increase in the number and complexity of substances found in the workplace—substances that may spill over into the community environment—makes imperative the dissemination, as efficiently and conveniently as possible, of certain basic information relating to occupational health hazards and resultant occupational diseases.

We would like to gratefully acknowledge the work of the contributors to this book. They are all highly skilled and expert occupational health professionals.

I would like to very gratefully acknowledge the work of editor Patricia J. Quinlan whose professional knowledge, organizational prowess, and dogged determination helped us finish this edition. And I also so thankfully acknowledge the work of project editor Carolyn Chmiel. She is new to our team, jumped in after the project began, and her professionalism and tireless attention to technical detail has helped to produce the best edition yet.

Barbara A. Plog, MPH, CIH, CSP
Editor in Chief
July 2012
Dedication

This book is dedicated in loving memory to:
Doris J. Plog, medical secretary and dedicated backbone of the kidney transplant unit
at the Tucson Veterans Administration Hospital
Henry J. Plog, airplane mechanic at Davis Monthan AFB and firefighter for the Tucson Fire Department

and

Edward W. Quinlan, retired U.S. Army Lt. Colonel and budget analyst for the
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Lillian M. Quinlan, wonderful mother and tireless volunteer in her church and community
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Susan Raterman, CIH, is the founder and President of The Raterman Group, Ltd., an industrial hygiene and environmental hazard consulting firm. The Raterman Group, Ltd. specializes in the areas of comprehensive industrial hygiene consulting, asbestos and lead hazard assessments and remediation oversight, indoor air quality evaluations, green/healthy building practices, and infec-
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Pete Rice, CIH, CSP, REHS, has 35 years of experience in developing, implementing, and supervising environmental and occupational safety and industrial hygiene programs, both domestic and international. He has participated in the recognition, evaluation, and control of safety and health practices and procedures on hundreds of various industrial, construction, and waste cleanup projects involving chemical, physical, biological, ergonomic, and safety hazards. In addition, Mr. Rice has been partly responsible for developing Cal/OSHA health standards for respiratory protection, ventilation, hazard communication, and asbestos. Mr. Rice currently serves as the Director for Environmental, Health, and Safety Programs for Ahtna Inc. and for ClickSafety (www.clicksafety.com), a leader in distance occupational safety and health learning, Mr. Rice teaches industrial hygiene and safety at the university level (University of California-Berkeley) and has trained numerous industrial hygienists and safety professionals. He formerly acted as the senior technical industrial hygienist, safety professional, and chief training officer for Cal/OSHA. Additionally, Mr. Rice has published numerous articles and book chapters, provided expert opinions and supported volunteer organizations in pursuit of improved occupational and environmental health and safety in both the business world and public health. He is Certified Industrial Hygienist, American Board of Industrial Hygiene 1981, No. 2156; Certified Safety Professional, Board of Certified Safety Professionals 1984, No. 7287; Registered Environmental Health Specialist, California 1977, No. 4265; California Community College Instructor Credential; MS, Environmental and Occupational Health and Safety, California State University, Northridge, 1977; BS, Environmental Health and Biology, California State University, Northridge, 1976.

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Jennifer Silk is an occupational safety and health consultant, and a training advisor to the United Nations Institute for Training and Research. She is retired OSHA, where she was the Deputy Director of Standards and Guidance. Jennifer was the team leader for development of the original Hazard Communication Standard. She represented the U.S. Government in negotiations to develop the Globally Harmonized System of Classification and Labeling of Chemicals, chaired the international coordinating group that managed development of the GHS, and served as the U.S. expert to the United Nations Subcommittee of Experts on the GHS.

Philip Smith, PhD, CIH, is a graduate of Brigham Young University (BS, Zoology, 1984), and the University of California, Berkeley (MPH, Environmental Health Science, 1987). He has been engaged in field industrial hygiene since 1987 when he began his career as an Industrial Hygiene Officer in the U.S. Navy. He has been a Certified Industrial Hygienist since 1993, and completed requirements for the PhD degree in toxicology at Utah State University in 1998. He served as a full-time faculty member in the graduate program at the Uniformed Services University of the Health Sciences in Bethesda, MD, between 1998 and 2003, and again from 2007 to 2010. While there he directed the research work of a number of doctoral and masters degree students, and participated in the successful reaccreditation of the university’s MSPH degree program by ABET. He also worked with the U.S. Marine Corps Chemical Biological Incident Response Force to develop methods to rapidly detect and identify chemical warfare agents and degradation products using gas chromatography-mass spectrometry in the field, and delivered training to the unit’s mobile laboratory operators to complete this mission. After completing more than 23 years of service in the Navy, Dr. Smith joined the U.S. Department of Labor as a member of the OSHA Health Response Team in 2010. He has authored or coauthored more than 40 peer-reviewed papers or book chapters related to his academic interests, which include laboratory methods and real-time detection techniques that provide high-certainty information to protect human health and the environment, including gas chromatography, mass spectrometry, and field-friendly sampling and analysis methods such as solid phase microextraction and thermal desorption. He has served twice as the chair of the AIHA Real-Time Detection Systems Committee.

Jack Standard, CIH, CSP, is a private consultant who worked for the majority of his career as an instructor and curriculum developer at OSHA's Directorate of Training and Education. He developed curriculum and instructed in many OSHA Training Institute courses in subject areas including industrial hygiene, safety standards for compliance officers, noise, hazardous materials, and respiratory protection. Mr. Standard continues to be the principal instructor in OSHA's Industrial Noise course. Prior to his career at OSHA, he was a noise control engineer in private industry.

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Michael Yost, MS, PhD, is a Professor in the Department of Environmental and Occupational Health Sciences at the University of Washington, as well as the Director of the Exposure Sciences program. His interests include optical remote sensing of chemicals in the environment, and physical agents, such as noise, vibration, and nonionizing radiation, in the workplace. Prior to joining the University of Washington in 1993, Dr. Yost was a Research Industrial Hygienist and a Lecturer in the School of Public Health at the University of California, Berkeley. He also served as a Reader at University of California-Berkeley’s Department of Electrical Engineering. Dr. Yost’s current research projects focus on developing novel tools for environmental and occupational exposure assessment.

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