

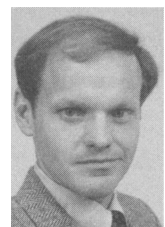
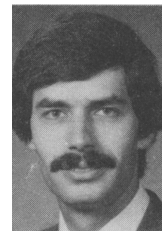
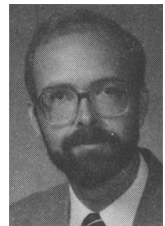
## AUTHORS — MARCH 1989

### PROBABILISTIC SAFETY ASSESSMENT AND RISK MANAGEMENT

#### RISK-BASED ANALYSIS METHODS APPLIED TO NUCLEAR POWER PLANT TECHNICAL SPECIFICATIONS

**David P. Wagner** (top) (ME, nuclear engineering, University of Tennessee, 1977) is a senior research scientist for the Columbus Division of Battelle Memorial Institute (BMI). He was principal investigator for the Electric Power Research Institute (EPRI)-sponsored research program on risk-based evaluation of nuclear power plant technical specifications. His current responsibilities include development and application of probabilistic risk methods in the nuclear power, chemical process, and aerospace industries. **Larry A. Minton** (center) (BS, engineering science, University of Cincinnati, 1982) is a research scientist for the Columbus Division of BMI. His responsibilities include designing and implementing the risk-based methods used in the SOCRATES computer program. His current interests include software and risk assessment methods development for the chemical and nuclear industries. **John P. Gaertner** (bottom) (BS, physics, Indiana University of Pennsylvania; MS, meteorology, Massachusetts Institute of Technology) is a project manager in the Systems Reliability Analysis Program of the Nuclear Power Division of EPRI. He has managed projects in the areas of nuclear plant risk assessment, maintenance analysis, and technical specifications improvement. He is the coordinator of Tech Spec related research at EPRI and a member of the NUMARC working group for Tech Spec Improvement. Prior to joining EPRI in 1983, he worked for Duke Power Company in the areas of environmental and nuclear risk assessment.

*David P. Wagner  
Larry A. Minton  
John P. Gaertner*



#### ANALYSIS AND QUANTIFICATION OF COMMON-CAUSE FAILURES ON THE BASIS OF OPERATING EXPERIENCE

**B. Thierry Meslin** (PhD, National Institute of Nuclear Science and Technology, Saclay, France, 1978) is an engineer in the operating department of the Nuclear and Fossil Generation Division of Electricité de France. His current activities involve the development of on-line computerized systems. Since 1984, he has been responsible for providing the operational data of the Paluel probabilistic safety analysis.

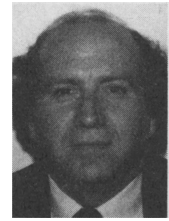
*B. Thierry Meslin*



## COMPARISON BETWEEN CANADIAN PROBABILISTIC SAFETY ASSESSMENT METHODS FORMULATED BY ATOMIC ENERGY OF CANADA LIMITED AND PROBABILISTIC RISK ASSESSMENT METHODS

**Hymie Sol Shapiro** (top) (BEng, chemical engineering, McGill University, Quebec, Canada; PEng and MA Sc, chemical engineering, University of Waterloo, Ontario, Canada, 1977) is a reliability engineering supervisor in the Safety Branch of the CANDU-3 project of Atomic Energy of Canada Limited (AECL). He joined AECL in 1975. He is responsible for performing probabilistic safety assessment (PSA) activities on the CANDU-3 project. He has 13 years of experience in nuclear power plant design, 8 years in performing PSAs, 3 years of procuring nuclear grade heat exchangers and pressure vessels, and 2 years of process design. **James Edward Smith** (BSc and PEng, mechanical engineering, University of Surrey, England, 1967) is a reliability engineering specialist in the Licensing and Risk Branch of AECL. He joined AECL in August 1981 and is responsible for formulating the company's current approach to performing PSA studies. He has 17 years of practical experience in performing reliability and safety analyses in such diverse projects as nuclear power plants, commercial aircraft, and copying machines.

*Hymie Sol Shapiro  
James Edward Smith*



## QUANTIFICATION OF DYNAMIC HUMAN ERROR PROBABILITIES IN TERMS OF SAMPLED TIMING DATA

**Yean-Chuan Yeh** (top) (PhD, nuclear engineering, Rensselaer Polytechnic Institute, 1984) is currently employed as a staff engineer at the Atomic Energy Council (AEC), Taiwan. He is responsible for the development and application of the analytical techniques and tools in support of the safety and reliability assessments carried out within the Nuclear Regulatory Division of the AEC. His recent research interests are in nuclear system reliability, risk analysis, and human factor evaluation. **Jyh-Tong Teng** (PhD, mechanical engineering, University of California, Berkeley, 1978) is an associate professor in the Department of Mechanical Engineering, Chung Yuan Christian University (CYCU). Before joining CYCU in 1987, he worked for 10 years at the General Electric Nuclear Energy Division. He has worked on a variety of projects including transient method development, emergency core cooling system/containment/plant safety evaluations, and probabilistic risk assessment. His current interests are in system thermal-hydraulic modeling and radionuclide source term evaluation.

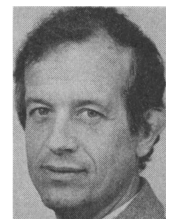
*Yean-Chuan Yeh  
Jyh-Tong Teng*



## OVERVIEW OF THE ELECTRIC POWER RESEARCH INSTITUTE RESEARCH PROGRAM ON COMMON-CAUSE FAILURES

**David H. Worledge** (top) (PhD, 1970, and BSc, 1967, University of Birmingham, United Kingdom) is the manager of the Risk Assessment Program, Nuclear Power Division, at the Electric Power Research Institute (EPRI), creating and managing a program of research projects to enhance the safety and availability of U.S. nuclear power plants. **Ian B. Wall** (ScD, Massachusetts Institute of Technology, 1964; BSc Eng., Imperial College of Science and Technology, United Kingdom, 1958) is the senior program manager for the Source Term Program, Nuclear Power

*David H. Worledge  
Ian B. Wall*



Division, at EPRI. He was previously chief of the Probabilistic Analysis Branch of the U.S. Nuclear Regulatory Commission Office of Nuclear Regulatory Research.

#### **A MODULAR STEADY STATES APPROACH FOR FUEL CYCLE FACILITY PROBABILISTIC RISK ASSESSMENT**

**Hans J. Wingender** (top) [Dr. phil. nat., nuclear physics, University of Frankfurt, Federal Republic of Germany (FRG), 1971] is head of the safety engineering department at NUKEM GmbH, Hanau, FRG. He previously worked in the education and training field at the Institute for Information and Training Systems at Darmstadt and with Daimler Benz AG in Stuttgart for 3 years. He joined NUKEM in 1974 and has been involved in the safety planning and construction of fuel cycle facilities from enrichment to final repository, excluding reactors. His interests are in making probabilistic risk assessment an operational tool for safety engineering, particularly in these areas. **R. Leicht** (Dr. rer. nat., nuclear physics, Max-Planck-Institute, FRG, 1975; Diploma, physics, University of Mainz, FRG, 1973) is a physicist in the safety engineering department at NUKEM GmbH, Hanau, FRG, where he is the group leader of the safety analysis group. His interests are in system reliability and risk and data analysis.

*Hans J. Wingender  
R. Leicht*



#### **TREATING DATA UNCERTAINTIES IN COMMON-CAUSE FAILURE ANALYSIS**

**Nathan Siu** (top) (MS, 1980, and PhD, 1984, nuclear engineering, University of California, Los Angeles) teaches and conducts research in the field of probabilistic risk and reliability assessment as an assistant professor of nuclear engineering at the Massachusetts Institute of Technology. He is currently interested in the analysis of dependencies during accident scenarios and the treatment of uncertainties. **Ali Mosleh** (MS, 1978, and PhD, 1981, nuclear engineering, University of California, Los Angeles) is an assistant professor of nuclear engineering at the University of Maryland, where he teaches and conducts research in the field of probabilistic risk and reliability of engineering systems. His research interests include analysis and modeling of common-cause failures, mechanism data analysis, and the development of expert systems.

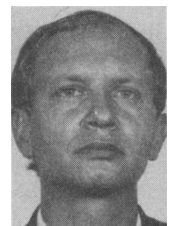
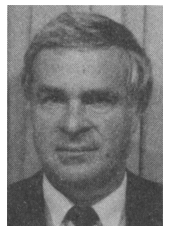
*Nathan Siu  
Ali Mosleh*



#### **PROBABILISTIC RISK ASSESSMENT RELATED TO MULTIPLE RUPTURES OF STEAM GENERATOR TUBES**

**Michel Bloch** (top) (Ecole Polytechnique, France, 1952; PhD, physics, California Institute of Technology, 1958) is a senior risk analyst at the Institut de Protection et de Sécurité Nucléaire (IPSN), Commissariat à l'Energie Atomique (CEA). After working on high-energy experimental physics, he joined IPSN in 1982 and participated in the safety analysis of Superphénix, a French liquid-metal fast breeder reactor. His current research interests are in probabilistic safety assessment techniques and aging safety aspects. **Daniel Dussarté** (center) (engineer, nuclear engineering, Institut National des Sciences et Techniques Nucléaires, Paris, 1980) works on safety analysis of French pressurized water reactors at the IPSN, CEA. His principal activities are in risk analyses of primary circuit mechanical equipment. **Jean-Louis Pierrey** (bottom) (engineer, Ecole Centrale des Arts et Manufactures, France, 1974) is head of the mechanical equipment analysis branch of the Department of Safety Analysis, which provides technical support for the French safety regulatory authority.

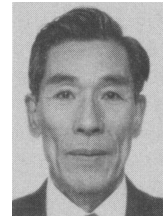
*Michel Bloch  
Daniel Dussarté  
Jean-Louis Pierrey*



**THE GO-FLOW METHODOLOGY: A RELIABILITY ANALYSIS OF THE EMERGENCY CORE COOLING SYSTEM OF A MARINE REACTOR UNDER ACCIDENT CONDITIONS**

**Takeshi Matsuoka** (top) (BSc, physics, Tokyo Institute of Technology, Japan, 1968; MS, physics, University of Tokyo, Japan, 1970; DEng, nuclear engineering, University of Tokyo, Japan) is a senior researcher of the Safety Section of Nuclear Technology Division at the Ship Research Institute in Tokyo, Japan. He studied at the Massachusetts Institute of Technology from 1979 to 1980. His research interests are in system reliability, risk analysis, and human factors. **Michiyuki Kobayashi** (center) (BEng, electrical engineering, Tokyo Electrical Engineering College, Japan, 1965) is chief of the Safety Section of Nuclear Technology Division at the Ship Research Institute. His research interests are in system reliability, plant dynamics and control of a marine nuclear plant. **Kazuo Takemura** (bottom) (Marine Engineer, Tokyo Nautical College, Japan, 1944) is chair of the Committee of Nuclear Ship in the Shipbuilding Research Association of Japan. He was a professor in charge of nuclear ship engineering at the Tokyo University of Mercantile Marine. His research interests are in nuclear system reliability and risk analysis.

*Takeshi Matsuoka  
Michiyuki Kobayashi  
Kazuo Takemura*



**THE USE OF ABNORMAL EVENT DATA IN NUCLEAR POWER REACTOR SYSTEM ANALYSIS USING THE SEQUENCE COMBINING METHOD**

**Henk W. Kalfsbeek** (MS, physics, 1974, and PhD, plasma physics, 1979, University of Utrecht, Netherlands) has been a member of the scientific staff at the Joint Research Centre, Ispra, since 1983. His current research activities involve the development of methods for the design and operation of data collection systems and methods of data analysis.

*Henk W. Kalfsbeek*



**SEAL LOSS-OF-COOLANT ACCIDENT AND RECOVERY ACTIONS FOLLOWING LOSS OF COMPONENT COOLING WATER**

**Shih-Kuei Cheng** (PhD, nuclear engineering, Massachusetts Institute of Technology, 1984) is a principal engineer of the Probabilistic Risk Assessment (PRA) Team at the Atomic Energy Council in Taiwan. He has been working on PRA projects for the nuclear power plants in Taiwan since 1985. His current research activities involve development of containment event tree and source-term calculations for the Chinshan nuclear power plant, which is a boiling water reactor (BWR)-4 with Mark-I containment.

*Shih-Kuei Cheng*



**USE OF PROBABILISTIC RISK ASSESSMENT AND ECONOMIC RISK AT THE PLANT DESIGN STAGE: AN APPLICATION**

**Selim Sancaktar** (top) (PhD, physics, Virginia Polytechnic Institute, 1975) is a principal engineer in the product risk analysis group in the Westinghouse Electric Corporation nuclear safety department. Previously, he was a faculty member in the nuclear engineering field. His current activities involve technical management of and contribution to projects involving application of probabilistic risk assessment (PRA) techniques to plant safety and licensing issues. **David R. Sharp** (PhD, electrical engineering, Carnegie-Mellon University, 1970) is the manager of the product risk analysis group in the Westinghouse Electric Corporation

*Selim Sancaktar  
David R. Sharp*

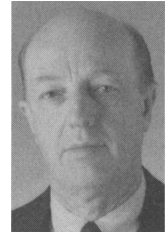


nuclear safety department. He has been involved in applications of PRA methods to various programs for nuclear and non-nuclear facilities both in the United States and abroad.

### LESSONS LEARNED FROM 21 NUCLEAR PLANT PROBABILISTIC RISK ASSESSMENTS

**B. John Garrick** (BS, physics, Brigham Young University, 1952; Diploma, nuclear reactor technology, Oak Ridge School of Reactor Technology, 1954–1955; MS, 1962, and PhD, 1968, engineering and applied science, University of California, Los Angeles) is president and chief executive officer of Pickard, Lowe and Garrick, Inc. (PLG). He has been a leader in the development and implementation of quantitative methods of risk analysis, risk management, and reliability analysis in the fields of nuclear power, aerospace, and chemical processing. He has directed more than 30 major probabilistic risk assessments in these three industries—more than any other worker in the field. His experience consists of 13 years at PLG (engineering, applied science, and management consulting), 18 years at Holmes & Narver, Inc. (technology, engineering, and construction), and 5 years with the U.S. Atomic Energy Commission. He has served on numerous national and international scientific and technical committees and special panels for the National Academy of Sciences, the International Atomic Energy Agency, the Congressional Office of Technology Assessment, the Accreditation Board for Engineering and Technology, and numerous other topic and company-specific committees and advisory panels.

*B. John Garrick*

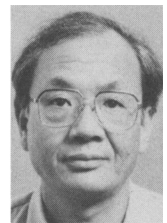


### FISSION REACTORS

#### PANCAKE CORE HIGH CONVERSION LIGHT WATER REACTOR CONCEPT

**Yukio Ishiguro** (top) (BS, physics, Kanazawa University, Japan, 1959; Dr. Eng., University of Kyoto, Japan) is a principal engineer at the Japan Atomic Energy Research Institute (JAERI). He is a head of the reactor system laboratory and is responsible for the conceptual design for the high conversion light water reactor (HCLWR). **Keisuke Okumura** (MS, nuclear engineering, University of Nagoya, Japan, 1986) is a researcher on the reactor system laboratory staff at JAERI. His current interests are in nuclear design and calculational schemes for HCLWRs.

*Yukio Ishiguro  
Keisuke Okumura*



### FUEL CYCLES

#### FOUR-BATCH FUEL MANAGEMENT WITH PLUTONIUM RECYCLING

**Corinne Bangil** (right) (MS, physics, University of Perpignan, France, 1983; Degree, nuclear engineering, Institut National des Sciences et Techniques Nucléaires, France, 1985) works in the fields of neutronics, fuel cycle research, and reactor operation.

*Corinne Bangil  
Gérard Gambier  
Michel Soldevila*



**Gérard Gambier** (top) (MS, physics, University of Paris, France, 1964; Degree, engineering, Ecole Supérieure d'Electricité, France, 1966; PhD, nuclear engineering, University of Paris, France, 1974) is deputy head of the Reactor Physics Section at Electricité de France (EdF). He has worked in research and development of high-temperature reactors. He is currently working on conventional and advanced light water reactors together with fast breeders. His main interests and activities are in neutronics, fuel cycle, thermohydraulics, and reactor operation. **Michel Soldevila** (bottom) (MS, physics, University of Paris, France, 1975; PhD, nuclear engineering, University of Paris, France, 1978) works at EdF in the area of pressurized water reactor physics. His main interests and activities are in fuel cycle research and neutronics. He has been involved in plutonium recycling studies performed at EdF.

