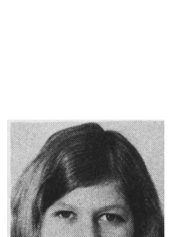
nuclear technology®

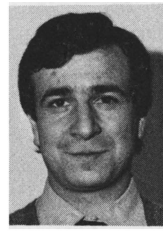
AUTHORS — OCTOBER 1982

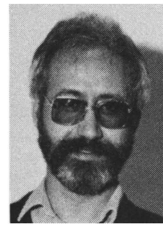
FISSION REACTORS

TRITIUM ANALYSIS OF IRRADIATED BURNABLE POISON RODS

Filippo D'Annucci
Elma Beth S. Pardue
Wilfried Rommelaere
Günter Bäro



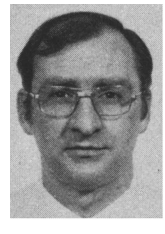
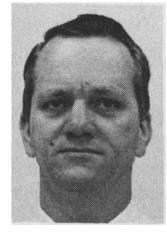




Filippo D'Annucci (top right) [PhD, physics, University of Pisa, Italy, 1974; Dr. Ing., University of Karlsruhe, Federal Republic of Germany (FRG), 1979] has been working with the Materials and Development Core Components Group of Brown Boveri Reaktor GmbH (BBR) since 1979. He is mainly engaged in problems concerning the behavior of nuclear materials and postirradiation examination (PIE) results. **Elma Beth S. Pardue** (top left) (BS, materials engineering, North Carolina State University, 1977; MMS, material science, University of Virginia, 1980) is an engineer in the Special Materials Projects Group of the Nuclear Materials Technology Section at the Babcock & Wilcox Lynchburg Research Center. Her primary activities in this group are advanced technology research on materials and failure analysis. **Wilfried Rommelaere** (bottom right) (Aggregaat HMO Mathematics, physics and economics, Torhout, Belgium, 1967) has been working with the nuclear engineering group of BBR. His main interests are the mathematical aspects of nuclear engineering problems. **Günter Bäro** (bottom left) (PhD, physics, University of Göttingen, FRG, 1971) is the supervisory engineer of the Materials and Development Core Components Group of BBR. His current interests are related to materials properties, fuel rod modeling, and PIE poolside work.

REDUCED TEMPERATURE RETURN-TO-POWER DEMONSTRATION

C. E. Meyer
N. P. Mueller
M. Plumier
M. G. Watts
R. Leroy
C. J. Saint-Mard

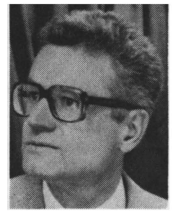



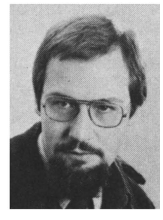
C. E. Meyer (top) (MS, nuclear engineering, University of Wisconsin, 1972) is a senior engineer with Westinghouse Nuclear Technology Division. He has worked in the areas of fuel design, reactor control, and simulator operations training. He is currently involved in the development of generic emergency operating procedures (including training aspects) for Westinghouse-designed pressurized water reactors (PWRs). **N. P. Mueller** (bottom) (MS, electrical engineering, University of Pittsburgh, 1967) is a functional analysis group manager with Westinghouse Nuclear Technology Division. He has worked in the areas of control systems design and testing, plant transient analyses, and model development and testing. He is currently involved with the integration of separate plant control systems into a single miniprocessor-based system for improved PWR load-follow capability. **M. Plumier** (photo not available) is a nuclear design group manager and **M. G. Watts** (photo not available) is a design engineer with Westinghouse Nuclear Europe in Brussels, Belgium. Together they provided the Westinghouse interface

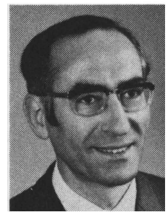
with utility personnel as well as supporting analytical and review functions. **R. Leroy** and **C. J. Saint-Mard** (photos not available) are officials in the consortium Société Belgo-Française d'Energie Nucléaire Mosane, which owns and operates the Tihange PWR power plant. They were instrumental in scheduling the unit to perform the subject demonstration.

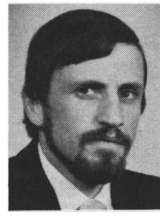
THE GERMAN RISK STUDY: ACCIDENT CONSEQUENCE MODEL AND RESULTS OF THE STUDY

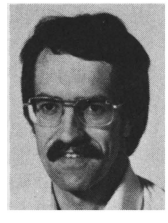
Anton Bayer
Klaus Burkart
Joachim Ehrhardt
Wolfgang Hübschmann
Manfred Schückler
Siegfried Vogt
Wolfgang Jacobi
Herwig G. Paretzke
Klaus-Rüdiger Trott
Eduard Hofer
Bernard Krzykacz

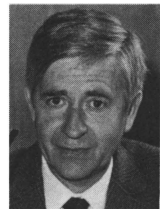






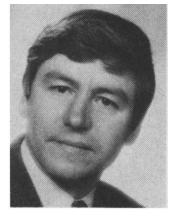


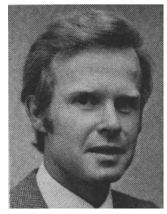


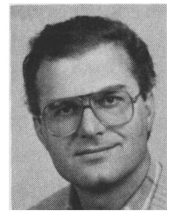


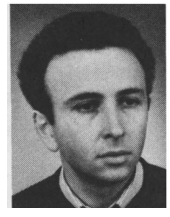
Anton Bayer (top right) (Dipl.-Phys., 1966, Dr.-Ing., 1971, and Dr.-Ing. habil., 1978, University of Karlsruhe) worked in the field of reactor physics until 1971 and then on the radiological impact of nuclear facilities. He is a scientist at the Kernforschungszentrum Karlsruhe (KfK) and, since 1980, a professor at the University of Karlsruhe. **Klaus Burkart** (top left) (Dipl.-Phys., 1962, and Dr.-Ing., 1970, University of Karlsruhe) is a member of the Probabilistic Risk Analysis Group of the Institute for Neutron Physics and Reactor Engineering, Karlsruhe Nuclear Research Center. Initially working in the fields of experimental fast and thermal neutron physics, his main interest is now focused on emergency planning for and licensing of nuclear installations as well as on calculation of early fatalities and modeling of protective countermeasures within reactor safety studies. **Joachim Ehrhardt** (second from top right) (PhD, mechanical engineering, University of Karlsruhe, 1975) is a physicist at the Institut für Neutronenphysik und Reaktortechnik, KfK. Until 1978 he was involved in the area of reactor noise analysis. He currently works on the consequence models and computer codes of the German Risk Study, especially chronic exposure pathway modeling. **Wolfgang G. Hübschmann** (center left) (Dr.-Ing., Technical University of Hannover, 1962) participated in fast reactor development at Karlsruhe Nuclear Research Center from 1962 to 1969. He was transferred to General Electric Company, San Jose, California, for one and a half years to work on nuclear superheat development. Since 1969 he has worked in the Health Physics and Safety Main Department and manages the Environmental Meteorology and Theory Department. His research activities include atmospheric dispersion, radiation exposure due to routine and accidental releases, and risk analyses. **Manfred Schückler** (third from top right) (Dipl.-Phys., University of Karlsruhe, 1973) worked at KfK on the radiological impact of nuclear facilities and developed computer codes for the German Risk Study until 1978. Since 1979 he has worked as an expert in the licensing process of nuclear facilities. **Siegfried Vogt** (bottom left) (Dipl. Meteorologe, Universite of Karlsruhe, 1968) has been a scientist in the Safety Department of KfK and a coworker in the Nuclear Safety Project since 1974. He works in the Environmental Meteorology Group and is engaged in the planning and performance of atmospheric diffusion experiments with tracers or with tetroon technique. He also develops computer codes for the determination of the probability and magnitude of health impacts from hypothetical accidents occurring in nuclear power plants. **Wolfgang Jacobi** (bottom right) (PhD, physics and biophysics, University of Frankfurt/Main, 1953) did scientific work at the Max-Planck-Institute for Biophysics in Frankfurt/Main, Federal Republic of Germany (FRG), from 1951 to 1957. He was head of the Radiation Physics Department at the

Hahn-Meitner-Institute in Berlin, FRG, from 1957 to 1972 and has been head of the Institute for Radiation Protection, Gesellschaft für Strahlen- und Umweltforschung in Munich-Neuherberg, FRG, since 1972. He is also a professor (apl.) at the Technical University of Munich. His scientific work has been in the areas of radiation biophysics, dosimetry, and risk assessment. **Herwig G. Paretzke** (top right) (DP, theoretical physics, Technische Hochschule München, 1968) is head of the Risk Analysis Group in the Institut für Strahlenschutz der Gesellschaft für Strahlen- und Umweltforschung (GSF), Neuherberg. He has been working on the quantification of low-level radiation risks and on best estimates of the dynamic transport of radionuclides through terrestrial ecosystems. Prior to his affiliation with GSF, he worked in the field of plasma physics at the Max-Planck-Institut für Physik, München, and at the Max-Planck-Institut für Plasmaphysik, Garching. His scientific work on radiation biophysics, radiation detection, and risk assessment has led to about 70 publications. **Klaus-Rüdiger Trott** (top left) (MD, 1967) has worked in radiobiology since 1968, receiving his habilitation degree in 1974 and becoming professor of radiation biology at the University of Munich in 1980. His main fields of research are experimental cancer radiotherapy and acute and chronic health effects of radiation. **Eduard Hofer** (bottom right) (Dipl.-Math., mathematics, Technical University of Munich, FRG, 1970) is head of a mathematics group at the Gesellschaft für Reaktorsicherheit (GRS). His professional interests are in numerical analysis and probabilistics. **Bernard Krzykacz** (bottom left) (Dipl.-Math., mathematics and statistics, University of Munich, FRG, 1974) participated in a research project at the Technical University of Munich from 1974 to 1978 on statistical reliability problems in civil engineering. He is presently with GRS where his research activities include probabilistic risk analysis for nuclear power plants.





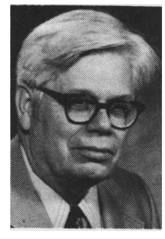


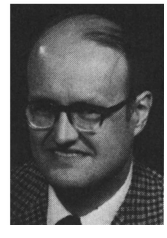


CHEMICAL PROCESSING

AN ALTERNATIVE SOLVENT CLEANUP METHOD USING A HYDRAZINE OXALATE WASH REAGENT

O. K. Tallent
James C. Mailen



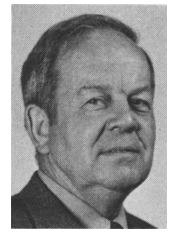


O. K. Tallent (top) (BS, chemistry, University of Tennessee, 1966) is a chemist at Oak Ridge National Laboratory (ORNL). His current interests include reprocessing of liquid-metal fast breeder reactor (LMFBR) and light water reactor (LWR) fuels with particular interest in solids dissolution and liquid recycle studies. **James C. Mailen** (PhD, chemical engineering, University of Florida, 1964) is a group leader at ORNL. His current interests include reprocessing of LMFBR and LWR fuels.

NUCLEAR FUELS

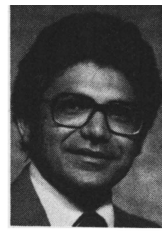
DETERMINATION OF THERMAL ACCOMMODATION COEFFICIENTS OF INERT GASES ON A SURFACE OF VITREOUS UO_2 AT ~35°C

Lloyd B. Thomas
Sudarshan K. Loyalka



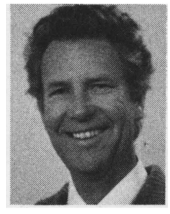
Lloyd B. Thomas (right) (AB, University of Missouri, 1930; PhD, University of Minnesota, 1935) is professor emeritus of chemistry at the University of Missouri-Columbia. He is internationally recognized for his pioneering work on measurements

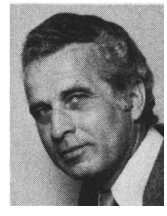
of accommodation coefficients on controlled surfaces and contributions to understanding of gas/surface interactions in general. He recently presented an invited paper, "Accommodation of Molecules on Controlled Surfaces–Experimental Developments at University of Missouri 1940–1980," at the 12th International Symposium on Rarefied Gas Dynamics at Charlottesville, Virginia (July 7-11, 1980). He was a visiting professor at the University of California, Berkeley from 1962 to 1963 and Oxford University from 1969 to 1970. **Sudarshan K. Loyalka** (right) (BE Mech. Hons., University of Rajasthan, India, 1964; MS, 1965, and PhD, 1967, nuclear engineering, Stanford University) is a professor of nuclear engineering and James C. Dowell Professor of Engineering at the University of Missouri-Columbia. His research interests are in the areas of kinetic theory of gases, neutron transport, aerosol mechanics, and nuclear reactor physics and safety. He was a visiting scientist at Max-Planck Institut für Strömungsforschung, Gottingen, West Germany, from 1969 to 1971.



BEHAVIOR OF $(U,Pu)O_2$ SPHERE-PAC FUEL, WITH PLUTONIUM IN THE LARGE SPHERES ONLY, IN LOW BURNUP TESTS UNDER PRESSURIZED WATER REACTOR CONDITIONS

Aart van der Linde
Jacques H. N. Verheugen



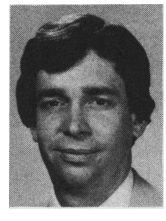


Aart van der Linde (top) (PhD, analytical chemistry, and PhD, physics, University of Utrecht, The Netherlands, 1960) has been working at the Netherlands Energy Research Foundation in Petten since 1962. Corrosion, fuel pin manufacture, and fuel pin behavior have been the main subjects of his studies. Since 1976 his research has focused on postirradiation examinations of sphere-pac pins from light water reactors. **Jacques H. N. Verheugen** (engineer, chemical technology, Technical University of Delft, The Netherlands, 1959) has worked at the Netherlands Energy Research Foundation in Petten since 1959. Fuel pin design and development, in particular the use of UB_4 as a burnable poison in UO_2 pellets, and the fabrication and in-pile performance of sol-gel sphere-pac fuel were his main topics of research. His current interest is the development of high-temperature ceramic materials for electrodes in magnetohydrodynamic energy conversion systems.

RADIOACTIVE WASTE MANAGEMENT

SOME PRELIMINARY WASTE MANAGEMENT CONSIDERATIONS FOR GROUND PROCESSING SYSTEMS SUPPORTING THE SPACE OPTION

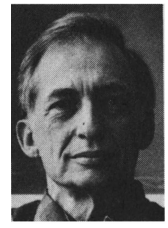
D. William Tedder



D. William (Bill) Tedder [BChE, Georgia Institute of Technology (GIT), 1972; MSChE, 1973, and PhD, 1975, University of Wisconsin; PE, University of Tennessee, 1978; PE, GIT, 1981] held the position of staff engineer for four years at Oak Ridge National Laboratory where he worked on actinide partitioning flow sheets for waste management. He has been an assistant professor of chemical engineering at GIT since 1979 where he teaches chemical process and plant design, optimization, and synthesis. His research interests are in solvent extraction, waste management, process optimization, and computer modeling. He is also a consultant and has served on a number of independent review committees.

EVALUATION OF AN INTERNATIONAL, PERPETUAL, AND RETRIEVABLE FACILITY FOR STORAGE OF VITRIFIED RADIOACTIVE WASTE

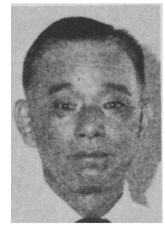
Leona Marshall Libby
M. G. Wurtele
Chris G. Whipple

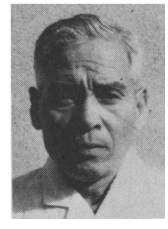


Leona Marshall Libby (top) (PhD, physics and chemistry, University of Chicago) has been professor of physics at New York University and the University of Colorado, and has served as adjunct professor in the experimental program of environmental science and engineering at the University of California, Los Angeles (UCLA). The program has 60 Doctor of the Environment graduates and 40 more students in process. **M. G. Wurtele** (center) (PhD, meteorology, UCLA, 1953) is professor and former chairman of the Department of Atmospheric Sciences at UCLA. His research includes the areas of atmospheric dynamics, turbulence and diffusion, and remote sensing. **Chris G. Whipple** (bottom) (PhD, engineering, California Institute of Technology) is technical manager of the Energy Study Center at the Electric Power Research Institute (EPRI). Previously he was manager of special studies in EPRI's Planning Division. He has served as a codirector for a North Atlantic Treaty Organization Advanced Study Institute on technological risk assessment and has taught risk-benefit analysis for three years in a short course for college teachers.

FUNDAMENTAL UNDERWATER CUTTING METHOD EXPERIMENT AS A DISMANTLING TOOL FOR A COMMERCIAL ATOMIC REACTOR VESSEL

Masanobu Hamasaki
Yasuichi Murao
Fumikazu Tateiwa

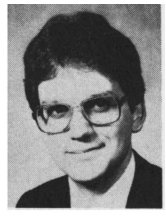


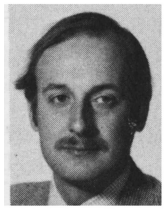


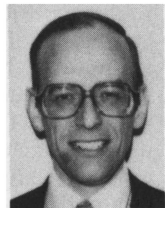
Masanobu Hamasaki (top) (Dr., welding, Faculty of Engineering, Osaka University, Japan, 1952) is leader of the underwater cutting of atomic reactor vessel program and has been director of the Machinery and Metal Department of the Government Industrial Research Institute (GIRI) in Shikoku since 1972. His current interests are underwater welding, underwater cutting, electron beam welding, laser welding, and laser cutting. **Yasuichi Murao** (center) (applied chemical, Takamatsu Technological High School, 1942) worked in the area of underwater gas cutting and was chief researcher of the Machinery and Metal Department, GIRI, until retirement in December 1981. **Fumikazu Tateiwa** (bottom) (electric, Kida High School, 1959) has worked in the area of underwater arc gouging and is chief researcher of the Machinery and Metal Department, GIRI. His current interest is underwater cutting.

RAPID ESTIMATION OF THE REGIONAL THERMAL RESPONSE TO A NUCLEAR WASTE REPOSITORY—LIMITING CASE ANALYSIS

Christopher J. Blesch
F. A. Kulacki
R. N. Christensen







Christopher J. Blesch (top) (BS, 1979, and MS, 1981, mechanical engineering, Ohio State University) is an engineer at the Owens/Corning Fiberglass Technical Center. His current research interests are heat and mass transfer in porous materials and thermal aspects of long-term, deep geological disposal of commercial nuclear wastes. **F. A. Kulacki** (center) (BS, mechanical engineering, 1963, and MS, gas engineering, 1966, Illinois Institute of Technology; PhD, mechanical engineering, University of Minnesota, 1971) is professor and chairman of the Department of Mechanical and Aerospace Engineering at the University of Delaware. His research interests include heat and mass transfer in geologic media due to nuclear waste repository and free convection processes spent fuel storage and disposal. **R. N. Christensen** (bottom) (BS, physics, Brigham Young University, 1968; MS, mechanical engineering, Stanford University,

1970; PhD, nuclear engineering, Stanford University, 1974) is associate professor of nuclear and mechanical engineering at Ohio State University. His research interests include heat transfer problems related to mined geologic repositories for nuclear wastes, including free and forced convection in a repository drift.

REGIONAL WASTE TREATMENT FACILITIES WITH UNDERGROUND MONOLITH DISPOSAL FOR ALL LOW-HEAT-GENERATING NUCLEAR WASTES

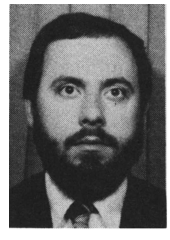
Charles W. Forsberg

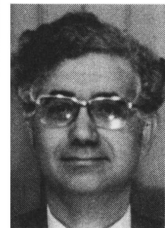
Charles W. Forsberg (BS, chemical engineering, University of Minnesota, 1969; ScD, nuclear engineering, Massachusetts Institute of Technology, 1973) is a staff member of the Chemical Technology Division of Oak Ridge National Laboratory. He is a principal investigator for the Integrated Data Base project, which inventories and projects nuclear waste quantities for the U.S. Department of Energy. His current interests include methods for disposal of large volume hazardous and radioactive wastes.

MATERIALS

FATIGUE CRACK GROWTH CURVE IN AIR ENVIRONMENT AT 300°C FOR STAINLESS STEELS

Jean-Louis Bernard
Georges S. Slama



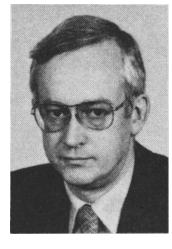


Jean-Louis Bernard (top) (MS, Ingénieur Institut supérieur des Matériaux et de la construction mécanique) is currently a member of the Framatome Material Department where he is in charge of fatigue studies and research. Before coming to Framatome he worked with the Office National Etudes et Recherches Aérospatiales. **Georges S. Slama** (PhD, Ingénieur Civil des Mines) is currently manager of the Framatome research group involved in studies of the metallurgy and mechanical properties of steels and nickel-base alloys used in the pressurized water reactor pressure boundary. Before coming to Framatome he was head of a research group at the Centre des Matériaux de l'Ecole des Mines de Paris.

HEAT TRANSFER AND FLUID FLOW

DISTRIBUTIONS OF VELOCITY AND TURBULENCE IN A PARALLEL FLOW ALONG AN ASYMMETRIC ROD BUNDLE

Klaus Rehme



Klaus Rehme (Dr.-Ing., mechanical engineering, University of Karlsruhe, BRD, 1967; Priv.-Doz., thermo- and fluid dynamics, University of Karlsruhe, 1974) has been a member of the Institute of Neutron Physics and Reactor Technology of the Karlsruhe Nuclear Research Center since 1962. He is presently head of the Thermal-Hydraulics Division. His principal research interests include fluid flow and heat transfer in noncircular channels, particularly in rod bundles of liquid-metal fast breeder reactor designs.

ENHANCEMENT OF HEAT TRANSFER BETWEEN TWO HORIZONTAL LIQUID LAYERS BY GAS INJECTION AT THE BOTTOM

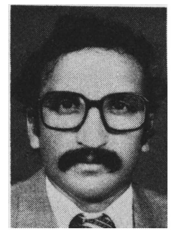
Heinrich Werle

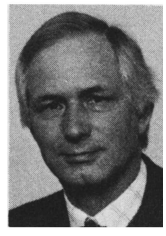
Heinrich Werle (Dr. Ing., University of Karlsruhe, Federal Republic of Germany, 1970) is research physicist in the Institute of Neutron Physics and Reactor Technology at Kernforschungszentrum Karlsruhe, where he is currently working on fast reactor safety.

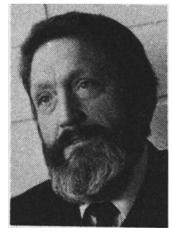
TECHNIQUES

DESIGN AND TESTING OF AN ELECTROCHEMICAL CARBON METER FOR SODIUM

Thiagarajan Gnanasekaran
Hans U. Borgstedt
Günther Frees



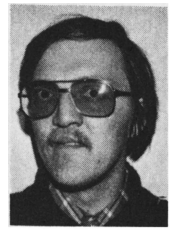


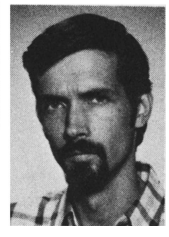


Thiagarajan Gnanasekaran (top) (MSc, chemistry, University of Madras, India, 1973) has been with the Reactor Research Center, Kalpakkam, since 1974. He has been working on the chemistry of sodium coolant, development of on-line monitors, and fuel-coolant chemical interactions. Within this field of interest, he was delegated to the Kernforschungszentrum Karlsruhe (KfK) from 1979 to 1981. **Hans U. Borgstedt** (center) [Dr. Rer. Nat., chemistry, University of Karlsruhe, Federal Republic of Germany (FRG), 1959] has been with KfK since 1963 and is now section head of the Corrosion Section. His main interests are in corrosion and mechanical properties of materials in liquid metals and impurity monitoring. **Günther Frees** (bottom) (Dipl.-Ing., mechanical engineering, University of Karlsruhe, FRG, 1956) is head of a liquid-metal technology group in KfK and experienced in work with liquid sodium since 1962. His current work is related to the sodium influence on mechanical properties and loop techniques.

OPTO: OPTIMIZATION PROGRAM FOR MULTICOMPONENT ACTIVATION DETECTORS

P. A. Aarnio
M. J. Koskelo





P. A. Aarnio (top) (MS, technical physics, Helsinki University of Technology, 1978) has been working on gamma spectrum analysis, activation detectors, and hadron cascade simulations. He is currently working at the European Organization for Nuclear Research, Geneva. **M. J. Koskelo** (MS, technical physics, 1976, and Dr. Techn., nuclear engineering, 1981, Helsinki University of Technology) has been working on gamma spectrum analysis programs and activation detectors. He is currently working for Canberra Industries, Inc., Connecticut.