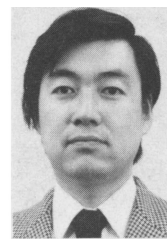


AUTHORS — SEPTEMBER 1987

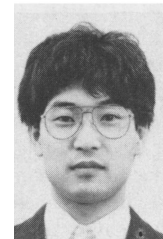
FISSION REACTORS

A DESIGN METHOD TO ISOTHERMALIZE THE CORE OF HIGH-TEMPERATURE GAS-COOLED REACTORS

*Makoto Takano
Kazuhiro Sawa*



Makoto Takano (top) (BS, 1975; MS, 1977; and PhD, 1980, nuclear engineering, Hokkaido University, Japan) has been a research engineer at the Japan Atomic Energy Research Institute (JAERI) since 1980. He has participated in core design and safety analysis of a high-temperature gas-cooled reactor (HTGR) that will be built by JAERI. His current interests are space-time core kinetics simulation and application of artificial intelligence on a nuclear-related data base. From 1985 to 1986, he was a visiting researcher at Kernforschungsanlage Jülich, Federal Republic of Germany, for dynamic analysis of the Arbeitsgemeinschaft Versuchsreaktor U nuclear process heat plant. Currently he works for the Organization for Economic Cooperation and Development/Nuclear Energy Agency, Paris, France. **Kazuhiro Sawa** (BS, 1982 and MS, 1984, nuclear engineering, Hokkaido University, Japan) has been a research engineer at JAERI since 1984. He has participated in core design and safety analysis of an HTGR. He is currently evaluating fission product release and transport.



COMPARISON OF HEAT TRANSPORT CAPABILITY OF A STEAM GENERATOR (SG) IN A HIGH-TEMPERATURE GAS-COOLED REACTOR WITH THAT OF AN SG IN OTHER TYPES OF REACTORS

Takao Hayashi



Takao Hayashi (BS, mechanical engineering, 1958, and PhD, nuclear engineering, 1972, Tohoku University, Japan) has worked on research reactors, such as the Japan Material Testing Reactor. In 1974, he joined the Japan Atomic Power Company (JAPC), where he did research on new types of power reactors, such as the high-temperature gas-cooled reactor and the liquid-metal fast breeder reactor. He is currently the deputy general manager of the engineering development department of JAPC.

NUCLEAR POWER PLANT KALKAR (SNR-300)

PREFACE — NUCLEAR POWER PLANT KALKAR (SNR-300)

Wulf Bürkle (top) [Dipl., engineering, Technical University of Braunschweig, Federal Republic of Germany (FRG)] worked as a chemical engineer with KSG, Stuttgart, and Goodyear S.A., Luxembourg. In 1968, he joined the Nuclear Division of Siemens AG and in 1973 the reactor department of Kraftwerk Union AG. In 1980, after assignments in the fast breeder development and as a project manager for the nuclear power plants Biblis and Buschere, Iran, he joined the Internationale Natrium-Brutreaktor-Bau Gesellschaft mbH in Bergisch Gladbach, FRG, as general manager. In 1982, he was assigned executive vice president of Interatom GmbH, Bergisch Gladbach. He is also vice president of Kernkraft Union AG and chairman of the INB advisory board. **Walter H. Köhler** (MSc, nuclear engineering, Massachusetts Institute of Technology, 1962; Dr.-Ing., University of Karlsruhe, FRG, 1964) was first assistant, then associate professor of nuclear engineering at Texas A&M University from 1965 to 1971. In 1971 he joined Interatom as department head for systems engineering. He is currently subdivision manager for technical cooperation for advanced reactors including the liquid-metal fast breeder reactor, high-temperature gas-cooled reactor, and fusion reactor.

*Wulf Bürkle
Walter H. Köhler*



KALKAR NUCLEAR POWER PLANT (SNR-300)—A SODIUM-COOLED FAST BREEDER REACTOR PROTOTYPE

Friedrich H. Morgenstern (diploma, Technical University of Aachen, Federal Republic of Germany) is a mechanical engineer. He joined the Reactor Development Division of Siemens AG in 1961. From 1968 to 1969, he was a member of the German delegation to the Southwest Experimental Fast Oxide Reactor project in Arkansas. Then he joined Interatom, which had taken over all fast reactor activities of Siemens AG as a subsidiary company. His fast reactor experience goes back to 1966 and lies mainly in the fields of fuel development, plant safety design, and project management. Since his assignment to the Internationale Natrium-Brutreaktor-Bau GmbH in 1979, he has been responsible for the licensing related work of the Kalkar nuclear power plant (SNR-300).

Friedrich H. Morgenstern



REACTOR VESSEL SYSTEM

Helmut Rothfuss (top) (Ing. grad., mechanical engineering) is a department manager at Interatom GmbH, Federal Republic of Germany (FRG). Since 1961 he has worked in the field of sodium-cooled reactors, particularly in the design and procurement of reactor and reactor components. Currently, he is working at the large sodium-cooled fast breeder reactor and at the modular gas-cooled high-temperature reactor. **Friedhelm Vogt** (Ing. grad., mechanical engineering, SIS-Hagen, FRG, 1954) worked at Steinmüller GmbH, Gummersbach, FRG, in the Power Plant Engineering Project Group. He joined Interatom

*Helmut Rothfuss
Friedhelm Vogt*



GmbH in 1958 and was involved with the design and development of nuclear reactors of the OMR (ESSOR, IszPa), pressurized water (NS-Otto-Hahn), and fast breeder (KNK-Ia, KNK II, SNR 300) type, as senior supervisor and department manager for mechanical engineering. Since 1972 he has served as subdivision manager responsible for reactor and fuel handling of the KKW-Kalkar (SNR 300). In 1984 he became head of the newly founded mechanical and plant engineering subdivision. His broad interests lie in various nuclear reactor engineering areas, including mechanical parts, in-service inspections, piping, and system design and development.

PRIMARY AND SECONDARY MAIN PIPING SYSTEMS

Kurt Vinzens (top) [process engineering, Technische Hochschule, Aachen, Federal Republic of Germany (FRG); PhD, thermodynamics, Technische Universität, Berlin, FRG, 1971] has worked in research and development of liquid-metal-heated steam generators at Interatom, Bergisch Gladbach, FRG, specializing in flow and vibration tests of core subassemblies of liquid-metal fast breeder reactors and hydraulic and vibration tests for gas-cooled reactor components. He has worked in stress analyses and is currently manager of the Department of Structural Integrity, Interatom. **Horst Kappauf** (Dipl.-Ing., civil engineering, GHS Wuppertal, FRG) has worked at Interatom since 1964. In 1974, he became head of the group for stress analyses of piping systems and, in 1979, manager for stress analyses of piping systems and components. He is a member of the KTA regulation committee, and he has made substantial contributions to the elevated temperature design of reactor components.

*Kurt Vinzens
Horst Kappauf*



FABRICATION OF INTERMEDIATE HEAT EXCHANGERS, STEAM GENERATORS, AND SODIUM PUMPS FOR SNR-300

Arie Johannes Van 't Hoft (top right) (BSc, mechanical engineering, Rotterdam Polytechnic, Netherlands, 1960) joined Neratoom in 1961 as leader of the mechanical engineering group. He became project manager in 1973, being responsible for the whole Neratoom delivery to the SNR-300. He is currently vice president of Neratoom. **Jacob Johan de Jong** (top left) (BSc, mechanical engineering, Rotterdam Polytechnic, Netherlands, 1975; BSc, economics and business administration, Erasmus University, Rotterdam, Netherlands, 1982) joined Neratoom in 1975 as a thermal-hydraulic engineer and was appointed project engineer of the SNR-300 steam generators (SGs) in 1981. In 1985, he became project manager of SNR-2 for Neratoom. He is now employed by Stork Boilers, Hengelo, Netherlands, as project manager of the piping department. **Jan Piet Vroom** (bottom right) (BSc, mechanical engineering, Amsterdam Polytechnic, Netherlands, 1962; MSc, nuclear engineering, Delft University of Technology, Netherlands, 1968) joined Neratoom in 1968 as a development engineer of rotating equipment. He has served as project manager of intermediate heat exchanger pumps and SG manufacturing for the SNR-300 since 1973. **Gerhard Robert Küpers** (bottom left) (MSc, mechanical engineering, Twente University of Technology, Netherlands, 1973) worked for BBC-Mannheim as a nuclear design engineer from 1974 until 1978. In 1979, he joined Neratoom as a system engineer, and since

*Arie Johannes Van 't Hoft
Jacob Johan de Jong
Jan Piet Vroom
Gerhard Robert Küpers*

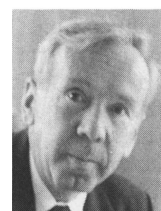
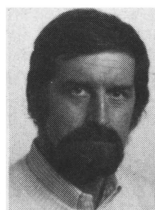


1981 has been Neratoom representative to the Internationale Natrium-Brutreaktor-Bau project management team for SNR-2 in Bensberg, Federal Republic of Germany. He is now head of the engineering department at Neratoom.

FABRICATION OF FUEL ELEMENTS INTERPLAY BETWEEN TYPICAL SNR MARK Ia SPECIFICATIONS AND THE FUEL ELEMENT FABRICATION

Willi K. Biermann (top right) [PhD, solid-state physics, University of Göttingen, Federal Republic of Germany (FRG), 1959] joined Interatom, a subsidiary of Kraftwerk Union AG, FRG, in 1966. He is head of the core and fuel main department, responsible for all engineering and development work for thermal and fast reactor cores. **Hans-Jochen Heuvel** (top left) (Dr.-Ing., metallurgy, Rheinisch-Westfälische Technische Hochschule, Aachen, FRG, 1972) has worked at Interatom in the area of nuclear materials since 1974, specializing in fast breeder fuel and absorber material development. **Servais Pilate** (second from top right) (civil engineer, mechanics, Faculté Polytechnique de Mons, Belgium, 1962) entered Belgonucléaire, Brussels, in 1963. He has worked on shielding for thermal reactors and core physics for fast neutron reactors, including SNR-300 and SNR-2 designs. He has been project leader for fast reactor fuel at Belgonucléaire since 1982. **Yvon Vanderborck** (second from top left) (civil engineer, metallurgy, Faculté Polytechnique de Mons, Belgium, 1968) has worked as an assistant at the university in the material and nondestructive testing department. He joined Belgonucléaire in 1971 and has been essentially in charge of materials problems related to fuel technology, technical specifications, fabrication followup, and quality assurance. **Eduard Pelckmans** (third from top right) (civil engineer chemistry, University of Louvain, Belgium, 1968) joined Belgonucléaire in 1971. He worked 2 years in the Joint Belgonucléaire-Studiecentrum voor Kernenergie (SCK)/Centre d'Étude de l'Énergie Nucléaire (CEN), Mol, Belgium, Mixed-Oxide (MOX) Research and Development (R&D) Group before he was section leader for the quality control of the fabrication of MOX fuels for both light and fast reactors. He is presently deputy manager of the operation department of the Fuel Manufacturing Division of Belgonucléaire, Dessel, Belgium. **Guido Vanhellemont** (third from top left) (PhD, physical chemistry, and graduate, corporate management, University of Louvain, Belgium, 1958) was employed for 8 years as a researcher on various types of nuclear ceramic fuel at the Belgian nuclear research center (SCK/CEN), Mol, Belgium. In 1966, he joined Belgonucléaire, where he managed the operation of the experimental pilot plant and later the industrial plant for the fabrication of MOX fuels for both light water and fast reactors. He is currently deputy manager of the Fuel Manufacturing Division of Belgonucléaire, Dessel, Belgium. **Horst Roepenack** (bottom right) (graduate, mechanical engineering, Munich Technical University, FRG, 1963) is general manager of Alkem GmbH, Hanau, FRG. Since 1964 he has been active in the nuclear fuel cycle industry. Since 1978, he has been responsible for R&D, manufacturing, and quality assurance. **Wolfgang Stoll** (bottom left) (graduate, Technical University of Vienna, Austria) spent 10 years on research and production in inorganic chemistry before moving first to Canada, where he trained in nuclear technology at Atomic Energy of Canada, Ltd., and then to Hanford in the United States. Since 1960 he has been technical manager in the nuclear fuel industry, and general technical manager of Alkem since its foundation in 1964. He spent 3 years on R&D

*Willi K. Biermann
Hans-Jochen Heuvel
Servais Pilate
Yvon Vanderborck
Eduard Pelckmans
Guido Vanhellemont
Horst Roepenack
Wolfgang Stoll*



at NUKEM and is a board member of KTG and the Wirtschaftsverband Brennstoffkreislauf, as well as a member of the German Fast Breeder Parliamentary Commission. He is honorary professor of technical radiochemistry at Karlsruhe University.

REFUELING SYSTEM FABRICATION AND TESTING

Dieter Althaus (top) [Dipl.-Ing., Fachhochschule of Siegen, Federal Republic of Germany (FRG)] is a mechanical engineer. He joined Interatom GmbH in Bensberg, FRG, in 1962 and specialized in radioactive material handling. Since 1984 he has been head of the Department of Reactor and Handling at the Kalkar nuclear power plant. **Nicolas Brahy** (Ingénieur civil des constructions, State University of Liège, Belgium, 1960) joined Belgonucléaire, Brussels, Belgium, in 1963. He is a member of a team in charge of the design, manufacture, and testing of a small swimming pool research reactor. Since 1969 he has been involved in the design and construction of components for the sodium-cooled fast breeder reactor. As assistant project manager, he is currently responsible for the mechanical aspects of the irradiated fuel storage equipment for the SNR-300.

*Dieter Althaus
Nicolas Brahy*

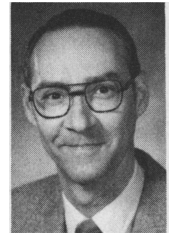


NUCLEAR SAFETY

TELLURIUM BEHAVIOR IN CONTAINMENT UNDER LIGHT WATER REACTOR ACCIDENT CONDITIONS

Edward C. Beahm (PhD, chemistry, Pennsylvania State University, 1973) joined Oak Ridge National Laboratory in 1974. Since 1983, he has been studying the chemistry and transport of fission products in light water reactor containments.

Edward C. Beahm



MODELING FOR COMPARISON OF LEUKEMIA INCIDENCE RISK BETWEEN NUCLEAR AND COAL POWER INDUSTRIES

Victor R. Prybutok (top) (PhD, environmental analysis and applied statistics, Drexel University, Philadelphia, Pennsylvania, 1984) is assistant professor of quantitative methods at Drexel University. His broad interests include statistical applications in the areas of quality control, graphical methods, and risk assessment from environmental hazards. He has worked as a senior biostatistician at the Campbell Institute for Research and Technology, Campbell Soup Company, Camden, New Jersey. **Leonard M. Gold** (BS, 1962, and MS, 1964, mechanical engineering, Drexel Institute of Technology; PhD, solid mechanics, 1969) is experienced in nuclear power plant design with an architectural engineering firm and design and production of main steam components for nuclear power plants. His most recent work is on the defense against the effects of swept-up dust and debris resulting from the detonation of a nuclear weapon.

*Victor R. Prybutok
Leonard M. Gold*



DETERMINATION OF OPTIMUM ALTERNATIVE LOW-LEVEL RADIOACTIVE WASTE DISPOSAL SITE/DISPOSAL TECHNOLOGY COMBINATIONS

Marcus H. Voth (top) [PhD, nuclear engineering, Pennsylvania State University (PSU), 1986] is director of the PSU Breazeale reactor. Prior to this appointment, he worked as a power reactor station nuclear engineer, performed extensive reactor licensing work, and supervised the operation of a medical isotope production facility. In these capacities he has worked with the entire reactor fuel cycle and with disposal of radioactive waste. His current technical interests include economics associated with radioactive waste disposal, research reactor applications, and implementation of nuclear technology in other disciplines. **Warren F. Witzig** (PhD, physics, University of Pittsburgh) served as head of the PSU nuclear engineering department during this study. He has recently retired from that position as Professor Emeritus and is engaged in private consulting. He has worked with the Westinghouse Research Laboratories, the Manhattan District Project, and the Knolls Atomic Power Laboratory, and was a cofounder of the NUS Corporation. His areas of interest include fuel management and burnup optimization, environmental matters, radioactive waste disposal, reactor safety, risk analysis, and economics associated with current and future nuclear power applications.

*Marcus H. Voth
Warren F. Witzig*

**THE EDAC SYSTEM AND NEW DEVELOPMENTS UNDER CONSIDERATION AT THE COMMISSARIAT À L'ENERGIE ATOMIQUE FOR CRITICALITY ACCIDENT DETECTION**

Francis Barbry (top) (MS, nuclear physics, University of Lyon, France, 1966) is a physicist and deputy head of the Critical Mass Laboratory at Valduc, France. Since 1966 he has worked for the French Atomic Energy Commission in the area of nuclear criticality safety. His current technical activities concern experimental and theoretical studies on criticality accidents (kinetics, dosimetry, source term, and criticality alarms). **Raymond Prigent** (graduate, electrical engineering, Conservatoire National des Arts et Métiers, France, 1965) is secretary of the Committee for Radiation Protection Instrumentation. He joined the French Atomic Energy Commission in 1959 and has worked on the research and development of instrumentation. He is currently in charge of the technical center of certification of radiation protection instrumentation.

*Francis Barbry
Raymond Prigent*

