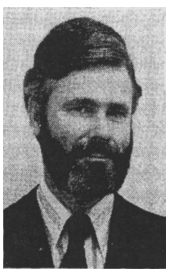
nuclear technology®

AUTHORS — SEPTEMBER 1977

COATED PARTICLE FUELS

PREFACE: COATED PARTICLE FUELS

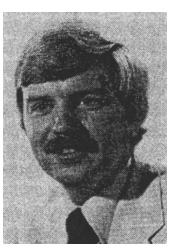
T. D. Gulden
H. Nickel

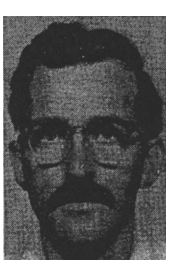


T. D. Gulden (top) (PhD, materials science, Stanford University, 1965) is manager of the High-Temperature Gas-Cooled Reactor Materials Design Department at General Atomic Company. For the past ten years he has been involved in various aspects of coated particle fuels work, including thermochemical performance, design, properties of coating materials, and fission product release. Prior to this work, he spent two years at the Berkeley Nuclear Laboratories in the U.K. performing basic research on irradiation effects in ceramics. Hubertus Nickel (Dr. rer. nat., physical chemistry, Technical University of Aachen, 1959) is presently head of the Department for Reactor Materials in the Nuclear Research Center (KFA), Jülich, Federal Republic of Germany. He is also a full professor of reactor materials and nuclear fuel elements at the Technical University of Aachen. The main activity of the Department of Reactor Materials is the development, characterization, irradiation testing, and postirradiation investigation of materials for advanced high-temperature reactor (HTR) systems. Attention is directed to research and development of both core-specific components, such as coated fuel particles, fuel elements for the different HTR types, reflector graphite and fuel matrix materials, and to non-nuclear components of the primary circuit. These metallic and ceramic components include hot ducts, turbine blades, methane reformer tubes, and heat exchangers. Basic research on fuel systems, materials analysis, and emission spectroscopy studies are also conducted in the department.

PROCESSING AND COMPOSITION CONTROL OF WEAK-ACID-RESIN-DERIVED FUEL MICROSPHERES

G. W. Weber
R. L. Beatty
V. J. Tennery



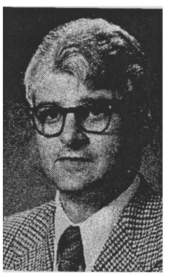


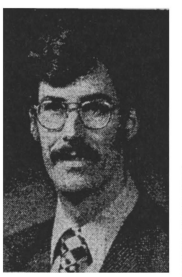
G. W. Weber (top) (BS, ceramic technology, Pennsylvania State University, 1965; PhD, ceramics science, Pennsylvania State University, 1974) has conducted research on high-temperature gas-cooled reactor (HTGR) fuel kernel chemistry and processing, coating processes, and irradiation testing. He is currently a group leader at Oak Ridge National Laboratory (ORNL) on experimental materials fabrication working with laser nozzles and mirrors, carbon-carbon composites for aerospace applications, chemical vapor deposition, and materials applications for fusion reactor concepts. R. L. Beatty (bottom) (BS, Pennsylvania State University, 1961; MS, University of Tennessee, 1966; PhD, University of Washington, 1974) has developed laboratory-scale equipment and processes for HTGR fuel kernel and coating fabrication, conducted research on pyrocarbon characterization, and been extensively involved with irradiation testing and evaluation. He

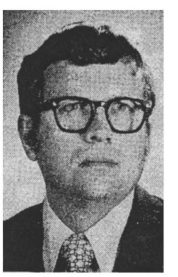
is presently on assignment to EIR, Switzerland, for advanced breeder fuels research. V. J. Tennery (right) (PhD, ceramic engineering, University of Illinois, 1959) is currently group leader of ceramic technology in the Metals and Ceramics Division at ORNL. He has been working in the area of nuclear fuel and neutron absorber materials for the past eight years. Most recently, this nuclear fuel work has included characterization methods for pyrocarbon and silicon carbide coatings on HTGR fuel particles and process development for weak acid resin-based HTGR fuel particles. The current paper is a result of this latter activity.

IMPROVED GAS DISTRIBUTOR FOR COATING HIGH-TEMPERATURE GAS-COOLED REACTOR FUEL PARTICLES

W. J. Lackey
D. P. Stinton
J. D. Sease



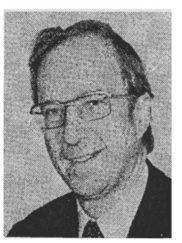


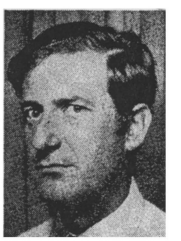


W. J. Lackey (top) (BS, metallurgical and ceramic engineering, 1961; PhD, ceramic engineering, 1969) is group leader of the Fuel Cycle Technology Group in the Metals and Ceramics Division at Oak Ridge National Laboratory (ORNL). He is involved in the fabrication and evaluation of nuclear fuels. David P. Stinton (center) (MS, ceramic engineering, Virginia Polytechnic Institute, 1974), is a lead engineer in the Metals and Ceramics Division at ORNL. He is involved in process development and characterization of carbon and silicon carbide coatings for high-temperature gas-cooled reactor fuel. John D. Sease (bottom) (BS and MS, ceramic engineering, Clemson University, 1958 and 1959) has been involved in the development of nuclear fuels fabrication processes at ORNL for 15 years. He is currently associated with development of liquid-metal fast breeder reactor fuel recycle technology.

COATED FUEL PARTICLES: REQUIREMENTS AND STATUS OF FABRICATION TECHNOLOGY

H. Huschka
P. Vygen





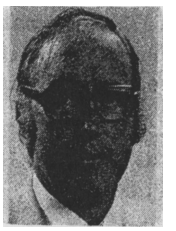
Hans Huschka (top) (PhD, chemistry, University of Vienna, 1959) is leader of the Fuels Materials and Process Development Department at Hochtemperaturreaktor-Brennelement-Gessellschaft (HOBEG). Peter Vygen (Dr. Ing., metallurgy, University of Clausthal, 1967) is an engineer in the Fuels Materials and Process Development Department at HOBEG. He is involved in the development of fuel fabrication processes and in fuel qualification.

NUCLEAR FUEL COATED PARTICLE DEVELOPMENT IN THE REACTOR FUEL ELEMENT LABORATORIES OF THE U.K. ATOMIC ENERGY AUTHORITY

P. L. Allen
L. H. Ford
J. V. Shennan

P. L. Allen (top) (Awarded First Class Honors, BSc, University of Liverpool, 1953) joined the United Kingdom Atomic Energy Authority (UKAEA) in 1956 after undertaking post-graduate research. He has been responsible for high-temperature reactor (HTR) fuel fabrication, with particular reference to fuel compact development. His current interests are ceramics fabrication, nuclear fuel reprocessing, and corrosion studies. L. H. Ford (bottom) (chemical engineering, Manchester University, 1956; PhD, Imperial College, London, 1960) joined the UKAEA in 1960 and was responsible for kernel and coated particle development from 1961 to 1976. His current interests are the dynamic and fatigue characteristics of advanced gas-cooled

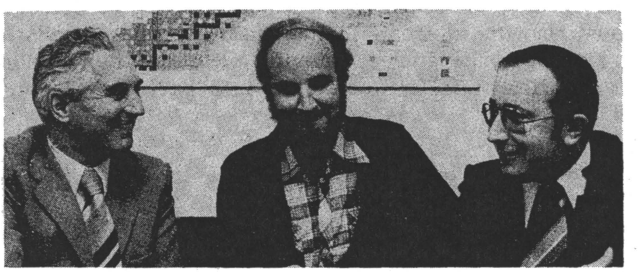
reactor fuel. J. V. Shennan (right) (BSc, Honors 1st Class, physical chemistry, University of Liverpool, 1953) joined UKAEA in 1955 after post-graduate research. He was leader of the group at the Reactor Fuel Laboratories (RFL), Springfield, engaged in the development of HTR fuel fabrication from 1961 to 1972. He is now research manager of the Chemical Technology Group at RFL, with interests covering chemical aspects of nuclear fuel, absorbers, moderator graphite, and engineering ceramics, notably REFEL silicon carbide.



FUNDAMENTALS ON THE AGGLOMERATE MODEL AND ITS RELATION TO THE PHYSICAL PROPERTIES OF PYROCARBON

J. Linke
K. Koizlik
H. Nickel

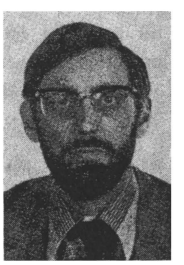
Jochen Linke (center) (Dipl. Phys., Technical University of Aachen, 1975) is taking his doctor's degree at the Nuclear Research Center (KFA), Jülich, in the Ceramic Division in the Department for Reactor Materials. The subject of his thesis is the deposition-mechanism of pyrocarbon from the gas phase. Karl Koizlik (right) (Dr. rer. nat., physics, Technical University of Erlangen, 1968, and Technical University of Aachen, 1972) is employed at KFA in the Department for Reactor Materials. He is working in the field of nuclear materials and is responsible for the development of characterization procedures for pyrocarbons. A second field of activity is the development of quantitative models for pyrolysis and pyrocarbon deposition. He is a part-time lecturer at the Technical University of Aachen and is a member of several scientific organizations. Hubertus Nickel (left) (Dr. rer. nat., physical chemistry, Technical University of Aachen, 1959) is presently head of the Department for Reactor Materials at KFA. He is also a full professor of reactor materials and nuclear fuel elements at the Technical University of Aachen.



COATED NUCLEAR FUEL PARTICLES: THE COATING PROCESS AND ITS MODEL

R. L. R. Lefevre
M. S. T. Price

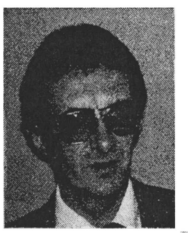
Raymond L. R. Lefevre (top) (technical engineer electronic, nuclear industries, Itsein Brussels, 1964) is employed at Belgonucleaire S.A., Dessel, Belgium. He is presently involved in the coordination of fuel fabrication activities for the SNR Fast Breeder Project. From 1967 to 1974 he was detached to the Dragon Project at Winfrith, where he was involved with the development of high-temperature reactor fuel fabrication equipment and processes as well as the manufacture of experimental fuels. His interests center on the coordination of all fuel fabrication activities, from design specification to the quality assurance program. M. S. T. Price (Royal Naval College, 1943), a principal scientific officer in the United Kingdom Atomic Energy Authority, is presently seconded to RAMCO Inc. for the High-Temperature Gas-Cooled Reactor Commercialization Study commissioned by the U.S. Energy Research and Development Administration. His experience includes being quality control manager at Powell Duffryn Carbon Products, Hayes, England (1950 to 1954), technical manager of the Atomic Energy Research Establishment Harwell Experimental Graphite Plant (1957 to 1960), leader of the Graphite Group in the OECD Dragon Project (1960 to 1961). group leader, Fuel Production Group, Dragon Project (1962 to 1969), and member of the senior staff of the Dragon Project as branch head of fuel operations (1969 to

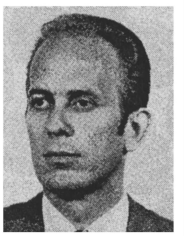


1976). His main interests are in carbon technology, nuclear fuel fabrication, quality assurance, gas-cooled reactor technology, and technology management.

AUTOMATIC SIZE ANALYSIS OF COATED FUEL PARTICLES

K. Wallisch
P. Koss

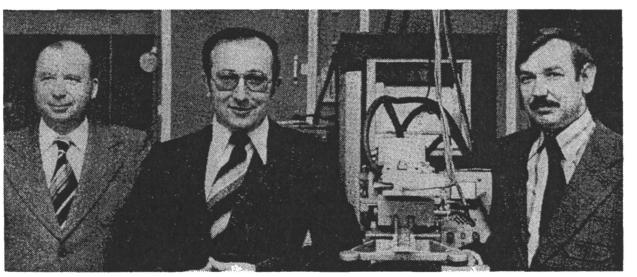


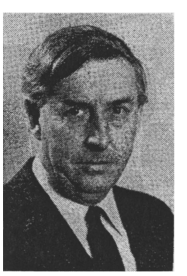


K. Wallisch (top) (electrical engineer, HTL, Vienna, 1958) is employed at SGAE (Austrian Atomic Energy Research Ltd.) and is leader of the group for development of methods and equipment for quality control of high-temperature gas-cooled reactor (HTGR) fuel particles. He has been involved in the characterization of pyrocarbon coatings and the development of coating equipment for pilot plant operation since 1961. P. Koss (PhD, physics, University of Vienna, 1958) is head of the Department for Metallurgy of SGAE at the Research Centre Seibersdorf, Austria. His interests include the material science aspects of high-temperature materials and the fabrication and evaluation of HTGR fuels. He is a part-time lecturer at the University of Vienna.

QUALITY CONTROL TECHNIQUES FOR PYROCARBON

W. Delle
K. Koizlik
M. S. T. Price
E. Wallura

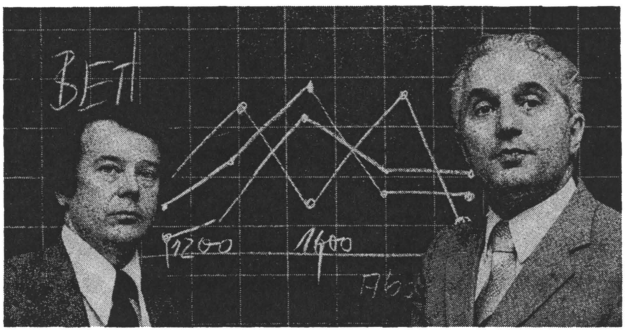




Wolfgang Delle (top left) (Dr. rer. nat., physics, Technical University of Aachen, 1958) is employed at Nuclear Research Center (KFA), Jülich, and is the head of the materials technology and characterization section of the Department for Reactor Materials. He is especially involved in the irradiation programs for graphitic materials and in the development of both characterization and quality control procedures for graphite, pyrolytic carbon, and silicon carbide to be used in high-temperature gas-cooled reactors (HTGRs). Karl Koizlik (top center) (Dr. rer. nat., physics, Technical University of Erlangen, 1968 and Technical University of Aachen, 1972) is employed at KFA in the Department for Reactor Materials. He is working in the field of nuclear materials and is responsible for the development of characterization procedures for pyrocarbon. A second field of activity is the development of quantitative models for pyrolysis and pyrocarbon deposition. He is a part-time lecturer at the Technical University of Aachen and is a member of several scientific organizations. M. S. T. Price (pictured alone) (Royal Naval College, 1943), a principal scientific officer in the United Kingdom Atomic Energy Authority, is presently seconded to RAMCO Inc. for the HTGR Commercialization Study commissioned by the U.S. Energy Research and Development Administration. His experience includes being quality control manager at Powell Duffryn Carbon Products, Hayes, England (1950 to 1954), technical manager of the Atomic Energy Research Establishment Harwell Experimental Graphite Plant (1957 to 1960), leader of the Graphite Group in the OECD Dragon Project (1960 to 1961), group leader in the Fuel Production Group, Dragon Project (1962 to 1969), and member of the senior staff of the Dragon Project as branch head of fuel operations (1969 to 1976). His main interests are in carbon technology, nuclear fuel fabrication, quality assurance, gas-cooled reactor technology, and technology management. Erich Wallura (top right) (Dr. rer. nat., experimental physics, Technical University of Aachen, 1966) joined KFA's Department for Reactor Materials in 1968. He is working on reactor materials for high-temperature reactors. His field of activity is the characterization of pyrocarbons.

A QUANTITATIVE CHEMICAL METHOD FOR THE DETERMINATION OF THE DISORDERED CARBON COMPONENT IN PYROCARBON COATINGS OF FUEL PARTICLES

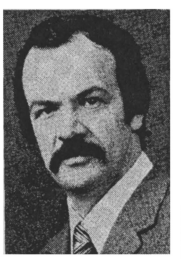
E. A. Wolfrum
H. Nickel

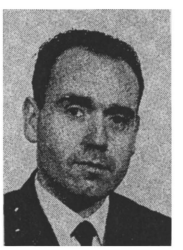


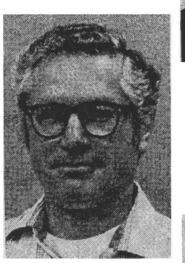
Erhard A. Wolfrum (left) (Dr. rer. nat., chemistry, Technical Universities of Braunschweig and Aachen, 1975) occupied himself in the Department for Reactor Materials with research questions pertaining to the deposition of pyrocarbon from the gas phase and the characterization of pyrocarbon. Since 1975 he has been employed in the Research and Development of the Rheinische Braunkohlenwerke AG, Köln, and works on problems of the purification and the use of carbon. His interests lie in the area of thermochemical carbon conversion. Hubertus Nickel (Dr. rer. nat., physical chemistry, Technical University of Aachen, 1959) is presently head of the Department for Reactor Materials in the Nuclear Research Center (KFA), Jülich. He is also a full professor of reactor materials and nuclear fuel elements at the Technical University of Aachen.

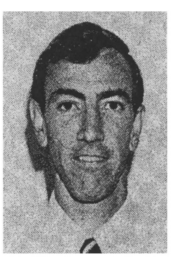
TRANSMISSION ELECTRON MICROSCOPY OF PYROCARBON COATINGS

E. Pollmann
J. Pelissier
C. S. Yust
J. L. Kaae





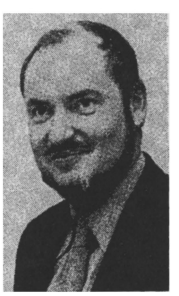




Ethwart A. Pollmann (top left) (Dipl. Phys., Technical University of Aachen, 1976), after finishing studies of mainly solid-state physics, has been investigating the structure of pyrocarbon layers on fuel particles for high-temperature reactors (HTRs) by electron microscopy in the Department for Reactor Materials at the Nuclear Research Center (KFA), Jülich, since 1974. Joseph L. Pelissier (top right) (Licence es Sciences, physiques, Grenoble University, 1966) started to work at the French Atomic Energy Commission as an electron microscopist for metallurgical studies. Since 1974, he has used these techniques to determine the structure and morphology of the pyrocarbon coatings of HTR particles. C. S. Yust (bottom left) (MS, metallurgical engineering, University of Tennessee, 1960) is a group leader in the Metals and Ceramics Division of Oak Ridge National Laboratory. His interests have included sintering of oxides, deformation processes in oxides, and electron microscopy of oxides, graphite, and pyrocarbon. J. L. Kaae (bottom right) (PhD, University of California at Los Angeles, 1965) has been with General Atomic Company since 1967, where he is involved with the properties and structure of pyrolytic carbon and coated particle behavior. Other areas in which he has worked are welding of high-strength steels and high-temperature low-cycle-fatigue behavior of austenitic metals.

INFLUENCE OF POROSITY ON THE IRRADIATION PERFORMANCE OF PYROCARBON COATINGS

P. Krautwasser
H. Nickel

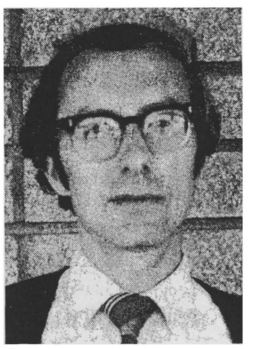


Peter Krautwasser (right) (Dr. rer. nat., physics, Technical University of Aachen, 1975) has been a staff member of the Department for Reactor Materials at the Nuclear Research Center (KFA), Jülich, since 1970. He is currently involved with the development of characterization techniques for pyrocarbon coatings and the comparison of material properties with fuel particle performance. From 1975 to 1976, he was on assignment to Metals and Ceramics Division at Oak Ridge National Laboratory, where he was engaged in

basic material research on pyrocarbon. Hubertus Nickel (Dr. rer. nat., physical chemistry, Technical University of Aachen, 1959) is presently head of the Department for Reactor Materials at KFA. He is also a full professor of reactor materials and nuclear fuel elements at the Technical University of Aachen.

PROPERTIES OF SILICON CARBIDE FOR NUCLEAR FUEL PARTICLE COATINGS

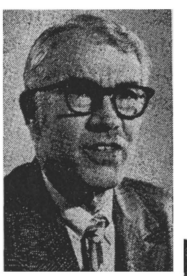
R. J. Price

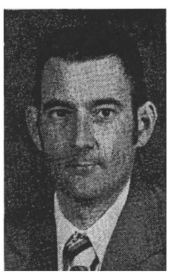


Robert J. Price (PhD, metallurgy, University of Cambridge, 1962) is a senior staff scientist in the Fuel Engineering Division of General Atomic Company. His technical experience has centered on research and development of materials used in the cores of high-temperature gas-cooled reactors. He is currently responsible for several programs on nuclear graphites, principally their properties under fast-neutron irradiation.

PRELIMINARY EXAMINATION OF THE HELIUM PERMEABILITY OF PYROCARBON COATINGS

C. S. Morgan
G. L. Powell

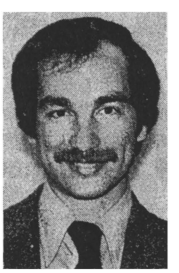


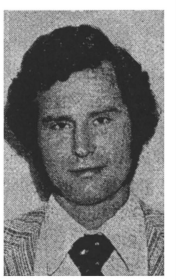


C. S. Morgan (top) (BS, chemical engineering; PhD, physical chemistry, Rice University) has been a research staff member of Oak Ridge National Laboratory (ORNL) for 20 years and is now engaged in the study of properties of pyrocarbon coatings of high-temperature gas-cooled reactor fuel particles. His previous studies include aqueous slurries and sintering mechanisms. G. Louis Powell (BS, chemistry, Presbyterian College, 1963; PhD, chemistry, University of North Carolina at Chapel Hill, 1967) is a development chemist with Union Carbide Corporation-Nuclear Division at the ORNL Y-12 Plant. His current interests include hydrogen transport and embrittlement in uranium alloys, surface chemistry, and kinetic spectroscopy.

PROPERTIES INFLUENCING HIGH-TEMPERATURE GAS-COOLED REACTOR COATED FUEL PARTICLE PERFORMANCE

D. P. Harmon
C. B. Scott

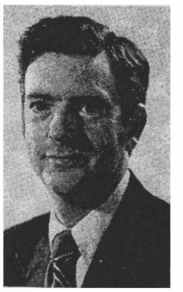


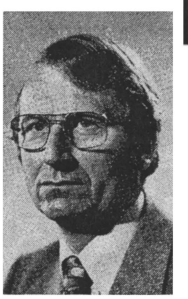


D. P. Harmon (top) (BS, University of California, 1963) is leader of the High-Temperature Gas-Cooled Reactor (HTGR) Fuel Irradiation Section at General Atomic Company (GA). He joined GA in 1968, and since that time he has been responsible for examinations of Fort St. Vrain (FSV) and large HTGR fuel irradiation tests. He has been a major contributor to the FSV and large HTGR fuel specifications. C. B. Scott (MS, ceramic engineering, University of Washington, 1971) is a senior scientist in the Fuel Materials Branch at GA. His principal areas of research are thermal performance and postirradiation examination of HTGR fuels.

NEUTRON-INDUCED PERMEABILITY OF PYROCARBON-COATED HIGH-TEMPERATURE GAS-COOLED REACTOR FUEL PARTICLES

R. A. Bradley
B. A. Thiele

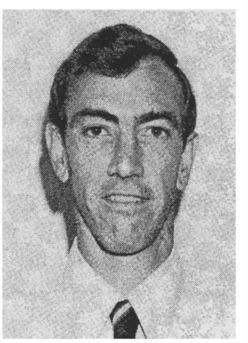




R. A. Bradley (top) (BS, ceramic engineering, Georgia Institute of Technology, 1960; MS, ceramic engineering, North Carolina State-Raleigh, 1968) is group leader in fuel cycle engineering in the Metals and Ceramics Division at Oak Ridge National Laboratory (ORNL). He is responsible for developing refabrication technology for nuclear fuels. The work reported in the paper was performed while he was on assignment to Kernforschungsanlage (KFA) Jülich, Federal Republic of Germany. B. A. Thiele (MS, metallurgy and ceramics, Technical University of Aachen, Federal Republic of Germany, 1963) is group leader of the Hot Metallography Group and task leader of high-temperature-reactor fuels development in the Institute for Reactor Materials at KFA. Thiele is presently on assignment to ORNL.

THE MECHANICAL BEHAVIOR OF BISO-COATED FUEL PARTICLES DURING IRRADIATION. PART I: ANALYSIS OF STRESSES AND STRAINS GENERATED IN THE COATING OF A BISO FUEL PARTICLE DURING IRRADIATION

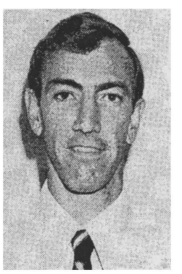
J. L. Kaae

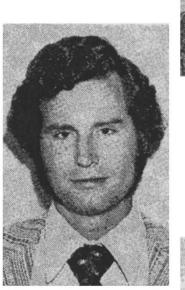


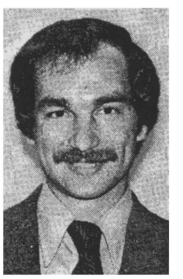
J. L. Kaae (PhD, University of California at Los Angeles, 1965) has been with General Atomic Company since 1967, where he is involved with the properties and structure of pyrolytic carbon and coated particle behavior. Other areas in which he has worked are welding of high-strength steels and high-temperature low-cycle-fatigue behavior of austenitic metals.

THE MECHANICAL BEHAVIOR OF BISO-COATED FUEL PARTICLES DURING IRRADIATION. PART II: PREDICTION OF BISO PARTICLE BEHAVIOR DURING IRRADIATION WITH A STRESS-ANALYSIS MODEL

J. L. Kaae
R. E. Bullock
C. B. Scott
D. P. Harmon







J. L. Kaae (top left) (PhD, University of California at Los Angeles, 1965) has been with General Atomic Company (GA) since 1967, where he is involved with the properties and structure of pyrolytic carbon and coated particle behavior. Other areas in which he has worked are welding of high-strength steels and high-temperature low-cycle-fatigue behavior of austenitic metals. R. E. Bullock (top right) (BS, physics, Louisiana Polytechnic Institute, 1956; MA, mathematics, 1963, and MS, physics, 1969, Texas Christian University) has worked in the nuclear energy field for 20 years. He spent 17 years on the ANP and NERVA Programs at General Dynamics Corporation, and 3 years on the high-temperature gas-cooled reactor (HTGR) at GA. His primary specialty is the evaluation of irradiation effects on carbonaceous materials including pyrocarbon, graphite, structural carbon composites, and organic-based matrix materials for fuel rods. C. B. Scott (bottom left) (MS, ceramic engineering, University of Washington, 1971) is a senior scientist in the Fuel Materials Branch at GA. His principal areas of research are thermal performance and postirradiation examination of HTGR fuels. D. P. Harmon (bottom right) (BS, University of California, 1963) is leader of the HTGR Fuel Irradiation Section at GA. He joined GA in 1968, and since that time he has been responsible for examinations of Fort St. Vrain (FSV) and large HTGR fuel irradiation tests. He has been a major contributor to the FSV and large HTGR fuel specifications.

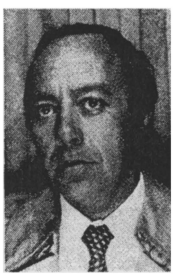
IMPROVEMENT OF A METHOD FOR PREDICTING FAILURE RATES OF COATED PARTICLES DURING IRRADIATION

Karl Bongartz

Karl Bongartz (Dr. rer. nat., physics, Technical University of Aachen, 1965) is working in the Department for Reactor Materials at the Nuclear Research Center (KFA), Jülich. He is involved in stress model calculations to predict and interpret the behavior of coated particle fuel during irradiation and also in the measurement of mechanical properties of coating materials. Before that, he worked at the OECD Dragon Project at Winfrith in the field of interpretation of coated particle irradiation test results.

RESTORATION OF CARBON MONOXIDE EQUILIBRIUM IN POROUS OXIDE HIGH-TEMPERATURE REACTOR FUEL PARTICLES

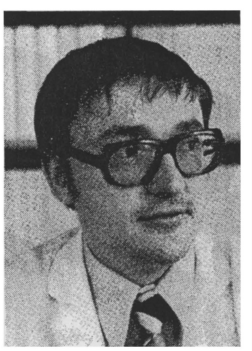
A. Strigl
E. Proksch



Anton Strigl (top) has been an engineer in the Department of Chemistry at the Seibersdorf Research Center of the Österreichische Studiengesellschaft für Atomenergie GmbH since 1961. He is involved in the process development and in the postirradiation evaluation of high-temperature gas-cooled reactor (HTGR) fuel. His special interest is in the mass spectrometric measurement of fission and reaction gases in coated particles. Emil Proksch (Dr. techn., chemistry, University of Technology, Vienna, 1958) has been head of the Department of Chemistry at the Seibersdorf Research Center since 1973. Before that time, he headed the Applied Radiation Chemistry Group at the same laboratory. His current interests are mainly in the field of HTGR fuel. Besides that, he is lecturing in radiation chemistry and radiation processing at the University of Technology in Vienna.

AMOEBA BEHAVIOR OF UO_2 COATED PARTICLE FUEL

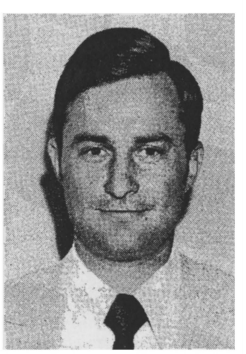
M. Wagner-Löffler



M. Wagner-Löffler (PhD, chemistry, University of Vienna, 1972) has been employed by Studiengesellschaft für Atomenergie, Austria, since 1972. He was on assignment to the OECD High-Temperature Reactor Dragon Project from 1973 to 1976. There he was working within the Fuel Research and Development Branch, in the main area of chemical phenomena in high-temperature gas-cooled reactor fuel. Since then he has started working on the fixation of high-level radioactive waste.

MIGRATION OF ThO_2 KERNELS UNDER THE INFLUENCE OF A TEMPERATURE GRADIENT

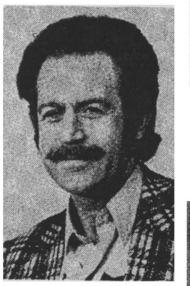
C. L. Smith



Craig L. Smith (PhD, materials science, Carnegie-Mellon University, 1972) is a staff scientist at General Atomic Company. His current interests include studies of the impact of temperature, temperature gradient, and burnup on the thermal stability of UC_2 and ThO_2.

SILICON CARBIDE CORROSION IN HIGH-TEMPERATURE GAS-COOLED REACTOR FUEL PARTICLES

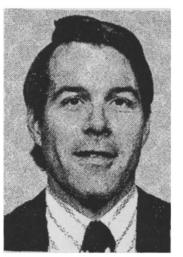
H. Grübmeier
A. Naoumidis
B. A. Thiele

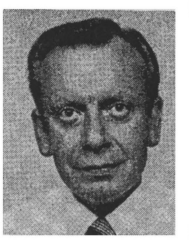


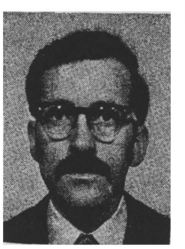
Helmut Grübmeier (top) (Dipl. Phys., physics, Technical University of Berlin, 1965) has been employed at the Nuclear Research Center (KFA), Jülich, since 1968. He is involved in electron probe microanalysis studies of reactor materials in the Department for Reactor Materials. His main field of interest is the behavior of fission products in nuclear fuels. Aristides Naoumidis (center) (Dr. rer. nat., chemistry, Technical University of Aachen, 1967) has worked at KFA as a research chemist since 1962 and is head of the Chemistry and Ceramics Division in the Department for Reactor Materials. His special interest in particular is in high-temperature behavior (fabrication, stability, corrosion, and irradiation) of ceramics and of high-temperature gas-cooled reactor and liquid-metal fast breeder reactor fuel. B. A. Thiele (bottom) (MS, metallurgy and ceramics, Technical University of Aachen, 1963) is group leader of the Hot Metallography Group and task leader of high-temperature-reactor fuels development in the Institute for Reactor Materials at KFA. He is presently on assignment to Oak Ridge National Laboratory.

STOICHIOMETRIC EFFECTS ON PERFORMANCE OF HIGH-TEMPERATURE GAS-COOLED REACTOR FUELS FROM THE U-C-O SYSTEM

F. J. Homan
T. B. Lindemer
E. L. Long, Jr.
T. N. Tiegs,
R. L. Beatty



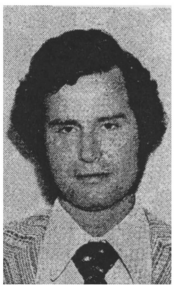


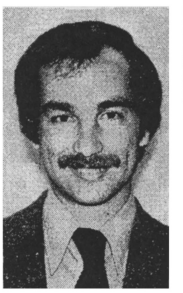


F. J. Homan (top left) (BS, met. eng., Cornell University, 1963) is a group leader in the Metals and Ceramics Division at Oak Ridge National Laboratory (ORNL), and is manager of the high-temperature gas-cooled reactor (HTGR) Base Technology Program at ORNL. He has worked in the areas of liquid-metal fast breeder reactor (LMFBR) and HTGR fuel development and fuel cycle economics for about 10 years. T. B. Lindemer (top right) (PhD, met. eng., University of Florida, 1966) is a group leader in the Chemical Technology Division at ORNL. His primary interest for the last 10 years has been the thermodynamics and kinetics of systems involving HTGR and LMFBR fuels and fission products. E. L. Long, Jr. (center left) (BS, chemical engineering, University of Tennessee, 1954) is a member of the Fuels Evaluation Group, Metals and Ceramics Division at ORNL. His previous work experience included light water reactor, FGBR, and LMFBR fuel performance evaluation, particularly postirradiation examination. He is currently on assignment to the Institute of Reactor Materials (IRW) at KFA, Jülich, Federal Republic of Germany. He is currently involved in basic studies of HTGR fuels within the German program. T. N. Tiegs (bottom right) (BS and MS, ceramic engineering, University of Illinois, 1973 and 1975) is a member of the Fuels Evaluation Group, Metals and Ceramics Division at ORNL. For the past 2 years, he has worked in the area of metallographic and microprobe examination of irradiated HTGR fuels. R. L. Beatty (bottom left) (BS, Pennsylvania State University, 1961; MS, University of Tennessee, 1966; PhD, University of Washington, 1974) developed laboratory-scale equipment and processes for HTGR fuel kernel and coating fabrication, conducted research on pyrocarbon characterization, and has been extensively involved with irradiation testing and evaluation of HTGR fuels. He is presently on assignment to EIR, Switzerland, for advanced breeder fuels research.

IRRADIATION PERFORMANCE OF FORT ST. VRAIN HIGH-TEMPERATURE GAS-COOLED REACTOR FUEL IN CAPSULE F-30

C. B. Scott
D. P. Harmon





C. B. Scott (top) (MS, ceramic engineering, University of Washington, 1971) is a senior scientist in the Fuel Materials Branch at General Atomic Company (GA). His principal areas of research are thermal performance and postirradiation examination of high-temperature gas-cooled reactor (HTGR) fuels. D. P. Harmon (BS, University of California, 1963) is leader of the HTGR Fuel Irradiation Section at GA. He joined GA in 1968, and since that time he has been responsible for examinations of Fort St. Vrain (FSV) and large HTGR fuel irradiation tests. He has been a major contributor to the FSV and large HTGR fuel specifications.

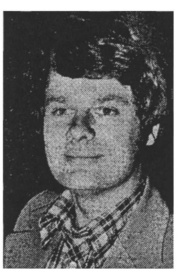
CESIUM RELEASE AND TRANSPORT IN BISO-COATED FUEL PARTICLES

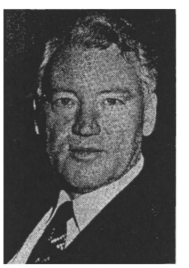
M. T. Morgan
A. P. Malinauskas

Marvin T. Morgan (right) (BS, Tennessee Polytechnic Institute) has been working on fission product release from coated particle fuels since 1962. He is currently a member of the Waste Isolation Group in the Chemical Technology Division at Oak Ridge National Laboratory (ORNL). His interests now include, besides fission product release from fuel, thermal and other properties of cement and borehole core samples, and the retention of fission products in cement. Anthony P. Malinauskas (PhD, physical chemistry, Massachusetts Institute of Technology) is head of the Chemical Development Section, Chemical Technology Division, at ORNL. His concerns include fission product behavior and transport in high-temperature gas-cooled reactor, light water reactor, and liquid-metal fast breeder reactor systems, separations, chemistry, and nuclear fuel reprocessing.

CESIUM RELEASE DATA FOR BISO-COATED PARTICLES

D. Stöver
R. Hecker

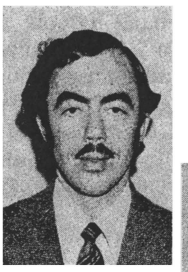
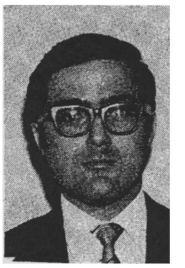
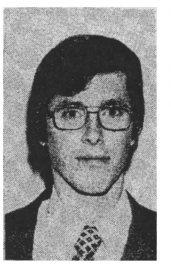
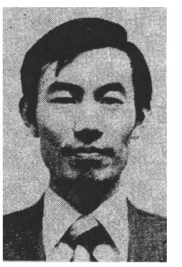




Detlev Stöver (top) (Dr. rer. nat., nuclear engineering, Technical University of Aachen, 1972) is group leader at the Institut für Reaktorentwicklung of the Nuclear Research Center (KFA), Jülich. He has worked on neutron physics, nuclear measuring techniques, and, since 1969, on diffusional studies of irradiated ceramic materials. His interest now is the calculation and data determination for fission product release from high-temperature reactor (HTR) fuel. Rudolf Hecker (Dr. rer. nat., physical chemistry, University of Köln, 1959) has been head of the Institut für Reaktorentwicklung of KFA since 1971, and is a professor of nuclear engineering at the Technical University of Aachen. His field of activity is HTR technology and physics, with such interests as fission product release from fuel, hydrogen and tritium permeation studies, reactor instrumentation, research with critical assemblies, and aspects of fusion reactor technology.

RELEASE OF METALLIC FISSION PRODUCTS FROM MULTILAYERED COATED PARTICLES

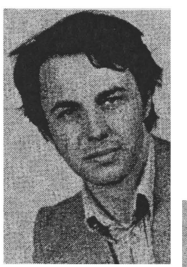
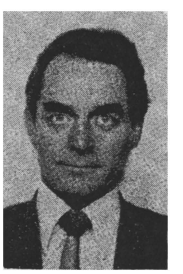
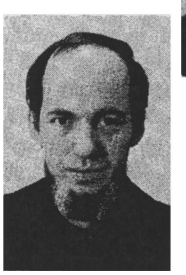
P. D. Smith
R. G. Steinke
D. D. Jensen
T. Hama

Peter D. Smith (top left) (MS, mechanical engineering, Drexel Institute of Technology, 1966) is a section leader in the Fuel Methods Department at General Atomic Company (GA). He is involved in numerical methods development, particularly in the areas of stress analysis and fission product transport. Robert G. Steinke (top right) (PhD, nuclear engineering, University of Michigan, 1973) formerly worked at GA developing numerical methods for reactor physics and fission product transport. He is now with the Liquid-Metal Fast Breeder Reactor Safety Group at Los Alamos Scientific Laboratory, where he is engaged in loss-of-coolant-accident modeling. Dan D. Jensen (bottom left) (PhD, chemistry, University of Washington, 1971) is a member of the Core Design Department at GA, where he is responsible for the verification of fission product transport codes. Teruo Hama (bottom right) (BS, electrical engineering, Nikon University, Japan, 1966) was assigned to the Core Design Department at GA for 18 months until September 1976. He is presently a member of the Nuclear Power Department of the Electric Power Development Company, Ltd., Japan, where his interests are nuclear fuel behavior during steady-state operation and postulated accident conditions.

SILVER RELEASE FROM COATED PARTICLE FUEL

H. Nabielek
P. E. Brown
P. Offermann

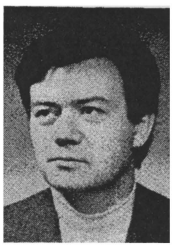
H. Nabielek (top) (DPh, physics, University of Vienna, 1969) started his scientific career in nuclear physics and electronics of high-temperature reactor (HTR) fuel in the OECD Dragon Project, with special emphasis on coated particle performance, and is presently engaged in the development of spherical fuel elements for pebble-bed reactors at the Nuclear Research Center (KFA), Jülich. P. E. Brown (center) (Chemistry Diploma, Oxford Polytechnic, 1951) is employed by the United Kingdom Atomic Energy Authority at Harwell in the Applied Chemistry Division, where, since 1961, he has been section leader for postirradiation examination studies of HTR fuels, with particular reference to the behavior of fission products. His other interests include hot laboratory facilities, gamma-ray spectrometry, and fuel reprocessing, the latter being his current area of work. P. Offermann (bottom) (Dr. rer. nat., physics, Technical University of Berlin, 1975) is employed at Hahn-Meitner-Institut, Nuclear Division (West Berlin) and is primarily involved with backscattering measurements for analytical purposes. Presently he is working on special problems of fission product transport in HTR fuel.

EMISSION OF FISSION GASES BY FAILED COATED OXIDE FUEL PARTICLES

Marie-Louise Pointud
Pierre Chenebault

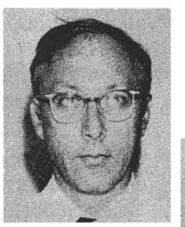
Marie-Louise Pointud (right) (Licence es Sciences Physiques, University of Paris, 1953) is employed by the Commissariat à l'Energie Atomique as a scientist in the Division de Métallurgie et d'Etude des Combustibles Nucléaires at Grenoble. She is involved in irradiation tests of high-temperature gas-cooled reactor (HTGR) fuel.

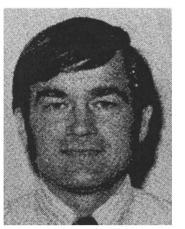
Pierre Chenebault (Ecole Supérieure de Chemie Industrielle de Lyon, 1959, Licence es Sciences Université de Lyon) is a leader of a group for defected fuels behavior in the Division de Métallurgie et d'Etude des Combustibles Nucléaires at Grenoble. Since 1963 he has been in charge of fission gas release studies from HTGR, liquid-metal fast breeder reactor, and pressurized water reactor fuels.

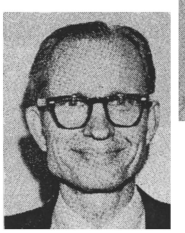


FISSION GAS RELEASE FROM FUEL PARTICLES AND FUEL RODS

B. F. Myers
N. L. Baldwin
W. E. Bell



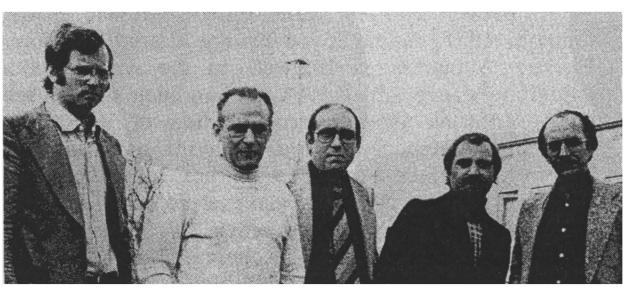




B. F. Myers (top) (PhD, Northwestern University, 1955), N. L. Baldwin (center) (BS, San Diego State College), and W. E. Bell (bottom) (PhD, University of California at Los Angeles, 1953) are members of the Fuel Chemistry Branch, Fuel Engineering Division, of General Atomic Company. Myers is concerned with analysis of fission product transport, Baldwin is responsible for fission product transport studies in high-temperature gas-cooled reactor systems, and Bell is manager of the Fuel Chemistry Branch and is responsible for fission product chemistry.

FISSION PRODUCT RELEASE FROM COATED PARTICLES EMBEDDED IN SPHERICAL FUEL ELEMENTS FOR HIGH-TEMPERATURE REACTORS

E. Groos
G. Mielken
R. Duwe
A. Müller
M. Will



Ekkehard Groos (second from left) (DPh, chemistry, University of Frankfurt, 1961) has been at the Department for Reactor Materials of the Nuclear Research Center (KFA), Jülich, since 1965, where he works on irradiation experiments and postirradiation examination for high-temperature reactor (HTR) development. Gerhard Mielken (far right) (Dipl. Ing., physics, University of Hamburg, 1964) has been deputy leader of the project for HTR Fuel and Graphite Development at KFA since his employment on the staff of the HHT Project, where he is responsible for fission release, plate-out, and component decontamination, leading a group of theoretical physicists in this field. Reiner Duwe (far left) (Dr. Ing., nuclear engineering, Technical University of Aachen, 1972) has been employed at KFA since 1966. He has worked on nuclear measuring techniques, especially gamma-ray spectrometry. His main field of interest now is measurement and calculation of fission product release and distribution in high-temperature gas-cooled reactor (HTGR) fuel elements. Alfons Müller (second from right) (Dr. rer. nat., physics, Technical University of Aachen, 1972) is working as a scientist at the Institute for Nuclear Safety Research of KFA in the field of HTGR accident analyses, especially in fission product problems. Michale Will (center) (Dipl. Ing., electrical and nuclear engineering, Technical University of Aachen, 1970) is employed on the staff of the HTB Project at KFA. He is responsible for the coordination of all fission product transport work.

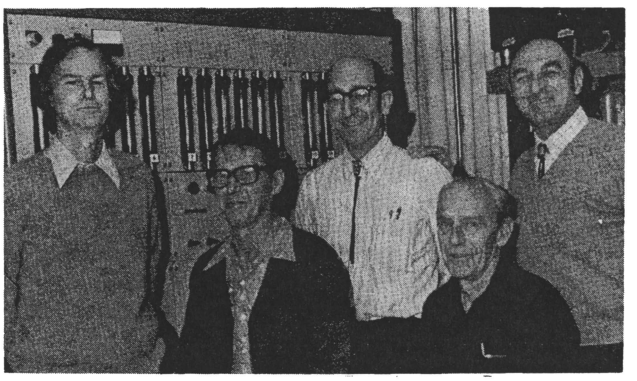
RELEASE OF RARE FISSION GASES FROM SPHERICAL ELEMENTS WITH COATED FUEL PARTICLES

K. Röllig

Klaus Röllig (PhD, physical chemistry, University of Marburg, 1966) joined the Material Branch of the OECD High-Temperature Reactor Dragon Project in 1966. Since 1969 he has worked with the Hochtemperatur-Reaktorbau GmbH (HRB, formerly BBK) in the field of fuel element design and development, fission product transport, and fuel cycle management.

CHEMICAL VAPOR DEPOSITION OF ZrC MADE BY REACTIONS OF $ZrCl_4$ WITH CH_4 AND WITH C_3H_6

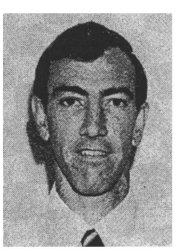
C. M. Hollabaugh
L. A. Wahman
R. D. Reiswig
R. W. White
P. Wagner

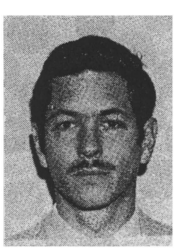


Charles M. Hollabaugh (far left) (BS, Texas Technological College, 1950; MS, University of Wichita, 1952; PhD, Lehigh University, 1959) is a physical chemist with a broad background in CVD technology. He has developed processes for advanced high-temperature gas-cooled reactor (HTGR) fuel particle coatings, particularly ZrC, and is presently involved with thermochemical hydrogen development. Lyle A. Wahman (second from left) (Engineering Trade School-Great Lakes Naval Training Center) has been a chemical and x-ray technician with the Los Alamos Scientific Laboratory (LASL) since 1959, where he has worked on various gas reactor programs. Robert D. Reiswig (center) (BS, University of Kansas, 1951; PhD, University of Wisconsin, 1956) is a metallurgical engineer specializing in the microscopic characterization of carbons and carbon-carbide composites. Ralph W. White (second from right) has been with the Chemistry and Metallurgy Division at LASL since 1954. He is experienced with cryogenics, superconductivity, and more recently, development of coating equipment and processes for advanced HTGR coated particle fuels. Paul Wagner (far right) (BA, MA, SUNY Albany, 1947 to 1948; PhD, University of Rochester, 1952) is a physical chemist who has been associated with HTGR materials research and development at LASL since 1956. He was involved with all phases of the High-Temperature Reactor Fuels Technology Program, from planning and implementation through irradiation testing.

IMPROVEMENTS IN THE PERFORMANCE OF NUCLEAR FUEL PARTICLES OFFERED BY SILICON-ALLOYED CARBON COATINGS

J. L. Kaae
S. A. Sterling
L. Yang





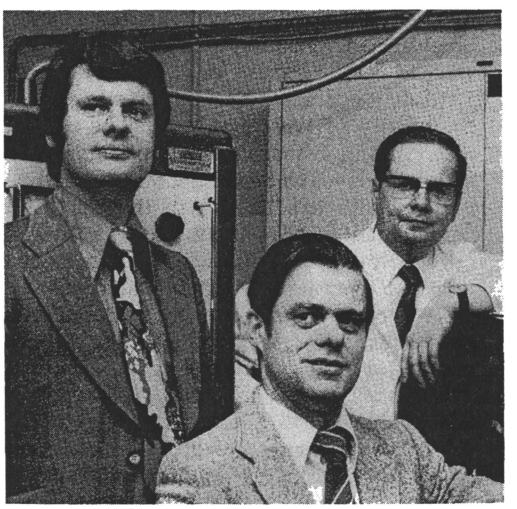
J. L. Kaae (top) (PhD, University of California at Los Angeles, 1965) has been with General Atomic Company (GA) since 1967, where he is involved with the properties and structure of pyrolytic carbon and coated particle behavior. Other areas in which he has worked are welding of high-strength steels and high-temperature low-cycle-fatigue behavior of austenitic metals. S. A. Sterling (bottom) (BS, physics, Massachusetts Institute of Technology, 1964; PhD, physics, University of California, 1969) is presently the manager of the Physical Chemistry Branch in the Advanced Materials Department at GA. He specializes in the irradiation testing and postirradiation characterization of advanced high-temperature gas-cooled reactor (HTGR) fuel materials. He has also been involved

in reactor physics experiments, the development of nondestructive testing techniques, and modeling the high-temperature properties of heat exchanger materials. Ling Yang (right) (PhD, physical chemistry, Imperial College of Science and Technology of University of London, 1948) was a research fellow in Princeton University from 1948 to 1951, and a research metallurgist in the Metals Research Laboratory of the Carnegie Institute of Technology (now Carnegie-Mellon University) from 1951 to 1959. He joined GA in 1959 and was responsible for high-temperature fuel and refractory metal cladding development from 1959 to 1972 for thermionic space power application. He started to work on advanced HTGR fuel development in 1973. Currently, he is the manager of the Advanced Materials Development Department at GA.

METALLIC FISSION PRODUCT RETENTION OF COATED PARTICLES WITH CERAMIC KERNEL ADDITIVES

R. Förthmann
H. Grübmeier
D. Stöver

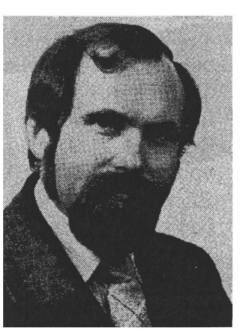
Rüdiger Förthmann (center) (Dr. rer. nat., chemistry, Technical University of Clausthal, 1965) is employed at the Department for Reactor Materials at Nuclear Research Center (KFA), Jülich, and is leader of the "Fuel Kernels" Group in the Chemistry Division. He is working on fabrication processes and irradiation testing of different types of fuel kernels for various applications. His particular interest is the development of materials with improved retention of metallic fission products. Helmut Grübmeier (right) (Dipl. Phys., physics, Technical University of Berlin, 1965) has been employed at KFA since 1968. He is involved in electron probe microanalysis studies of reactor materials in the Department for Reactor Materials. His main field of interest is the behavior of fission products in nuclear fuels. Detlev Stöver (left) (Dr. rer. nat., nuclear engineering, Technical University of Aachen, 1972) is group leader at the Institut für Reaktorentwicklung at KFA. He has worked on neutron physics, nuclear measuring techniques and, since 1969, on diffusional studies of irradiated ceramic materials. His interest now is the calculation and data determination for fission product release from high-temperature reactor fuel.



COATED PARTICLE FUEL ELEMENT FOR PRESSURIZED WATER REACTORS

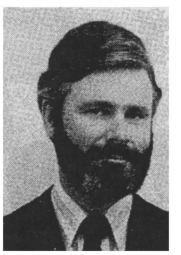
Werner Katscher

Werner Katscher (MS, engineering science, Technical University of Aachen, 1966; PhD, engineering science, Technical University of Aachen, 1975) is presently a member of the Institute for Nuclear Safety Research of the Nuclear Research Center (KFA), Jülich, and is responsible for safety experiments in the field of high-temperature gas-cooled reactors, especially experiments on graphite corrosion. From 1966 to 1975, he was engaged in the development of fuel elements for research reactors.



CONCLUDING REMARKS: COATED PARTICLE FUELS

H. Nickel
T. D. Gulden



Hubertus Nickel (top) (Dr. rer. nat., physical chemistry, Technical University of Aachen, 1959) is presently head of the Department for Reactor Materials in the Nuclear Research Center (KFA), Jülich, Federal Republic of Germany. He is also a full professor of reactor materials and nuclear fuel elements at the Technical University of Aachen. T. D. Gulden (PhD, materials science, Stanford University, 1965) is manager of the High-Temperature Gas-Cooled Reactor Materials Design Department at General Atomic Company. For the past ten years he has been involved in various aspects of coated particle fuels work including thermochemical performance, design, properties of coating materials, and fission product release. Prior to this work, he spent two years at the Berkeley Nuclear Laboratories in the U.K. performing basic research on irradiation effects in ceramics.

Dr. Ryohei Kiyose, Associate Editor for Asia

We are pleased to announce the appointment of our second Associate Editor overseas, Ryohei Kiyose as Associate Editor for Asia. Dr. Kiyose brings a history of past scientific contributions and service that makes this additional service to the American Nuclear Society exceptionally promising.

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Tokyo, Japan

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