

AUTHORS — JULY 1988

NEXT EUROPEAN TORUS (NET)

NEXT EUROPEAN TORUS OBJECTIVES, GENERAL REQUIREMENTS, AND PARAMETER CHOICES

Romano Toschi (top right) (Dr., 1954, and Prof., 1966, electrical engineering, University of Bologna, Italy) participated in the design and construction of the Frascati electron synchrotron from 1956 to 1960. From 1963 to 1970, he led a research program on magnetohydrodynamic (MHD) power generation. He became head of the Ente Nazionale per l'Energia Elettrica Fusion Program in 1970, then was director of the Frascati Research Center from 1976 to 1983, when he was appointed leader of the Next European Torus (NET) Team. **Max Chazalon** (top left) (Ing. Civil des Mines, Ecole des Mines de Saint Etienne, France, 1962) in 1964 joined the reactor construction department of Commissariat à l'Energie Atomique (CEA) (which later became Technicatome), where he contributed to the design, construction, and commissioning of several fission reactors in the areas of reactor vessel and heat extraction systems engineering. In 1971 he moved to the Testing Division of the Direction des Application Militaires of CEA where he was head of the Engineering Section. He joined the NET Team in 1983 as head of the nuclear and plant engineering group. **Folker Engelmann** (center right) [Dipl.-Phys., 1953, and Dr. rer. nat., 1956, Technische Hochschule (TH) München, Federal Republic of Germany (FRG); professor, theoretical plasma physics, Universiteit Utrecht, The Netherlands, 1976] has been deputy leader of the NET Team and head of the NET physics group since 1983. He previously worked as a scientific assistant at TH München and as a research worker at Fontenay-aux-Roses, France, Frascati, Italy, and Jutphaas, The Netherlands. **Jos Nihoul** (bottom left) (Lic. Phys. and Dr. rer. nat., Katholieke Universiteit Leuven, Belgium, 1957) joined the Studiecentrum voor Kernenergie/Centre d'Etude de l'Energie Nucléaire at Mol, Belgium, for experimental research on radiation damage in materials. In 1967, he became head of the materials science department. He has been a member of the International Atomic Energy Agency Fusion Power Coordinating Committee since 1975 and was chairman of the European expert group on fusion materials from 1979 to 1983. He coordinated the fusion technology programs performed at Mol from 1981 to 1985. In 1986, he was appointed head of the technology group of NET. **Jürgen Raeder** (bottom right) [Dr. Ing., 1967, and Prof., 1986,

Romano Toschi
Max Chazalon
Folker Engelmann
Jos Nihoul
Jürgen Raeder
Ettore Salpietro



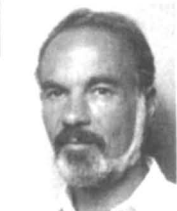
Technische Universität (TU) München, FRG] has been with Max-Planck-Institut für Plasmaphysik (IPP) since 1967. In 1973, he was a guest at Stanford University and he has lectured at TU since 1975. He became head of fusion systems studies at IPP in 1975. He has been a member of the NET Project Board and head of NET general system analysis since 1983. **Ettore Salpietro** (right) (Dr.-Ing., nuclear, Palermo University, Italy, 1968) worked for a year as a control engineer in a power station. He then joined the Laboratori Gas Ionizzati to work on MHD power generation and thermonuclear fusion as leader of the Frascati tokamak magnets, vacuum vessel, and system integration groups. In 1976, he joined the Joint European Torus (JET) to design the plasma shaping coils. He later became group leader of mechanical structure and assembly, then of magnets and services, responsible for the assembly of the JET basic machine. In 1983, he became leader of the NET tokamak engineering group and chairman of the electromagnetic group for Phase II, Part 3 of the International Tokamak Reactor.



NEXT EUROPEAN TORUS PHYSICS BASIS

Folker Engelmann (top right) [Dipl.-Phys., 1953, and Dr. rer. nat., 1956, Technische Hochschule (TH) München, Federal Republic of Germany (FRG); Professor, theoretical plasma physics, Universiteit Utrecht, The Netherlands, 1976] has been deputy leader of the Next European Torus (NET) Team and head of the NET physics group since 1983. He previously worked as a scientific assistant at the TH München and as a research worker at Fontenay-aux-Roses, France; Frascati, Italy; and Jutphaas, The Netherlands. **M. F. A. Harrison** (top left) is a physicist at the United Kingdom Atomic Energy Authority Culham Laboratory. He has a background of experimental research in the fields of basic atomic collision physics, ion source development, and the technology of electric space propulsion. He is currently involved in boundary physics problems related to tokamaks and in particular the modeling of reactor-like conditions. **Raffaele Albanese** (second from top right) (Deg., aeronautical engineering, 1982; PhD, electrical engineering, Napoli, Italy, 1987) is presently a research scientist at the University of Salerno, Italy. Previously, he was a member of the NET Team in the tokamak engineering group and, more recently, in the physics group. His present research concerns eddy currents and their effects on the evolution and the stability of toroidal plasmas. **Kurt Borrass** (center left) (Dipl.-Phys. and Dr. rer. nat., Universität München, FRG, 1974) has worked at the Institut für Plasmaphysik, Garching, FRG, since 1975 on plasma transport, plasma control, and systems codes. In 1983 he joined the NET Team, where he has been involved with the NET scoping studies and the assessment of the NET-related physics data base. A photograph and a biography for **O. De Barbieri** were not available. **E. S. Hotston** (third from top right) (BSc and PhD, London) has spent most of his professional life as a physicist in research and development within the energy and power producing area. He is currently engaged in research at the Culham Laboratory. **Aldo Nocentini** (bottom left) (Deg., physics, Trieste University, Italy, 1962) is associate professor of mathematical physics in the Department of Mathematical Sciences, Trieste University. Since 1965 his main research field has been plasma physics for controlled thermonuclear fusion. He has collaborated with European plasma physics laboratories (Frascati, Italy, and Jutphaas, The Netherlands) and, since 1983, with NET. **Jean-Georges Wégrowe** (bottom right) (Ing. ESE, Paris, 1960; Dr.-Ing., Paris, 1963) has

*Folker Engelmann
M. F. A. Harrison
Raffaele Albanese
Kurt Borrass
O. De Barbieri
E. S. Hotston
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Jean-Georges Wégrowe
Giorgio Zambotti*



been employed by the European Community since 1965 at the Max-Planck-Institut für Plasmaphysik. He has been in charge of a common French-German tokamak/stellarator project (WEGA 1972-1981) devoted to the study of radio-frequency plasma heating. This experiment was run at the Commissariat à l'Energie Atomique, Grenoble, France. He joined the NET Team in 1983. **Giorgio Zambotti** (right) is associate professor of statistical mechanics at the department of Nuclear and Theoretical Physics, University of Pavia, Italy. Initially, he studied quantum mechanics and low-energy nuclear physics, and then turned to statistical mechanics and plasma physics. He currently is a member of the NET Team, on a 1-year leave from the University of Pavia. In collaboration with J-G. Wégrowe, he has written a code for a one-dimensional model of propagation and absorption of lower hybrid waves, for realistic spectra including runaway electrons. The coupling to a ray-tracing code and to a transport code are now in progress.



NEXT EUROPEAN TORUS GENERAL DESCRIPTION AND LAYOUT

Max Chazalon (top right) (Ing. Civil des Mines, Ecole des Mines de Saint Etienne, France, 1962) in 1964 joined the reactor construction department of Commissariat à l'Energie Atomique (CEA) (which later became Technicatome), where he contributed to the design, construction, and commissioning of several fission reactors in the areas of reactor vessel and heat extraction systems engineering. In 1971, he moved to the Testing Division of the Direction des Application Militaires of CEA, where he was head of the Engineering Section. He joined the Next European Torus (NET) Team in 1983 as head of the nuclear and plant engineering group. **Paul Dinner** (top left) (MSc, physics, Laurentian University, Canada, 1973; MEng, University of Toronto, Canada, 1977) joined Ontario Hydro in 1974, where he was a design group leader responsible for radioactive emissions control and waste management. In 1981, he joined the Canadian Fusion Fuels Technology Project, where he managed design and development studies on tritium use in fusion facilities. Since 1984, he has been attached to the NET Team, where he has been responsible for the design of tritium and vacuum systems in the nuclear and plant engineering group. **Neil Mitchell** (bottom right) (PhD, mechanical engineering, University of Cambridge, United Kingdom, 1979) worked for 2 years with GEC on fluid mechanics aspects of turbomachinery design before joining Culham Laboratory in 1981. He was involved in the mechanical/electrical design and analysis of several fusion-related projects until coming to the tokamak engineering group of the NET Team in 1983. His responsibility has been plasma configuration calculations and coil/conductor analysis. **Ettore Salpietro** (bottom left) (Dr.-Ing., nuclear, Palermo University, Italy, 1968) worked for a year as a control engineer at a power station. He then joined the Laboratori Gas Ionizzati to work on magnetohydrodynamic power generation and thermonuclear fusion as leader of the Frascati tokamak magnets, vacuum vessel, and system integration groups. In 1976, he joined the Joint European Torus (JET) to design the plasma shaping coils. He later became group leader of mechanical structure and assembly, then of magnets and services, responsible for the assembly of the JET basic machine. In 1983, he became leader of the NET tokamak engineering group and chairman of the electromagnetic group for Phase II, Part 3 of the International Tokamak Reactor.

*Max Chazalon
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NEXT EUROPEAN TORUS BASIC MACHINE

Ettore Salpietro (top right) (Dr.-Ing., nuclear, Palermo University, Italy, 1968) worked for a year as a control engineer in a power station. He then joined the Laboratori Gas Ionizzati to work on magnetohydrodynamic (MHD) power generation and thermonuclear fusion as leader of the Frascati tokamak magnets, vacuum vessel, and system integration groups. In 1976, he joined the Joint European Torus (JET) to design the plasma shaping coils. He later became group leader of mechanical structure and assembly, then of magnets and services, responsible for the assembly of the JET basic machine. In 1983, he became leader of the Next European Torus (NET) tokamak engineering group and chairman of the electromagnetic group for Phase II, Part 3 of International Tokamak Reactor (INTOR). **Federico Casci** (top left) (Dr.-Ing., mechanical engineering, Politecnico of Milan, Italy, 1982) started his scientific carrier with a 3-year fellowship at Max-Planck-Institut für Plasmaphysik, Federal Republic of Germany (FRG). His first research fields were burn control and MHD equilibria in tokamaks. A research engineer in the research department of Franco Tosi, he joined NET in early 1985. His main work areas are the mechanical configuration and maintenance, in particular the system integration and the assembly of the NET machine, and the computer-aided design (CAD) system data handling. **Flaviano Farfaletti-Casali** (second from top right) (doctorate, engineering, Politecnico of Milan, Italy) has been involved, since 1971, in conceptual studies and design activity in the field of fusion reactors. A sector head in the Systems Engineering and Reliability Division at the Joint Research Centre at Ispra, he is responsible, as research area coordinator, for the activities on reactor studies in the framework of the fusion technology and safety program. A member of the European delegation at the INTOR Workshop, he is directly involved in the NET design for the problems of configuration and maintenance. **Friedrich Fauser** (second from top left) (Ing. grad., Schule Gauss, Berlin, FRG, 1952) is a vacuum process engineer in Leybold AG, Köln and Hanau, FRG, and is responsible for the development and application of industrial vacuum systems. He joined the NET Team in 1986 and works in the tokamak engineering group on the vacuum vessel and cryostat. **Hartmut Gorenflo** (third from top right) (technician, 1963; mathematical technical assistant, 1968) has worked at Max-Planck-Institut für Plasmaphysik (IPP) since 1964 with plasma theory, MHD generators, high power iodine lasers, and systems studies. Since 1983 he has been a member of the NET Team. **Luciano Ingala** (third from top left) (PI, Nuclear Energy Institute, Milan, Italy, 1967) worked from 1969 to 1980 on reactor experiments at Ispra, Italy. He worked at JET from 1980 to 1983 in the remote handling group and joined the NET Team in 1981 to work mainly on CAD systems in connection with the remote handling area. **Thomas Kaltner** (fourth from top right) (mechanical engineering, 1984, and industrial engineering, 1987, Fachhochschule Munich, FRG) worked in the Institut für Plasmaphysik at Garching (IPP) until 1985. Since then he has been a member of the NET Team. There he is involved in the design of the NET basic machine components. **Gianbattista Malavasi** (bottom left) (PI, Mechanical Technical Institut, Modena, Italy, 1955) worked from 1959 until 1979 on thermonuclear fusion at Laboratorio Gas Ionizzati, Frascati, Italy. He was a member of the team for the design and construction of the Frascati tokamak experiment. He worked on JET from 1980 to 1984 in the Magnet System Division. He then joined the NET Team to collaborate on the design of the layout of the basic machine, in particular on the mechanical area. **Joseph Minervini** (bottom right) [PhD, mechanical engineering, Massachusetts Institute of Technology

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Friedrich Fauser
Hartmut Gorenflo
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Thomas Kaltner
Gianbattista Malavasi
Joseph Minervini
Neil Mitchell
Rudolf Pöhlchen*



(MIT), 1981] spent 2 years as a National Academy of Sciences National Research Council postdoctoral research associate at the National Bureau of Standards, Boulder, Colorado, before joining the research staff at the MIT Plasma Fusion Center. His research interests are in the area of applied superconductivity including ac losses, stability and magnet design. He joined the NET Team in 1986 where he is involved in the development and analysis of the superconductors for the poloidal and toroidal field coils. **Neil Mitchell** (top) (PhD, mechanical engineering, University of Cambridge, United Kingdom, 1979) worked for 2 years with GEC on fluid mechanics aspects of turbomachinery design before joining Culham Laboratory in 1981. He was involved in the mechanical/electrical design and analysis of several fusion-related projects until coming to the tokamak engineering group of the NET Team in 1983. His responsibility has been plasma configuration calculations and coil/conductor analysis. **Rudolf Pöhlchen** (bottom) (Dipl.-Ing., electrical engineering, Technische Universität Berlin, FRG, 1964) has worked at Max-Planck-Institut für Plasmaphysik from 1964 to 1973 and was part of the magnet technical group from 1969 where he was group leader for computations in electrical and mechanical engineering. From 1973 to 1983 he was a member of the JET Team and in 1978 was the group leader for the toroidal coil and cooling plant design, manufacture, and commissioning. From 1983 to 1985 he was a member of the Asdex Upgrade Team, magnet design, and manufacture and since 1986 has been a member of the NET Team in magnet design.



NEXT EUROPEAN TORUS IN-VESSEL COMPONENTS

Max Chazalon (top right) (Ing. Civil des Mines, Ecole des Mines de Saint Etienne, France, 1962) in 1964 joined the reactor construction department of Commissariat à l'Energie Atomique (CEA) (which later became Technicatome), where he contributed to the design, construction, and commissioning of several fission reactors in the areas of reactor vessel and heat extraction systems engineering. In 1971, he moved to the Testing Division of the Direction des Application Militaires of CEA, where he was head of the Engineering Section. He joined the Next European Torus (NET) Team in 1983 as head of the nuclear and plant engineering group. **Jean-Louis Boutard** (top left) (Ecole Centrale des Arts et Manufactures, Paris, France; Doctorat d'Etat es Sciences Physiques, Université de Paris-Sud, Orsay, France, 1976) was a member of the French liquid-metal fast breeder reactor project at Saclay from 1976 to 1986, where he contributed to the development of irradiation-resistant structural materials for the core components. He joined the NET Team in 1986 and is responsible for the program on the irradiation effects on the steels of the first wall and blanket. **Michael Ian Budd** (bottom right) (BSc, Technical University of Sheffield, United Kingdom, 1981) has worked with the glass/ceramics group of GEC Engineering Research Centre, Stafford, United Kingdom, where he was involved in research and development of novel glasses and glass-ceramics. He joined NET in 1986 as a member of the materials technology group and is responsible for protection materials. His main areas of interest include characterization of thermal shock resistance of graphites, carbon fiber composites, and silicon carbide, and hydrogen isotope storage/recycling in these materials. **Antonino Cardella** (bottom left) (Dr.-Ing., nuclear engineering, University of Palermo, Italy, 1977) worked for Carlo Gavazzi SpA, Milan, from 1978 to 1980 on the design and assembly of components for boiling water nuclear reactors and from 1980 to 1982 as a stress analyst. From 1982 to 1984, he

- Max Chazalon*
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- Antonino Cardella*
- Wolfgang Dänner*
- Paul Dinner*
- Dain Evans*
- Markus Iseli*
- Bernard Libin*
- Frans Moons*
- Jos Nihoul*
- Marc A. Vassiliadis*
- Gottfried Vieider*
- Chung Hsiung Wu*
- Ezio Zolti*



worked for Ansaldo SpA at the Joint Research Centre Ispra on the first-wall and blanket design for the International Tokamak Reactor project. He joined the NET Team in 1984 and works with the nuclear and plant engineering group for the design and analysis of in-vessel components. **Wolfgang Dänner** (top right) [Dipl.-Ing., mechanical engineering, Technische Hochschule München, Federal Republic of Germany (FRG), 1963; Dr.-Ing., Technische Hochschule Karlsruhe, FRG, 1970] worked from 1963 to 1970 at Kernforschungszentrum Karlsruhe, FRG. Since 1970 he has been at the Max-Planck-Institut für Plasmaphysik, where he worked on blanket and first-wall problems within the framework of the "Projekt Systemstudien." He joined the NET Team in 1983 and is in charge of neutronics analysis and blanket development. **Paul Dinner** (top left) (MSc, physics, Laurentian University, Canada, 1973; MEng, University of Toronto, Canada, 1977) joined Ontario Hydro in 1974, where he was a design group leader responsible for radioactive emissions control and waste management. In 1981, he joined the Canadian Fusion Fuels Technology Project, where he managed design and development studies on tritium use in fusion facilities. Since 1984, he has been attached to the NET Team, where he has been responsible for the design of tritium and vacuum systems in the nuclear and plant engineering group. **Dain Evans** (second from top right) (BSc, University of Wales, United Kingdom, 1955; PhD, University of Birmingham, United Kingdom, 1960) worked at the GEC Hirst Research Centre from 1960 to 1986 in the development of liquid-phase sintered refractory alloys, soldering and brazing processes, and associated phase diagram studies, as well as evaluation of critical materials. He joined the NET Team in 1986 and is engaged in fabrication studies. **Markus Iseli** (second from top left) [Dipl.-Ing., Swiss Federal Institute of Technology (ETH), Zürich, Switzerland, 1978; Dr. sc. techn., Institute of Process Engineering, Refrigeration, and Cryogenics, ETH, 1985] has worked as a process engineer in the separation and mixing plant group at Sulzer Brothers Ltd., Winterthur, Switzerland, since 1984. He joined the NET Team in 1985 as a member of the nuclear and plant engineering group and is mainly involved in the study of tritium systems. **Bernard Libin** (third from top right) (Dipl.-Eng., electrical and nuclear engineering, ENSEM, University of Nancy, France, 1967; Dipl.-Eng., INSTN, Saclay, France, 1968) worked on nuclear gas reactors engineering at the Creusot-Loire group, until 1977. Since then, he has worked at Novatome and has been largely involved in the design and manufacture of major thermal components (heat exchangers, steam generators) of the French fast breeder reactors. He joined the NET Team in 1985 with responsibility for testing and development of nuclear in-vessel components. **Frans Moons** (third from top left) (Ir., electromechanical engineering, Leuven, Belgium, 1973) worked at Studiecentrum voor Kernenergie/Centre d'Etude de l'Energie Nucléaire (SCK/CEN), the Belgian Nuclear Research Center at Mol, as project engineer responsible for design and exploitation of irradiation rigs at the BR2 materials testing reactor. He joined the NET project in 1983 within the nuclear and plant engineering group and worked mainly on divertor design. **Jos Nihoul** (bottom right) (Lic. Phys. and Dr. rer. nat., Katholieke Universiteit Leuven, Belgium, 1957) joined the SCK/CEN Mol, Belgium, for experimental research on radiation damage in materials. In 1967, he became head of the materials science department. He has been a member of the International Energy Agency Fusion Power Coordinating Committee since 1975 and was chairman of the European expert group on fusion materials from 1979 to 1983. He coordinated the fusion technology programs performed at Mol from 1981 to 1985. In 1986, he was appointed head of the technology group of NET. **Marc A. Vassiliadis** (bottom left) (BSc, physics, University of Paris, France, 1966;



PhD, material sciences, Bordeaux, France; Postdoctoral Fellowship, engineering/materials science, Brown University, 1970-71) joined the NET Team in 1985 to work on insulating materials (inorganic and organic) and liquid breeding materials as well as resource supplies for some of the strategic elements needed for NET and the industrial devices to follow. **Gottfried Vieider** (top) (Dipl.-Ing., Technical University Vienna, Austria, 1961) worked until 1967 at the STAL-LAVAL Turbine Company in Sweden. Since then he has been with Studsvik Energiteknik AB, Sweden, where he worked on fast breeder research. He joined the NET Team in 1983 and is concerned with first-wall and blanket engineering. **Chung Hsiung Wu** (center) (BSc, physics, Institute of Technology, Taipei, Taiwan, 1962; MSc, 1968, and PhD, 1971, physical chemistry, Institute of Technology, Aachen, FRG) joined Kernforschungsanlage, Jülich, FRG, in 1971 as research scientist in fusion chemistry. From 1979 to 1980, he served as a research fellow in the surface physics group at Princeton University. He has served as leader of tritium chemistry groups at Jülich and also chair of a working group blanket and tritium chemistry of European fusion study groups. He joined the NET Team in 1984, specializing in tritium chemistry and plasma-material interaction. **Ezio Zolti** (bottom) (mechanical engineering, University of Rome, Italy, 1968) is a NET Team member in the technology group. He has had experience in theoretical structural mechanics of fast breeder core and plant components. His current interests include the thermomechanics and macroscopic material behavior of plasma-facing components of fusion systems.



NEXT EUROPEAN TORUS OPERATION CYCLE

Ettore Salpietro (top right) (Dr.-Ing., nuclear, Palermo University, Italy, 1968) worked for a year as a control engineer at a power station. He then joined the Laboratori Gas Ionizzati to work on magnetohydrodynamic power generation and thermonuclear fusion as leader of the Frascati tokamak magnets, vacuum vessel, and system integration groups. In 1976, he joined the Joint European Torus (JET) to design the plasma shaping coils. He later became group leader of mechanical structure and assembly, then of magnets and services, responsible for the assembly of the JET basic machine. In 1983, he became leader of the Next European Torus (NET) tokamak engineering group and chairman of the electromagnetic group for Phase II, Part 3 of the International Tokamak Reactor. **Raffaele Albanese** (top left) (Deg., aeronautical engineering, 1982; PhD, electrical engineering, Napoli, Italy, 1987) is presently a research scientist at the University of Salerno, Italy. Previously, he was a member of the NET Team in the tokamak engineering group and, more recently, in the physics group. His present research concerns eddy currents and their effects on the evolution and the stability of toroidal plasmas. **Enzo Coccoresse** (center right) (Deg., electrical engineering, University of Naples, Italy, 1972) is presently a full professor of electrotechnics at the University of Reggio Calabria, Italy. A former member of the JET Team during the design phase, he is now a part-time member of the NET Team, where his main activity is the field of plasma position control and eddy currents effects. **Raffaele Martone** (bottom left) (Deg., electrical engineering, University of Naples, Italy, 1974) is presently a full professor of electrotechnics at the University of Salerno, Italy. His research interests are mainly in electromagnetics, with particular reference to the design of magnetic fusion devices. **Neil Mitchell** (bottom right) (PhD, mechanical engineering, University of Cambridge, United Kingdom, 1979) worked for 2 years with GEC on fluid mechanics aspects of turbomachinery design before joining Culham Laboratory in 1981. He was involved

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in the mechanical/electrical design and analysis of several fusion-related projects until coming to the tokamak engineering group of the NET Team in 1983. His responsibility has been plasma configuration calculations and coil/conductor analysis. **Guglielmo Rubinacci** (right) (graduate, electrical engineering, University of Naples, Italy, 1975) is currently an associate professor of electrotechnics at the University of Salerno, Italy. His research interests are mainly in electromagnetics with particular reference to the design of magnetic fusion devices.



NEXT EUROPEAN TORUS ASSEMBLY AND MAINTENANCE

Max Chazalon (top right) (Ing., Civil des Mines, Ecole des Mines de Saint Etienne, France, 1962) in 1964 joined the reactor construction department of Commissariat à l'Energie Atomique (CEA) (which later became Technicatome), where he contributed to the design, construction, and commissioning of several fission reactors in the areas of reactor vessel and heat extraction systems engineering. In 1971, he moved to the Testing Division of the Direction des Application Militaires of CEA, where he was head of the Engineering Section. He joined the Next European Torus (NET) Team in 1983 as head of the nuclear and plant engineering group. **Ettore Salpietro** (top left) (Dr.-Ing., nuclear, Palermo University, Italy, 1968) worked for a year as a control engineer in a power station. He then joined the Laboratori Gas Ionizzati to work on magnetohydrodynamic (MHD) power generation and thermonuclear fusion as leader of the Frascati tokamak magnets, vacuum vessel, and system integration groups. In 1976, he joined the Joint European Torus (JET) to design the plasma shaping coils. He later became group leader of mechanical structure and assembly, then of magnets and services, responsible for the assembly of the JET basic machine. In 1983, he became leader of the NET tokamak engineering group and chairman of the electromagnetic group for Phase II, Part 3 of the International Tokamak Reactor (INTOR). **Federico Casci** (center right) (Dr. Ing., mechanical engineering, Politecnico of Milan, Italy, 1982) started his scientific carrier with a 3-year fellowship at Max-Planck-Institut für Plasma-physik. His first research fields were burn control and MHD equilibria in tokamaks. A research engineer in the research department of Franco Tosi, he joined NET in early 1985. His main work areas are the mechanical configuration and maintenance, in particular the system integration and the assembly of the NET machine, and the computer-aided design system data handling. **Flaviano Farfaletti-Casali** (bottom left) (PhD, engineering, Politecnico of Milan, Italy) has been involved, since 1971, in conceptual studies and design activity in the field of fusion reactors. A sector head in the Systems Engineering and Reliability Division at the Joint Research Centre, Ispra, he is responsible, as research area coordinator, for the activities on reactor studies in the framework of the fusion technology and safety program. A member of the European delegation at the INTOR Workshop, he is directly involved in the NET design for the problems of configuration and maintenance. **Clive Holloway** (bottom right) (PhD, mechanical engineering, Polytechnic of Wales, United Kingdom) worked from 1976 to 1982 at British Nuclear Fuels Ltd. on the development of remote handling equipment for nuclear fuel reprocessing. He joined Spar Aerospace in 1982 and was engaged in the design of equipment to disassemble the core of a Canada deuterium uranium reactor. From 1983 to 1985, he worked at Princeton Plasma Physics Laboratory as the team

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Clive Holloway
Giabattista Malavasi
Neil Mitchell
Eckhard Theisen
A. Suppan*



leader responsible for design and development of remote handling equipment for Tokamak Fusion Core Experiment. Since 1986, he has been the remote handling specialist for NET. In this position, he is responsible for defining the remote maintenance requirements and specifying the remote handling equipment. **Gianbattista Malavasi** (top) (PI, Mechanical Technical Institut, Modena, Italy, 1955) worked from 1959 to 1979 on thermonuclear fusion at Laboratori Gas Ionizzati, Frascati, Italy. He was a member of the team for the design and construction of the Frascati tokamak experiment. He worked on JET from 1980 to 1984 in the Magnet System Division. He then joined the NET Team to collaborate on the design of the layout of the basic machine, in particular on the mechanical area. **Neil Mitchell** (center) (PhD, mechanical engineering, University of Cambridge, United Kingdom, 1979) worked for 2 years with GEC on fluid mechanics aspects turbomachinery design before joining Culham Laboratory in 1981. He was involved in the mechanical/electrical design and analysis of several fusion related projects until coming to the tokamak engineering group of the NET Team in 1983. His responsibility has been plasma configuration calculations and coil/conductor analysis. **Eckhard Theisen** (bottom) (Dipl.-Ing., Kaiserslautern University, Federal Republic of Germany, 1982) has worked at NOELL Company as a mechanical engineer in the field of remote handling for fission reactors and nuclear reprocessing plants. He joined the NET Team in 1986 and is involved with the geometric integration of in-vessel components. A photograph and a biography for **A. Suppan** were not available.



HEATING AND CURRENT DRIVE SYSTEMS

Jean-Georges Wégrowe (top right) (Ing. ESE, Paris, France, 1960; Dr.-Ing., Paris, France, 1963) has been employed by the European Community since 1965 at the Max-Planck-Institut für Plasmaphysik, Federal Republic of Germany (FRG). He has been in charge of a common French-German tokamak/stellarator project (WEGA 1972-1981) devoted to the study of radio-frequency plasma heating. This experiment was run at the Commissariat à l'Energie Atomique, Grenoble, France. He joined the Next European Torus (NET) Team in 1983. **Folker Englemann** (top left) (Dipl.-Phys., 1953, and Dr. rer. nat., 1956, Technische Hochschule München, FRG; Professor, theoretical plasma physics, Universiteit Utrecht, The Netherlands, 1976) has been deputy leader of the NET Team and head of the NET physics group since 1983. He previously worked as a scientific assistant at the TH München and as a research worker at Fontenay-aux-Roses, France; Frascati, Italy; and Jutphaas, The Netherlands. **Flaviano Farfaletti-Casali** (bottom right) (doctorate, engineering, Politecnico of Milan, Italy) has been involved, since 1971, in conceptual studies and design activity in the field of fusion reactors. A sector head within the Systems Engineering and Reliability Division at the Joint Research Centre at Ispra, he is responsible, as research area coordinator, for the activities on reactor studies in the framework of the fusion technology and safety program. A member of the European delegation at the International Tokamak Reactor Workshop, he is directly involved in the NET design for the problems of configuration and maintenance. **Frans Moons** (bottom left) (Ir., electromechanical engineering, Leuven, Belgium, 1973) worked at Studiecentrum voor Kernenergie/Centre d'Etude de l'Energie Nucléaire, the Belgian Nuclear Research Center at Mol, as project engineer responsible for design and exploitation of irradiation rigs at the BR2 materials testing reactor. He joined the NET project in 1983 within the nuclear and plant engineering group and worked mainly on divertor design.

*Jean-Georges Wégrowe
Folker Englemann
Flaviano Farfaletti-Casali
Frans Moons*



NEXT EUROPEAN TORUS PLASMA EXHAUST AND FUEL PROCESSING SYSTEMS

Paul Dinner (top right) (MSc, physics, Laurentian University, Canada, 1973; MEng, University of Toronto, Canada, 1977) joined Ontario Hydro in 1974, where he was a design group leader responsible for radioactive emissions control and waste management. In 1981, he joined the Canadian Fusion Fuels Technology Project, where he managed design and development studies on tritium use in fusion facilities. Since 1984, he has been attached to the Next European Torus (NET) Team, where he has been responsible for the design of tritium and vacuum systems in the nuclear and plant engineering group. **Max Chazalon** (top left) (Ing. Civil des Mines, Ecole des Mines de Saint Etienne, France, 1962) in 1964 joined the reactor construction department of Commissariat à l'Energie Atomique (CEA) (which later became Technicatome) where he contributed to the design, construction, and commissioning of several fission reactors in the areas of reactor vessel and heat extraction systems engineering. In 1971 he moved to the Testing Division of the Direction des Applications Militaires of CEA where he was head of the Engineering Section. He joined the NET Team in 1983 as head of the nuclear and plant engineering group. **Dain Evans** (center right) (BSc, University of Wales, United Kingdom, 1955; PhD, University of Birmingham, United Kingdom, 1960) worked at the GEC Hirst Research Centre from 1960 to 1986 in the development of liquid-phase sintered refractory alloys, soldering and brazing processes, and associated phase diagram studies, as well as evaluation of critical materials. He joined the NET Team in 1986 and is engaged in fabrication studies. **Friedrich Fauser** (center left) [Ing. grad., Ing. Schule Gauss, Berlin, Federal Republic of Germany (FRG), 1952] is a vacuum process engineer in Leybold AG, Köln and Hanau, FRG, and is responsible for the development and application of industrial vacuum systems. He joined the NET Team in 1986 and worked in the tokamak engineering group on the vacuum vessel and cryostat. **Markus Iseli** (bottom right) [Dipl.-Ing., Swiss Federal Institute of Technology (ETH), Zürich, Switzerland, 1978; Dr. sc. techn., Institute of Process Engineering, Refrigeration, and Cryogenics, ETH, 1985] has worked as a process engineer in the Separation and Mixing Plant Group at Sulzer Brothers Ltd., Winterthur, Switzerland since 1984. He joined the NET Team in 1985 as a member of the nuclear and plant engineering group and is mainly involved in the study of tritium systems. **Chung Hsiung Wu** (bottom left) (BSc, physics, Institute of Technology, Taipei, Taiwan, 1962; MSc, 1968, and PhD, 1971, physical chemistry, Institute of Technology, Aachen, FRG) joined the Kernforschungsanlage, Jülich, in 1971 as a research scientist in fusion chemistry. From 1979 to 1980, he served as a research fellow in the surface physics group at Princeton University. He has served as leader of tritium chemistry groups at Jülich and also as chair of a working group on blanket and tritium chemistry of European fusion study groups. He joined the NET Team in 1984, specializing in tritium chemistry and plasma/material interaction.

*Paul Dinner
Max Chazalon
Dain Evans
Friedrich Fauser
Markus Iseli
Chung Hsiung Wu*



TESTING OF THE NUCLEAR IN-VESSEL COMPONENTS: REQUIREMENTS AND PROGRAM

Bernard Libin (right) (Dipl. Eng., electrical and nuclear engineering, ENSEM, University of Nancy, France, 1967; Dipl. Eng., INSTN, Saclay, France, 1968) worked on nuclear gas reactors engineering for the Creusot-Loire group, until 1977. Since then, he has worked at Novatome and has been largely involved in the

*Bernard Libin
Jean-Louis Boutard
Max Chazalon*



design and manufacture of major thermal components (heat exchangers, steam generators) of the French fast breeder reactors. He joined the NET Team in 1985 with responsibility for testing and development of nuclear in-vessel components. **Jean-Louis Boutard** (top) (Ecole Centrale des Arts et Manufactures, Paris, France, Doctorat d'Etat es Sciences Physiques, Université de Paris-Sud, Orsay, France, 1976) was a member of the French liquid-metal fast breeder reactor project at Saclay from 1976 to 1986, where he contributed to the development of irradiation-resistant structural materials for the core components. He joined the NET Team in November 1986 and is responsible for the program on the irradiation effects on the steels of the first wall and blanket. **Max Chazalon** (bottom) (Ing. Civil des Mines, Ecole des Mines de Saint Etienne, France, 1962) in 1964 joined the reactor construction department of Commissariat à l'Energie Atomique (CEA) (which later became Technicatome) where he contributed to the design, construction, and commissioning of several fission reactors in the areas reactor vessel and heat extraction systems engineering. In 1971, he moved to the Testing Division of the Direction des Application Militaires of CEA where he was head of the Engineering Section. He joined the Next European Torus Team at Garching in 1983 as head of the nuclear and plant engineering group.



RELIABILITY AND AVAILABILITY ASSESSMENTS FOR THE NEXT EUROPEAN TORUS

Rolf Bünde

Rolf Bünde (Dipl.-Ing., mechanical engineering, Universität Hannover, Federal Republic of Germany, 1964) has worked in the area of design and development of steam turbines at BBC, Mannheim, and on the development of closed cycle helium turbines at the Institute for Turbomachinery, Universität Hannover. Since 1970 he has worked at the Institut für Plasmaphysik, Garching, in the area of magnetohydrodynamic power generation, energy systems analysis, fusion fuel reserves, fusion power plant codes, costing, and net energy balance. He has also lectured on fusion technology at the Technische Universität München. Since 1983 he has been responsible for the Next European Torus Reliability and Availability Program.



SAFETY ASPECTS OF THE NEXT EUROPEAN TORUS

*Werner Gulden
Jürgen Raeder*

Werner Gulden (top) [Dipl.-Ing., 1969; Dr.-Ing., 1973, Universität Stuttgart, Federal Republic of Germany (FRG)] from 1973 to 1980 developed program systems for nuclear safety analyses at Institut für Kernenergetik und Energiesysteme, Universität Stuttgart, then joined Kernforschungszentrum Karlsruhe in 1981 as member of the project management of Projekt Nukleare Sicherheit. Since 1975, he has lectured on applied computer science at Universität Stuttgart. Since 1984, he has been a member of the Next European Torus (NET) Team, responsible for the safety and environment program. **Jürgen Raeder** [Dr.-Ing., 1967, and Prof., 1986, Technische Universität (TU) München, FRG] has been with Max-Planck-Institut für Plasmaphysik (IPP) since 1967. In 1973, he was a guest at Stanford University and he has lectured at TU since 1975. He became head of fusion systems studies at IPP in 1975. He has been a member of the NET Project Board and head of NET general system analysis since 1983.



SCOPING STUDIES FOR THE NEXT EUROPEAN TORUS

Kurt Borrass (top) [Dipl.-Phys. and Dr. rer. nat., Universität München, Federal Republic of Germany (FRG), 1974] has worked at the Institut für Plasmaphysik, Garching, FRG, since 1975 on plasma transport, plasma control, and systems codes. In 1983 he joined the Next European Torus (NET) Team, where he has been involved with the NET scoping studies and the assessment of the NET-related physics data base. **William R. Spears** (BSc, mathematical engineering, Warwick University, United Kingdom, 1973; MS, nuclear engineering, Pennsylvania State University, 1976) is a member of the general systems analysis group of the NET Team. He has been involved in a number of reactor systems studies since joining the U.K. Atomic Energy Authority's Culham Laboratory in 1976. After his assignment to NET in 1983, he has continued this work, concentrating more extensively on the costing aspects of both NET and power reactors.

Kurt Borrass
William R. Spears

