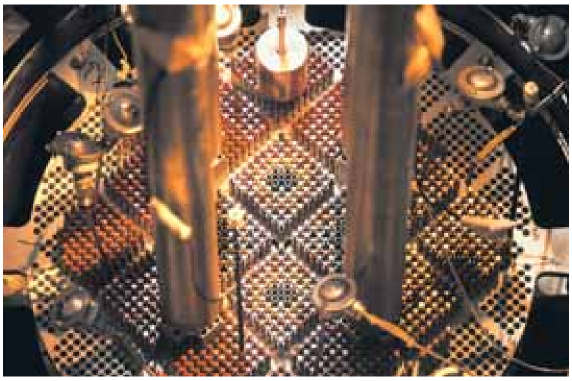
Nuclear Science

Nuclear Science Committee (NSC)

The aim of the NEA nuclear science programme is to help member countries identify, pool, develop and disseminate basic scientific and technical knowledge used to ensure safe and reliable operation of current nuclear systems, as well as to develop next-generation technologies. The main areas covered are reactor physics, fuel behaviour, criticality safety, partitioning and transmutation of nuclear waste and radiation shielding.

The NEA nuclear science programme includes studies of relevance to both current nuclear reactors and to more advanced and innovative reactor systems. Examples in the first category are reactor stability and transient studies, employing the most advanced calculation methods to simulate different phenomena in existing reactors, and studies on nuclear fuel behaviour, under normal and off-normal operating conditions. Work related to advanced and innovative reactor systems includes physics benchmarks for high-temperature reactors and for nuclear waste transmutations systems; workshops and information exchange meetings have been organised in such areas as high-temperature engineering and nuclear production of hydrogen.



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Close-up of fuel pins at the Eole research reactor in France.

Reactor physics

The NEA has an ongoing programme to model different reactor stability and transient events. A series of benchmark studies on the consequences of a main steam line break in a PWR has been completed and the last volume was published in 2003. Two other benchmark studies, one on the effect of a turbine trip on a BWR and one on a coolant transient in a VVER-1000 reactor, are being pursued. A new benchmark, based on unique data from a BWR full-size fuel bundle test, provided by the Nuclear Power Engineering Company (NUPEC) in Japan, is being started.

A number of physics benchmarks related to the utilisation of MOX fuels in reactors are under way. These investigations refer to the analysis of several critical configurations based on data from, for example, the Swedish KRITZ and the Belgian VENUS experimental reactors. The benchmark programme also includes a study of a high-temperature reactor (HTR) fuelled with reactor-grade plutonium.

Fuel cycle physics

The NEA science programme covers many activities related to the behaviour of nuclear fuel in a reactor. A modelling exercise has been conducted with the aim of predicting fuel temperature and rod pressure in irradiated, solid and hollow MOX fuel pellets. The predictions will be compared to experimental data released by the Halden reactor in Norway and the results will be published in 2004.

The NEA and the IAEA are co-operating on an exercise to model nuclear fuel at extended burn-up (FUMEX-II). The NEA contribution to this exercise is to provide the required experimental data from its International Fuel Performance Experiments Database (IFPE), which contains a large number of fuel behaviour data, both from commercial irradiations as well as from experiments performed at material test reactors.

The increased interest in high burn-up fuels has prompted the NEA to establish an expert group which will write a comprehensive report on the potential benefits of very high burn-up fuel cycles (60-100 GWd/t), covering both scientific/technical aspects and economic aspects. The study is restricted to identifying problem areas and is not aimed at solving the identified problems.

A report on *Plutonium Management in the Medium Term* was published. The report reviews the technical options available for plutonium management in the medium and longer term, and is intended to serve as a reference source for researchers as well as utilities.

- The scientific and technical feasibility of using nuclear power to produce hydrogen was discussed at a workshop in October 2003.
- A study of the consequences of a main steam line break in a pressurised water reactor (PWR) was published.
- A study was launched on the potential scientific/technical and economic benefits of very high burn-up fuel cycles.
- A report on the capability of modern computer programs to simulate highly heterogeneous reactor cores loaded with MOX fuel was published.

Scientific issues in partitioning and transmutation

Different techniques to reduce the radiotoxicity of nuclear waste are being studied, ranging from chemical separation methods to accelerator-driven reactor systems (ADS) for the partitioning and transmutation of high-level waste from irradiated fuel. The chemical partitioning part of this work comprises the writing of a state-of-the-art report on national programmes in dry and aqueous reprocessing of spent fuel, and another more detailed report on dry reprocessing. The reports will be published in the first half of 2004. The major issues on current technology of fuel development for transmutation are also being evaluated and the report, suggesting necessary R&D, will be published in 2004.

A set of guidelines for improving the reliability of high power proton accelerators is being developed in the field of waste transmutation with ADS. Two benchmark exercises, related to the physics and safety of ADS, are also being pursued. One of the benchmarks studies the consequences on the reactor of a loss of the accelerator beam; the other benchmark examines the capability of current calculation methods and programs to model a small, fast neutron reactor coupled to a deuteron accelerator. The underlying experimental data originate from the MUSE-4 experiment in Cadarache, France.

Nuclear criticality safety

The International Criticality Safety Benchmark Evaluation Project (ICSBEP) issued a new edition of its handbook in autumn 2003. The publication contains 3 070 critical and sub-critical experimental configurations, of which 189 were added in 2003. The comprehensive overview of the project was published in two special issues (September and October 2003) of the journal *Nuclear Science and Engineering*.

Two reports on the use of burn-up credit in nuclear fuel cycle operations were published. They relate to mixed-uranium and plutonium-oxide (MOX) fuels, irradiated in PWRs. One of the publications reports on the calculation of infinite PWR

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Installation of a fission chamber at the Minerve research reactor in France.

fuel pin reactivity for fresh and irradiated MOX fuels with various MOX compositions, burn-ups and cooling times, whereas the other publication deals with an investigation of the spatial and spectral effects during the irradiation of the MOX fuel.

Radiation shielding

A new version of the International Database for Integral Shielding Experiments (SINBAD) was issued in October 2003. The CD-ROM publication contains 33 reactor, 21 fusion neutronics and 5 accelerator shielding experiments. The database is jointly maintained by the NEA and the Radiation Safety Information Computational Center (RSICC) in the United States.

Homogenisation techniques tend to introduce large uncertainties when using deterministic transport calculation methods for calculating whole reactor cores. A benchmark exercise using a MOX fuel assembly was conducted to test the capability of modern computer programs to simulate highly heterogeneous reactor cores, without using homogenisation techniques. The report of the exercise was published in 2003 and will be of particular interest to reactor physicists and computer program developers.

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