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, fuel cycle physics and chemistry, criticality safety and radiation shielding.

The NEA nuclear science programme is to a large extent devoted to international comparison exercises or benchmark studies for the validation of computation methods and data used to predict the behaviour and performance of different nuclear systems. In addition, the nuclear science programme sponsors specialist meetings and workshops and co-ordinates the preparation of state-of-the-art reports as necessary.

Reactor physics

The NEA has an ongoing programme of international comparison exercises to model reactor stability and transient events, as well as to study different reactor physics parameters for high-temperature reactors. Among the reactor stability benchmarks could be mentioned a study on a reactivity transient simulation in a VVER-1000 reactor and a study of a boiling water reactor (BWR) full-size bundle test based on experimental data from Japan. First results from a benchmark study of a plutonium-fuelled high-temperature reactor are being analysed and specifications for a pebble bed modular reactor (PBMR) core physics modelling exercise are being developed.

The NEA programme also covers scientific studies related to the burning of weapons-grade plutonium in reactors. Both fuel behaviour and reactor physics issues are being addressed in the ongoing studies. Results from an international comparison exercise of a three-dimensional mixed-oxide (MOX) fuelled reactor core, based on experimental data from the Belgian VENUS-2 reactor, was published in 2004.

Another current issue in reactor physics calculations is the ability of modern deterministic transport codes to model three-dimensional reactor core problems without using spatial homogenisation. The NEA has organised an international benchmark on this issue and the report will be published in early 2005.

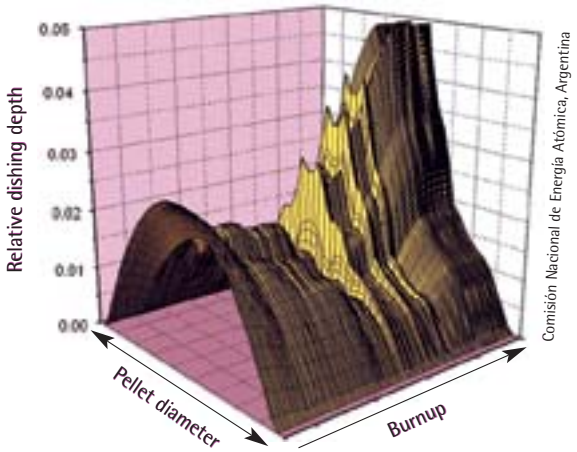
The International Reactor Physics Benchmark Experiments (IRPhE) project to evaluate and preserve well-documented integral nuclear data, measured at different reactors or mock-up experiments, continues. Four new evaluations were completed in 2004 and seven additional evaluations are ready for an independent peer review before publication.

The NEA also published a series of reports from the EC-sponsored CRISSUE-S project, which aims at evaluating fundamental technical issues related to the interaction between thermal-hydraulics and neutron kinetics in light water reactors (LWRs).

Fuel behaviour

A new edition of the NEA International Fuel Performance Experiments (IFPE) database was released in 2004. The database contains measured fuel behaviour data such as fuel temperatures, fission gas release, fuel swelling, clad deformation and mechanical interactions. The data are mainly used for model development and code validation. Some data sets were, for example, recently utilised in the IAEA-coordinated exercise on Fuel Modelling at Extended Burn-up (FUMEX). The IFPE database was also extensively discussed at a seminar on pellet-clad interaction in water-cooled reactors held in March 2004.

Dishing shape evolution of a fuel pellet during irradiation.



Fuel cycle physics and chemistry

The NEA recently launched a study with the objective to assemble and organise information to obtain a better understanding of the issues involved in the transition from current fuel cycles to long-term sustainable fuel cycles, and to assess specific needs related to that transition.

The treatment of spent nuclear fuel is presently performed by the industry using different aqueous chemical processes. Alternative dry processes, using pyrochemical methods, are beginning to receive greater attention, and in response to this interest the NEA published a status report in 2004 on *Pyrochemical Separations in Nuclear Applications*.

- A seminar to discuss pellet-clad interaction in water reactors was organised in March 2004.
- A report was published on the effects of a beam interruption in an accelerator-driven, mixed-oxide (MOX) fuelled, lead-bismuth-cooled reactor.
- A status report on pyrochemical separations in nuclear applications was published.
- A workshop on utilisation and reliability of high power proton accelerators in an accelerator-driven system was organised in May 2004.
- The need for integral critical experiments with low-moderated MOX fuels was discussed at a workshop in April 2004.
- A workshop on shielding of accelerators, targets and irradiation facilities (SATIF) was organised in May 2004.

Scientific issues in partitioning and transmutation

In relation to partitioning, a report on current national programmes in member countries and a study to evaluate critical performance parameters for chemical processes used in different fuel cycle scenarios are being prepared. The latter study is being performed in close co-operation with the Nuclear Development Committee activity on the impact of advanced fuel cycle options on waste management policies.

Regarding transmutation, the NEA has conducted a series of benchmarks studying the effect of accelerator beam interruptions in an accelerator-driven reactor system. A report on such a beam interruption in an accelerator-driven mixed-oxide (MOX) fuelled lead-bismuth-cooled reactor was published in 2004. Another benchmark, based on the MUSE-4 experiment performed at CEA Cadarache, France was completed, and the report will be published in early 2005.

Nuclear criticality safety

The NEA science programme in the nuclear criticality safety area deals with issues relevant to the fabrication, transportation and storage of fuel and to other operations related to the fuel cycle. The 2004 edition of the *International Handbook of Evaluated Criticality Safety Benchmark Experiments* contains 379 evaluations representing 3 331 critical configurations. The handbook is mainly used by criticality safety analysts to perform necessary validations of their calculation techniques and tools.

A workshop to review the need for integral critical experiments with low-moderated, mixed-oxide (MOX) fuel was organised in April 2004. The recommendations from the workshop were to encourage the release of unpublished, relevant experimental data and to define a framework for the selection of new experimental programmes. A small ad hoc group was formed to develop such a framework and to make recommendations on suitable experiments. Two proposed experiments, one from France and one from Russia, were finally recommended and further investigations will be undertaken to define a framework for these experiments.

Radiation shielding and reactor dosimetry

The Shielding Integral Benchmark Database (SINBAD) has been updated with 12 new experiments and a new edition was released in February 2004. The database was presented at the 10th International Conference on Radiation Shielding held in May 2004. In connection with this conference, the NEA organised a workshop on Shielding of Accelerators, Targets and Irradiation Facilities (SATIF).

The Radiation Damage Facility at the Fermi National Accelerator Laboratory, United States.

FNAL, United States

A reactor dosimetry benchmark, based on experimental data, was launched in March 2004. This benchmark aims at comparing the capability of current computation methods to perform 3-dimensional dosimetry calculations of a MOX-fuelled reactor.

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