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.

Highlights

- A report on *Research and Test Facilities Required in Nuclear Science and Technology* was published.
- The 4th NEA Information Exchange Meeting on Nuclear Production of Hydrogen was held in Oak Brook, Illinois, USA on 14-16 April.
- An NEA Workshop on Criticality Safety Research Needs for Future Nuclear Systems was held at Idaho State University, Pocatello, Idaho, USA on 21-22 September.
- A report on the scientific aspects of *Nuclear Fuel Cycle Transition Scenario Studies*, including a European scenario, was published.

The NEA nuclear science programme conducts international benchmark exercises to validate computational methods and data used to predict the behaviour and performance of different nuclear systems. It also coordinates and drafts state-of-the-art reports and organises expert meetings and workshops as needed.

Fuel cycle physics and chemistry

Following the publication of the reports on *Nuclear Fuel Cycle Transition Scenario Studies* and on *Nuclear Fuel Cycle Synergies and Regional Scenarios for Europe*, work in this area continued in 2009 with a benchmark exercise on the performance of different scenario codes and a review of a global fuel cycle transition scenario. The results of these studies will be available in 2010.

A report on curium separation and management is being prepared for publication in 2010. The report will cover curium separation methods, storage and disposal requirements, as well as curium handling experience in different countries.

A study of homogeneous versus heterogeneous recycling of transuranics in fast reactors is being completed. The study compares criteria for choosing between different recycle modes and specific scenarios for their implementation. It will also address fuel- and target-related issues with respect to potential limitations on the maximum allowable minor actinide content, residence time, helium production and management, and remote fabrication implications.

The potential benefits and impacts of advanced fuel cycles with partitioning and transmutation (P&T) are also being studied. A comparative analysis has been undertaken of existing studies addressing the impact of advanced fuel cycles on the performance of geological repositories. This analysis will identify possible goals for future studies and make recommendations on the appropriate criteria for evaluating the impact of P&T.

Reactor physics

A new study has been initiated on sodium fast reactor (SFR) core feedback and transient response. A comparative analysis of the safety characteristics of two different SFR cores (one large core of 3 600 MW thermal and one medium core of 1 500-2 500 MW thermal), and three fuel types (oxide, carbide and metal) will be undertaken with the goal of identifying the advantages and drawbacks of each concept based on nominal performances and global safety parameters.

A benchmark exercise on the performance of mixed-oxide (MOX) fuel in a pressurised water reactor (PWR), based on experimental data from the SCK•CEN BR3 reactor, was completed and published in 2009. It is being followed by another fuel performance benchmark of MOX fuel prepared with weapons-derived plutonium, based on irradiation tests in the advanced test reactor at the Idaho National Laboratory in the United States.

The possibility to burn minor actinides in thermal reactors is being investigated. A review of fuel and core design issues will be the object of a report. It is intended that the latter will specify whether actinide burning in thermal reactors is achievable, and if so, how and with what possible benefits and advantages.

A new depletion benchmark for a high-temperature gas-cooled reactor (HTGR), covering both prismatic and pebble bed cores, has been started. The specifications of the first phase of the benchmark were issued in 2009, and the results are expected to be published in 2010.

Material science

NEA work in the area of material science is pursued along two axes. One is more theoretical, devoted to multi-scale modelling of fuels and structural materials, and the other is more practical, devoted to the development of innovative fuels and structural materials.

Activities related to multi-scale modelling of fuels review and evaluate modelling and simulation techniques currently employed in the selection of materials used in nuclear systems. They include a review of standards for primary radiation damage, the validation and benchmarking of methodology, and the publication of state-of-the-art reports for the methods used in modelling fuels and structural materials.

Activities devoted to the development of innovative fuels and structural materials cover, for example, fuel fabrication techniques, irradiation performance of fuels, characterisation and post-irradiation examination methods. A state-of-the-art assessment is also being made of priority areas for research on structural materials, including the identification of areas where experimental protocols and standards are needed and where the sharing of available experimental installations could be possible.

Nuclear criticality safety

The report entitled *Inter-code Comparison Exercise for Criticality Excursion Analysis* was published. It provides results from a benchmark exercise based on pulse mode experiments with uranyl nitrate solutions using the TRACY and SILENE experimental facilities located in Japan and France.

The SILENE experimental facility in France.

CEA

The use of advanced Monte Carlo techniques for criticality safety assessment is being reviewed with the objective of guiding and encouraging practitioners to use improved methodologies in their work. Different advanced Monte Carlo techniques will be assessed, possibly by conducting benchmark exercises. Guidelines for applying new techniques to problems of importance to practitioners will be proposed.

The NEA database for spent nuclear fuel, SFCOMPO, is continuously being updated. In addition, the database is being analysed with the aim of improving the quality of the data and possibly redefining the structure of the database to facilitate the use of the available data.

The 2009 issue of the International Criticality Safety Benchmark Evaluation Project (ICSBEP) handbook contained evaluations from 4 283 critical or sub-critical configurations and 24 criticality-alarm/shielding configurations. In addition, it included five fundamental physics measurements evaluations relevant to criticality safety applications. The searching tool and associated database (DICE) for the handbook was updated and improved.

R&D facilities in nuclear science

The study on *Research and Test Facilities Required in Nuclear Science and Technology* was published in both English and French in 2009. A Japanese edition will be released in 2010. A database, containing information about approximately 800 R&D facilities, was also developed and made available through the NEA website (www.nea.fr/rtfdb/).

Integral experiments for minor actinide management

The need for new integral experiments for minor actinide management is being studied with the aim of improving the detailed design of transmutation systems, as well as the precise prediction of the composition of spent fuel. The study will focus on reviewing existing integral data, specifying missing experimental work and evaluating target accuracies of nuclear data required for minor actinide management. The final report will also provide recommendations for further international co-operation in this area.

Knowledge preservation

The NEA preserves information from important and well-documented experiments in selected nuclear application areas, such as reactor physics (IRPhE), fuel behaviour (IFPE), radiation shielding (SINBAD) and criticality safety (ICSBEP). This activity is performed in close collaboration with the NEA Data Bank. The data collected are made available to the nuclear community in a comprehensive, structured format for use in benchmark validation exercises.

Peer review

At the request of the Belgian authorities, an international peer review of the MYRRHA project was organised by the NEA. The project aims to design, construct and operate an accelerator-driven, lead-bismuth-eutectic-cooled, sub-critical, fast-neutron reactor. The main findings, conclusions and recommendations of the review were presented to the Belgian authorities and a report was published at the end of 2009.

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