Joint Projects and Other Co-operative Projects

NUCLEAR DEVELOPMENT

The International Advisory Group (IAG) for the Jules Horowitz Reactor (JHR)

The International Advisory Group (IAG) for the Jules Horowitz Reactor (JHR), established under NDC auspices, met for the first time in November 2003. The objectives of the IAG are to support the establishment of the JHR as an international R&D infrastructure (mainly for material testing but also for other research purposes) for the nuclear industry, and to assist in JHR project monitoring from an international perspective. The second meeting of the IAG is scheduled to take place in September 2004.

P. Stroppa, CEA, France

View of the core at the Cabri research reactor in France.

NUCLEAR SAFETY

The Halden Reactor Project

The Halden Reactor Project has been in operation for more than 40 years and is the largest NEA project. It brings together an important international technical network in the areas of nuclear fuel reliability, integrity of reactor internals, plant control/monitoring and human factors. The programme is primarily based on experiments, product developments and analyses carried out at the Halden establishment in Norway, and is supported by approximately 100 organisations in 20 countries.

The 2003 programme of work in the fuel area continued to focus on high burn-up fuel properties. Experiments addressed the performance of UO_2, gadolinia and MOX fuels in a variety of conditions relevant to operation and licensing. Various cladding alloys were also tested, especially as related to corrosion and creep behaviour. The work included a first in-pile test in preparation of an important loss-of-coolant accident (LOCA) series with high burn-up fuel that will start in 2004. A new test aimed to investigate the cracking behaviour of reactor internals material in BWRs was started in 2003. At the same time, preparations were made for a new PWR test. The programme on human factors focused on tests and data analyses carried out in the Halden man-machine laboratory. The human factor work also encompasses new designs and evaluations of human-system interfaces and control rooms. This involves, amongst others, the use of the Halden Virtual Reality Facility.

The Halden Project operates by way of three-year renewable mandates; the current mandate runs from 2003 to 2005. Unfortunately, a few small, non-penetrating cracks were detected in a segment of the primary reactor piping during a scheduled reactor inspection that took place in June 2003. The investigations and the activities oriented towards the repair work and the recovery of reactor operation started promptly. By the end of the year, the repair was practically completed, including the post-repair inspections. The reactor is expected to return to power in February 2004.

The project continued its summer school programme, which is supported by the NEA Nuclear Safety Division. This is in follow-up to a recommendation of the Halden Board to actively pursue the transfer of nuclear technology and know-how to the younger generation.

The Cabri Water Loop Project

The Cabri Water Loop Project is investigating the ability of high burn-up fuel to withstand the sharp power peaks that can occur in power reactors due to rapid reactivity insertion in the core (RIA accidents). It involves substantial facility modifications and upgrades and consists of 12 experiments to be performed with fuel retrieved from power reactors and refabricated to suitable length. The project began in 2000 and will run for eight years. The experimental work is being carried out at the *Institut de radioprotection et de sûreté nucléaire* (IRSN) in Cadarache, France, where the Cabri reactor is located. Programme execution also involves laboratories in participating organisations for fuel preparation, post-irradiation examinations and test channel instrumentation. Organisations in 12 countries, including regulators, industry and research organisations, participate in the project.

Two tests have been carried out so far. They involved fuel with very high burn-up (~70 MWd/kg) and having two types of modern cladding materials. They were subjected to energy injection beyond what is expected for power reactor cases. The fuel examinations after both tests confirmed that the fuel did not fail.

Two meetings of the Technical Advisory Group (TAG) took place in 2003, during which the outcome of the experimental work carried out so far and related analyses were presented and discussed. The TAG also addressed technical issues related to the water loop design and to the tests that will be performed in the future. One meeting of the project Steering Committee was also held in 2003.

This focused on the review of the test matrix and of the criteria for selecting the test rods.

The MASCA Project

The first phase of the MASCA Project investigated the consequences of a severe accident involving core melt. It started in mid-2000 and was completed in July 2003. The second phase of the project started thereafter upon recommendation of the member countries and the CSNI. It will last for three years.

The programme is supported by organisations in 17 countries and is based on experiments that are mainly carried out at the Kurchatov Institute and that make use of a variety of facilities in which corium compositions prototypical of power reactors can be tested. The tests in the first phase of the programme were primarily associated with scaling effects and coupling between thermal-hydraulic and chemical behaviour of the melt.

The tests of the second phase aim to provide experimental information on the phase equilibrium for different corium mixture compositions that can occur in water reactors. This determines the configuration of materials in case of stratified pools and thus the thermal loads on the vessel. In order to enhance the application of MASCA results for reactor cases, the influence of an oxidising atmosphere and the impact of non-uniform temperatures (presence of crusts or solid debris) will be addressed in addition to scaling effects. The programme is also intended to generate data on relevant physical properties of mixtures and alloys that are important for the development of qualified mechanistic models.

During 2003 there were two meetings of the project steering bodies. In addition, extensive technical discussions and communications with project members took place in connection with the establishment of the Agreement for the new phase of the project. A MASCA seminar will be held in 2004 aiming to review and discuss the results obtained so far.

The MCCI Project

The Melt Coolability and Concrete Interaction (MCCI) Project is managed by the USNRC, carried out at the Argonne National Laboratory (USA), and has participants from 13 countries. It was started early in 2002 and will continue for four years. It addresses ex-vessel phenomena, which occur in the hypothetical case that the molten core is not retained inside the reactor vessel and is spread in the reactor cavity where it can interact with the concrete structure.

The MCCI Project is to provide experimental data of relevance to the type of severe accident mentioned above and to resolve two important accident management issues. The first one concerns the verification that the molten debris that has spread on the base of the containment can be stabilised and cooled by water flooding from the top. The second issue concerns the two-dimensional, long-term interaction of the molten mass with the concrete structure of the containment, as the kinetics of such interaction is essential for assessing the consequences of a severe accident. To achieve these basic objectives, supporting experiments and analyses are being performed, with a view to providing an understanding of the phenomena of interest, and to producing a consistent interpretation of the results relevant to accident management.

Two Programme Review Group meetings and two Management Board meetings were held in 2003. The experiments on water ingress mechanisms continued, showing how cooling of the melt by water is affected by the concrete-melt composition. The effect of concrete type, i.e. siliceous and limestone types (used respectively in Europe and the United States), has also been addressed. Material properties such as porosity and permeability are also derived from these tests. A melt-concrete interaction test was carried out at the end of 2003. It included a device to determine the strength of the solid upper crust, a parameter that is of great interest for modelling and understanding MCCI at plant scale. The evaluation of the results of this test will be performed in 2004. Discussions have taken place in the project steering bodies about test interpretation and on the best way to support the analytical work accompanying the experiments. The USNRC, the ANL and the French CEA have carried out most of the analyses so far.

The SETH Project

The SETH Project is supported by 14 NEA member countries. It started in 2001 and is to run for four years. It consists of thermal-hydraulic experiments in support of accident management, which are carried out at facilities identified by the CSNI as those requiring international collaboration to sponsor their continued operation. The tests carried out at Framatome's *Primär Kreislauf* (PKL) in Germany,

Kurchatov Institute, Russia

The RASPLAV cylindrical wall facility during preparations for the MASCA experimental programme.

which were completed in 2003, investigated boron dilution accidents that can arise from a small-break, loss-of-coolant accident (LOCA) during mid-loop operation (shutdown conditions) in PWRs. The final report of the PKL tests will be completed in 2004.

The experiments to be carried out at the Paul Scherrer Institute (PSI) PANDA facility in Switzerland are to provide data on containment three-dimensional gas flow and distribution issues that are important for code prediction capability improvements, accident management and design of mitigating measures. They were prepared during 2003, especially as regards the sophisticated test instrumentation. The experimental series will start in mid-2004 and will continue throughout 2005.

An analytical exercise addressing code predictability – mostly related to the PKL experiments – took place in 2003 by means of a workshop that was convened in Barcelona, Spain. A similar exercise is intended to be carried out for the PANDA tests, involving in particular users of clad failure detection (CFD) codes.

Framatome, France

View of the PKL facility in Germany.

The PKL-2 Project

During 2003, Framatome ANP prepared a proposal for a new test series to be carried out in the PKL facility, which was to constitute the basis of the PKL-2 project. The draft proposal was circulated among potential participants and subsequently revised according to the input received. Discussions on the establishment of this new project were successfully completed towards the end of 2003.

The PKL experiments will focus on the following PWR issues that are currently receiving great attention within the international reactor safety community:

- boron dilution events after small-break, loss-of-coolant accidents;
- loss of residual heat removal during mid-loop operation with a closed reactor coolant system in context with boron dilution;
- loss of residual heat removal during mid-loop operation with an open reactor coolant system;
- an additional test to be defined in agreement with the project partners according to the state of open issues such as:
  - boron precipitation during large-break LOCAs, or
  - boron dilution after steam generator tube rupture.

The project will start in 2004 and will last three years.

The PSB-VVER Project

The objective of the PSB-VVER Project is to provide experimental data of relevance to the validation of safety codes in the field of VVER-1000 thermal-hydraulics. The project, in which seven countries participate, started in 2003 and will be completed at the end of 2006. It consists of five PSB-VVER experiments addressing:

- scaling effects;
- natural circulation;
- small, cold leg break LOCAs;
- primary to secondary leaks;
- 100% double-ended, cold leg break (indicative, actual size to be agreed upon).

Extensive pre- and post-test analyses are to accompany the experimental programme throughout the experimental series. The possibility of setting up sets of international standard problems – either limited to project participants or with broader attendance – will also be considered in light of the resources that this effort requires.

The first two tests of the project were successfully carried out and reported upon in 2003. The test matrix for the remaining part of the programme was discussed and revised by members. Preparations were made also in relation to a blind test exercise where a test would be predicted by calculations before its execution. Two meetings of the project's Programme Review Group were held in 2003 with support of the OECD/NEA.

The Bubbler Condenser Project

The Bubbler Condenser Project was undertaken in December 2001 to resolve remaining issues on bubbler-condenser performance under accident conditions. The experimental part of the project was completed in 2002; the data interpretation and the project's final report were completed in 2003.

The bubbler condenser is a system for VVER 440/213 reactors which is devised to reduce the pressure build-up in the reactor building during a loss-of-coolant accident. The project provided answers on remaining safety research issues by means of in-depth analyses of previous experimental results and of three new experiments carried out at the Electrogorsk Research Center (EREC) in Russia. Regulatory bodies and utilities from the

Czech Republic, Hungary and the Slovak Republic, as well as experts from France, Germany and the United States participated in the project and supported the experimental work with pre- and post-test analyses. The European Union also participated in the project. Czech, Hungarian and Slovak utilities provided the financing for the test programme.

The ICDE Project

The International Common-cause Data Exchange (ICDE) Project collects and analyses operating data related to "common-cause" failures (CCF), which have the potential to affect several systems, including safety systems. The project has been in operation since 1998, and a new agreement covering the period 2002-2005 came into force in 2002. Eleven countries participate.

The ICDE Project is envisaged to include all possible events of interest, comprising complete, partial and incipient CCF events, called "ICDE events". The project covers the key components of the main safety systems, such as centrifugal pumps, diesel generators, motor-operated valves, power-operated relief valves, safety relief valves, check valves, reactor protection system circuit breakers, batteries and transmitters.

These components have been selected because probabilistic safety assessments have identified them as major risk contributors in the case of common-cause failures. Qualitative insights from the analysis of the data will help reduce the number of CCF events that are risk contributors. In the long term, the project will provide a broad basis that would enable the quantification of CCF events.

The Fire Project

The Fire Project started in 2002 and will run for three years, with the main purpose of encouraging multilateral co-operation in the collection and analysis of data relating to fire events in nuclear environments. The objectives are to:

- define the format for, and collect fire event experience (by international exchange) in, a quality-assured and consistent database;
- collect and analyse fire events data over the long term so as to better understand such events, their causes and their prevention;
- generate qualitative insights into the root causes of fire events that can then be used to derive approaches or mechanisms for their prevention or for mitigating their consequences;
- establish a mechanism for the efficient feedback of experience gained in connection with fire events, including the development of defenses against their occurrence, such as indicators for risk-based inspections; and to record event attributes to enable quantification of fire frequencies and risk analysis.

The quality coding guidelines and the quality assurance procedure were established in 2003. Thereafter, data acquisition was started.

At present, the project participants are the Czech Republic, Finland, France, Germany, Japan, Spain, Sweden, Switzerland and the United States. Several more are expected to join in the near future.

The OPDE Project

The Piping Failure Data Exchange (OPDE) Project started in 2002, currently has 12 participating countries, and will run for three years. Its goals are to:

- collect and analyse piping failure event data to promote a better understanding of underlying causes, impact on operations and safety, and prevention;
- generate qualitative insights into the root causes of piping failure events;
- establish a mechanism for efficient feedback of experience gained in connection with piping failure phenomena, including the development of defence against their occurrence;
- collect information on piping reliability attributes and factors of influence to facilitate estimation of piping failure frequencies.

The OPDE Project is envisaged to include all possible events of interest with regard to piping failures. It will cover piping components of the main safety systems (e.g. ASME Code Classes 1, 2 and 3). It will also cover non-safety piping systems that, if leaking, could lead to common-cause initiating events such as internal flooding of vital plant areas. As an example, raw water systems such as non-essential service water could be a significant flood source given a pipe break. Specific items may be added or deleted upon the unanimous decision of the Project Review Group. Steam generator tubes are excluded from the OPDE project scope.

The project has successfully completed the trial phase and is currently finalising the review of the data already in the database. A first release of the database was distributed to project members in 2003.

Almaraz NPP, Spain

Piping failure can affect both operations and safety in a nuclear power plant. In-service inspection programmes are in place to detect degradation at an early stage.

RADIOLOGICAL PROTECTION

The Information System on Occupational Exposure (ISOE)

Since its start in the early 1990s, ISOE has become a unique worldwide programme to discuss, promote and co-ordinate international co-operative undertakings for the radiological protection of workers at nuclear power plants; a forum for discussing occupational exposure management issues; and the repository of the world's largest database on occupational exposure from nuclear power plants. This joint NEA/IAEA programme is the only one in the field of occupational exposure that enjoys active participation of radiation protection experts from both utilities and national regulatory authorities. This programme supplies data to the European Commission and to UNSCEAR.

At the end of 2003, data in the ISOE programme had grown to include 407 operating commercial nuclear reactors and 59 commercial nuclear reactors in cold-shutdown or some stage of decommissioning, representing 68 utilities in 29 countries. Regulatory authorities from 26 countries participate in ISOE. In 2003, elements of the ISOE system were further consolidated, particularly the data input and data analysis software of the ISOE database on occupational exposure, and the ALARA communication network. To further enhance the use of the system, ISOE performed an evaluation of the programme and reviewed its working procedures. As a result of this evaluation, ISOE decided to offer new ISOE products, such as an ISOE newsletter and selected ISOE products on the web, and to further promote the use of the ALARA communication network. An international ALARA workshop was held in Orlando, Florida, USA to exchange operational dose reduction experience. Finally, ISOE re-approved its Terms and Conditions as valid until the end of 2007.

A. Gonin, CEA, France

Electronic dosimetry is part of the radiation dose management system in place in Saclay, France.

RADIOACTIVE WASTE MANAGEMENT

The Sorption Project

The NEA Sorption II Project was launched in October 2000 with the objective of demonstrating the applicability of different chemical thermodynamic modelling approaches to support safety assessments of geological repositories. To allow an evaluation of the respective merits and limitations of different thermodynamic sorption models, the project was implemented in the form of a comparative modelling exercise based on selected datasets for radionuclide sorption by both simple and complex materials. These were organised into seven test cases that were prepared and distributed to participating organisations. A Technical Direction Team (TDT) evaluated the existing database, developed test cases for sorption modelling, and will carry out the subsequent analysis and interpretation of modelling outcomes. In total, 20 modelling teams are participating in the exercise, making it possible to base conclusions of the project on a broad range of experience and expertise.

Using additional information gained from a workshop held in October 2002 in Spain, the TDT further interpreted and synthesised the project outcomes and delivered a draft of the final project report. In analysing the modelling outcomes, model fits as well as predictions were quantitatively compared with the respective experimental data. Particular attention was paid to elucidating the effects of certain model components and of decisions implicit in the development of preferred models on model performance.

The draft Sorption II report identifies the strengths and drawbacks of various typical approaches and stresses the importance of the quality of data and specific estimates used in modelling. Its intended audience is radioactive waste management organisations and regulators, as well as modellers and experimentalists who are involved in performance assessment. As final steps for phase II of the Sorption Project it is foreseen to externally review the draft report and to organise an international workshop to discuss project results.

The Thermochemical Database (TDB) Project

The Thermochemical Database (TDB) Project is designed to help meet the specialised modelling

requirements for safety assessments of radioactive waste disposal sites. As part of the project, chemical thermodynamic data are collected and critically evaluated by review teams of experts. The review teams publish their results in:

- books in the TDB Chemical Thermodynamics Series (five volumes already published, four more in preparation) that serve as extensive reference material, documenting the sources and procedures followed in order to select the recommended data and therefore meeting high standards of transparency and traceability;
- electronic files containing the selected thermochemical data, available form the NEA Data Bank.

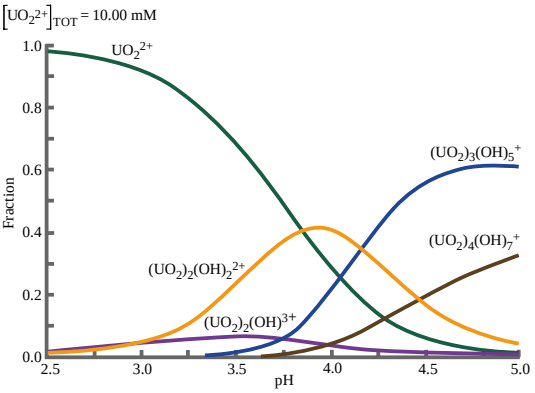
A book in the TDB series entitled *Update on the Chemical Thermodynamics of Uranium, Neptunium, Plutonium, Americium and Technetium* was published in 2003 and is available from Elsevier Science Publisher. Reviews of chemical thermodynamic data for inorganic compounds and complexes of selenium, nickel and zirconium, and of selected organic compounds and complexes of uranium, neptunium, plutonium, americium, selenium, nickel, technetium and zirconium are being finalised.

A new phase of the project was started in 2003 with an exploratory stage, comprising the collection and review of bibliographic references on the inorganic complexes and compounds of thorium, iron, tin and molybdenum. The complete review of these elements will begin in 2004.

The Co-operative Programme on Decommissioning

The Co-operative Programme for the Exchange of Scientific and Technical Information Concerning Nuclear Installation Decommissioning Projects (CPD) is a joint research project operating under Article 5 of the NEA Statute since its inception in 1985. Half way through its fourth 5-year Agreement, the CPD is refocusing its efforts on the exchange of decommissioning experience among its participating projects. This exchange continues to include biannual meetings of the Technical Advisory Group, during which the site of one of the participating projects is visited, and good and bad examples of decommissioning experience are openly exchanged for the benefit of all.

The 42 projects currently in the CPD include the decommissioning of 29 reactors, 9 reprocessing plants, 3 fuel material plants, and 1 isotope handling facility. As a result of the wide variation in the type of facility being decommissioned and in the environment under which the activity is undertaken, and in order to assist in the comparison of information and experience the focus of the programme has been divided into seven broad areas: inventories, cutting techniques, remote operation, decontamination, melting, and the interfaces between decommissioning and radioactive waste management and radiation protection.



Examples of a TDB publication on CD-ROM and a graph on speciation in the U(VI) hydroxide system at zero ionic strength.

In 2003 the CPD finalised an in-depth review of its 18-year-old Agreement resulting in a consolidation of the Co-operative Agreement and the Amending Protocol regulating the financial aspects of the programme into a single document. This new Agreement, which came into force on 1st January 2004, more clearly defines the scope of the information exchange actions that participants would undertake within the bounds of the Agreement. In addition to this work, the CPD finalised an internal report summarising its first fifteen years of experience. CPD members also contributed to an NEA workshop on decommissioning and participated in the NDC Expert Group on Decommissioning Strategies and Costs. The Technical Advisory Group, through which the Programme's technical and scientific exchanges take place, met twice in 2003.

View of a dismantled reactor vessel in Germany.

Energiewerke Nord GmbH, Germany