

Nuclear Safety and Regulation

Highlights

- Recognising 40 years of successful co-operation on nuclear safety issues, the CSNI and the CNRA jointly organised in June the NEA Safety and Regulation Forum on Multilateral Co-operation in Nuclear Safety Research and Regulation.
- The CSNI and the CNRA organised several workshops, most notable were those on licensees' nuclear safety management and the effectiveness of inspections; evaluation of uncertainties in relation to severe accidents and level-2 probabilistic safety analysis; fire probabilistic safety analysis; and better nuclear power plant maintenance: improving human and organisational performance.
- In 2005 two new multilateral "Joint Projects", one on PWR thermal-hydraulics, called the ROSA Project, and another on computer-based safety systems, named the COMPSIS Project, were started (see the section on page 30 for details). A number of technical proposals for new joint projects organised under NEA auspices were also put forth and discussed during the year.

Committee on Nuclear Regulatory Activities (CNRA)

The CNRA contributes to developing a consistent and effective regulatory response to current and future challenges. These challenges include operational experience feedback, increased public expectations concerning safety in the use of nuclear energy, industry initiatives to improve economics and inspection practices, the necessity to ensure safety over a plant's entire life cycle, and new reactors and technology.

Operating experience

The joint NEA/IAEA Incident Reporting System (IRS) is the only international system providing regulators and government bodies with information about lessons learnt from safety-significant events at nuclear power plants. The IRS co-ordinators exchange information about recent events during their annual meetings and jointly define topics of interest for further work.

In June 2005 the CSNI and the CNRA agreed to transfer responsibility for the Working Group on Operating Experience (WGOE) from the CSNI to the CNRA. A new mandate for the group was approved with the main objective to share experience and knowledge, to analyse and to provide expert insights from operating experience in order to reach timely conclusions on trends, lessons learnt and effective responses in the short to medium term, as well as to promote proposals for re-assessment of safety, additional research, new or revised regulatory inspection practices, improvements in managing operations, and other actions to maintain and improve safety in the longer term. The newly constituted group will hold its first meeting in early 2006 to establish its programme of work. It will also organise an International Conference on Improving Nuclear Safety through Operational Experience Feedback in May.

The "Blue Book", which is a periodic publication jointly issued by the NEA and the IAEA, and including a summary of lessons learnt from significant operating events and generic studies performed in the last three years, was approved by both committees and will be published by the NEA early in 2006.

Regulatory challenges in using operational experience

The fundamental objective of all nuclear safety regulatory bodies is to ensure that nuclear utilities operate their plants at all times

in an acceptably safe manner. In meeting this objective, learning from experience has been a key element throughout the history of nuclear power, and the CNRA has recognised that there is a continuing need to further enhance international exchanges in this area.

In 2005, a report on *Regulatory Challenges in Using Nuclear Operational Experience* was finalised for publication early in 2006. The primary focus of this report is on how regulatory bodies can ensure that operating experience is used effectively to promote the safety of nuclear power plants. To the extent that the operator has responsibility for safely operating the nuclear power plant, it is important for that operator to have an active programme for collecting, analysing and acting on the lessons of operating experience that could affect the safety of the plant. It is the nuclear regulator's responsibility to oversee the operator's activities to ensure that the plant is operated safely. Therefore, a key topic in this report is the role of operating experience in the regulator's management system.

Regulatory inspection practices

As part of the activities of the Working Group on Inspection Practices (WGIP), inspectors from regulatory bodies meet periodically to exchange information and experience related to regulatory safety inspection processes and to carry out related studies. A new mandate was approved for the WGIP; it notes the important relationship between inspection practices and operating experience and how regulatory inspections must be supplemented by reviews and by other regulatory controls to yield an integrated assessment of safety and to provide a basis for enforcement, an essential part of the regulatory oversight process.

A joint NEA/IAEA international workshop on Licensees' Nuclear Safety Management and the Effectiveness of Inspections

was held in January in Tokyo, and hosted by the Japan Nuclear Energy Safety Organisation (JNES) in co-operation with the Japanese Nuclear and Industrial Safety Agency (NISA). The relative roles of operators and regulators in evaluating the safety significance of inspection results, what determines how and when the operator reports the results, where the regulator fits into the picture and how they reconcile their differences were the key issues addressed during the meeting, which brought together head regulators and senior managers from industry.

The proceedings of the International Workshop on Risk-informed Inspection, Inspection of Performance of Licensee Organisation, and Inspection Aspects of Plant Near or at End-of-life were issued. The workshop was hosted by the Hungarian Atomic Energy Authority (HAEA).

In addition, several issues are currently being studied by the working group, including inspection efforts, regulatory inspection philosophy, inspection organisation and inspection practices. A proposal has also been approved to begin a new task on inspection of fire protection systems.

Nuclear regulators and the public

Transparency is one of the keys to public acceptance of nuclear energy. Information officers from regulatory bodies meet once a year to exchange information and experience related to communication with the public and to carry out related studies. In 2005, the mandate of the Working Group on Public Communication (WGPC) was revised, and now includes the production of notes addressing developments, tools, procedures and achievements in the area of nuclear regulatory communication with the public and stakeholders. The notes aim to reach a large audience, identifying specific regulatory challenges in public communication and suggesting ways to deal with them.

The two main topics discussed in 2005 were the challenges associated with public communication during abnormal situations and the publicity given to regulatory decisions. The discussions should result in notes which will highlight lessons learnt and good practices. The WGPC will use the findings from this work to continue to assist its members on related matters of regulatory transparency. Regulatory transparency will also be the subject of a workshop planned to be held in Japan in 2007.

Committee on the Safety of Nuclear Installations (CSNI)

The CSNI contributes to maintaining a high level of safety performance and safety competence by identifying emerging safety issues through the analysis of operating experience and research results, contributing to their resolution and, when needed, establishing international research projects.

Multilateral co-operation in nuclear safety research and regulation

The year 2005 marked 40 years of multilateral exchanges through NEA committees concerned with nuclear safety research and regulation. The first multilateral safety committee set up in 1965 under the European Nuclear Energy Agency (forerunner to the NEA) was the Committee on Reactor Safety Technology (CREST). To commemorate the occasion, the CSNI and the CNRA jointly organised the NEA Safety and Regulation Forum on Multilateral Co-operation in Nuclear Safety Research and Regulation on 14-15 June 2005 in Paris, France. Over 100 participants attended.

The forum sessions covered: What Have We Learnt; Learning from Each Other – International Approaches; and The Way Forward. Delegates also participated in smaller discussion groups to look more closely at how the safety committees should respond to new information and at ways to improve international harmonisation of nuclear safety practice and approaches. A special discussion group was formed, consisting of experienced committee members and nuclear professionals from the younger generation. This group's goal was to develop an outlook on the future of nuclear safety from different generational viewpoints.

The forum identified four areas to guide the NEA programme of work in view of providing efficient support to member countries. These areas were:

- the need to learn lessons from others – operating experience feedback;
- the need to have convergence of safety practices;

- the need to preserve safety research (multinational research);
- knowledge transfer and efficient use of current know-how.

Analysis and management of accidents

Several CSNI activities in the area of safety assessment and research continue to relate to the analysis and management of accidents. Such work primarily concerns the thermal-hydraulics of the reactor coolant system and related safety and auxiliary systems; in-vessel behaviour of degraded cores and in-vessel protection; containment behaviour and containment protection; and fission product release, transport, deposition and retention. According to CSNI recommendations, efforts will need to be made in some areas that do not fall within the framework of these disciplines, notably in the fire safety area.

The main objective regarding thermal-hydraulics of the reactor coolant system and related safety and auxiliary systems is to improve and expand the application of best-estimate codes, including uncertainty analysis, in nuclear power plant safety and design evaluations. During 2005, progress was made on the assessment of practicability, quality and reliability of best-estimate methods, including uncertainty evaluation, in applications relevant to nuclear reactor safety. The aim is to make recommendations regarding best-estimate methods and tools, and their application in the licensing process (a long-term objective). This work is mainly based on loss-of-coolant analyses using experimental data and plant data. It also involves the use of computerised fluid dynamics (CFD) codes and their application to nuclear

safety. Existing guidance for the application of single-phase CFD was reviewed in 2005, and its adequacy and completeness for nuclear reactor safety applications is being investigated, while the orientation of the future development and assessment of two-phase CFD tools to be used in nuclear reactor safety problems will be defined (a medium-term objective). A report was issued on this subject in 2005.

Regarding in-vessel behaviour of degraded cores, a report was issued in 2005 on the progress made on the TMI-2 accident analyses. The international standard problem based on experiments performed in the TOSQAN, MISTRA and ThAI facilities (ISP-47) remained the main 2005 activity in relation to containment behaviour. The final report was completed. The state-of-knowledge report on post-accident iodine chemistry was drafted in 2005 and is currently under review, while a state-of-the-art report on aerosols is in progress. The work on data preservation for thermal-hydraulic aspects of severe accidents continued. With regard to the Co-ordinated Programme on Steam Explosion Resolution for Nuclear Applications (SERENA), the code capability assessment part of the programme was completed in 2005 and a proposal for an experimental phase of the programme was presented to the CSNI. This proposal will be discussed at an ad hoc expert meeting in 2006.

A workshop on the evaluation of uncertainties in relation to severe accidents and level-2 PSA was held in 2005 in Aix-en-Provence, France. The workshop, which was hosted by the French *Institut de radioprotection et de sûreté nucléaire* (IRSN), attracted 80 participants and included the presentation of 25 papers. Recommendations on how to proceed in order to build consensus in this field were made in the final discussion panel.

Ageing and structural integrity of reactor components

The main topics investigated in this area include metal components, concrete structures, seismic behaviour of structures and components and the ageing of wire systems. Maintenance, in-service inspection and testing of structures, systems and components important to safety need to be of such a standard and frequency as to ensure that levels of reliability and effectiveness remain in accordance with the design assumptions. Over the past few years, several guides and code cases have been developed to facilitate the practical implementation of risk-informed, in-service inspection (RI-ISI) programmes. The status report on RI-ISI methodologies was completed in 2005, showing that the concept of RI-ISI has been successfully implemented in several OECD countries and is now, along with non-destructive testing qualification, providing improved in-service inspection, reducing both plant risks and radiation exposure to inspection personnel.

In 2005, activities on fatigue and thermal fatigue were further pursued and the benchmark on thermal fatigue was completed. Reactor pressure vessel integrity was addressed through a benchmark on probabilistic structural integrity methods. The International Standard Problem on Containment Capacity (ISP-48) was completed and provided valuable insights into the behaviour of concrete containment under severe loadings. The workshop on seismic input motions incorporating recent geological studies was held in Japan on 15-17 November 2005, thus completing the series. Methods to calculate seismic input motions for nuclear power plants and related uncertainties will continue to be explored through close co-operation with geologists and seismologists.

Risk assessment

The main mission of the Working Group on Risk Assessment (WGRisk) is to advance the understanding and utilisation of probabilistic safety assessment (PSA) as a tool to support decision making in member countries on matters related to nuclear safety. While PSA has matured greatly over the past decades, further work is still required to refine methods and to apply PSA methodology to new areas.

WGRisk conducted activities in several areas in 2005, including risk-informed regulation, fire risk assessment, developing a framework for information exchange on human reliability, uncertainties in severe accident management (level-2 PSA), uses of PSA in emergency management, passive system reliability and software reliability. The group also discussed PSA for advanced reactors in detail. The working group collaborates with other CSNI and CNRA working groups in the areas of operational experience, human factors, structural integrity and accident management. Co-operation also takes place with other NEA standing technical committees.

Four workshops were held during the year. The first one examined recent developments in fire risk analysis. The second, organised in the form of a technical meeting with the IAEA, addressed risk-informed decision making and risk-informed regulation. The third meeting was organised jointly with the CSNI groups on accident management and structural integrity to evaluate uncertainties in relation to severe accidents and level-2 PSA. Finally, a seminar was organised with the EC Joint Research Centre on emergency and risk zoning around nuclear power plants.

CSNI Technical Opinion Papers on *Living PSA and its Use in the Nuclear Safety Decision-making Process* and on *Development and Use of Risk Monitors at Nuclear Power Plants* were published. Work began on updating the state-of-the art report on level-2 PSA and the report on status, uses and developments in the use of PSA in member countries.

Integrated assessment of safety margins

Factors such as ongoing power uprates, longer operating cycles, new fuel designs and increased fuel burn-up, combined with plant ageing and plant life extension require a comprehensive, integrated assessment in order to evaluate their potential cumulative safety impact. An extensive Action Plan on Integrated Assessment of Safety Margins (SMAP) began to be formulated in 2004, aiming to develop a methodology for the assessment of synergistic safety margin reductions. The proposed SMAP relies on the premise that an adequate combination of deterministic and probabilistic methods can provide the best achievable framework for solving the safety margin assessment. The Action Plan is due to be completed in 2006.

Fuel safety margins

In 2005, the NEA Special Expert Group on Fuel Safety Margins (SEGFSM) continued the systematic assessment of the technical basis for current safety criteria and their applicability to high burn-up, as well as to the new fuel designs and materials being introduced in nuclear power plants. A concise review of existing fuel experimental data under reactivity-induced accident (RIA) and loss-of-coolant accident (LOCA) conditions as well as how these data affect fuel safety criteria at increasing burn-up was carried out. The review encompasses the experience gained by the institutions that participate in the SEGFSM activities and

primarily addresses experimental results relevant to western BWR and PWR fuel, including Russian VVER fuel.

Experience shows that the results of the LOCA tests are very sensitive both to the way the tests samples are prepared for the tests and to the way the tests are performed. The preparation of test samples includes the selection of their geometry, surface treatment, the oxidation/corrosion process and pre-hydriding. At the same time, parameters, such as oxidation time and temperature, heating rate and cooling rate have a significant impact on the final ductility of testing samples. In 2005, SEGFSM completed its collection of information on LOCA test methodologies. This work will help better understand, interpret and/or compare LOCA test results from different laboratories, as well as harmonise test techniques for further experimental studies of LOCA fuel safety criteria.

In 2005, the SEGFSM also continued to review the adequacy of existing codes for the simulation of high burn-up fuel behaviour under accident conditions. A benchmark for the Halden irradiated LOCA test was organised in co-operation with the OECD Halden Reactor Project. The benchmark showed that further effort is needed to better model and validate high burn-up phenomena as related to internal pressure; transient fission gas release; collapse of the fuel pellet column after ballooning of the cladding; oxidation and related hydriding; ballooning; and related fuel blockage. The experimental database on actual irradiated fuel claddings requires additional data. Ongoing national and international fuel safety research programmes are expected to fill the existing gaps.

Human and organisational factors

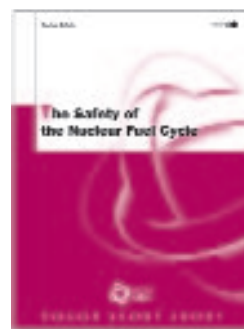
Activities of the Special Expert Group on Human and Organisational Factors (SEGHOF) included a report on systematic methods for safety management; a report on human factors in NPP modifications; investigation into the improvement of NPP maintenance safety by inclusion of human and organisational factors; and human performance in advanced control rooms. A new activity was undertaken on systematic approaches to safety culture.

As part of the SEGHOF activities, a workshop was organised in Ottawa on Improving Human and Organisational Performance. The conclusions show that maintainability must be integrated into design at an early stage (keeping in mind that this and regulation of maintenance require a multi-disciplinary approach), and that pre-job planning may significantly improve maintenance performance.

Fuel cycle safety

The Fuel Cycle Safety Group brings together regulatory and industry specialists to address a broad range of interests, including safety assessments, nuclear criticality safety, probabilistic safety assessment, safety management, decommissioning and site remediation, fire protection and human factors. An important accomplishment in 2005 was the publication of the third edition of *The Safety of the Nuclear Fuel Cycle*, which represents the most up-to-date analysis of the safety aspects of the nuclear fuel cycle. The report addresses safety and technical aspects of fuel cycle operations and provides information on operating practices, experiences gained from operation and the lessons learnt from major incidents. The facilities associated with these activities have an extensive and well-documented safety record, which has been

accumulated over the past 50 years by technical experts and safety authorities.



Research facilities for existing and advanced reactors

Following a CSNI recommendation, a group of senior research managers was constituted with the aim of providing the necessary input and elaborating elements of strategy for maintaining key safety research facilities and possibly expanding their use. The group is to revise an earlier CSNI report on the subject, and will address a number of technical disciplines and related facilities, aiming to define priorities for possible joint international initiatives or programmes in the future. Extensive consultations and report revisions took place during 2005 and will continue in the first half of 2006, including consultation with industry. During 2005 the group developed a set of recommendations based on a systematic, comparative assessment of the various test facilities available in NEA countries, and on their value for resolving relevant safety issues. The report is due to be completed in mid-2006.

Safety of digital instrumentation and control

Digital instrumentation and control (I&C) systems have replaced analogue systems almost completely in the industry, and they require different competencies, notably computer skills. In 2005, the joint CNRA and CSNI ad hoc expert group on digital instrumentation and control produced a document including recommendations for regulatory and operational safety research actions to be considered by the committees. The group concluded that regulators and the industry would benefit from a compilation of descriptions of national regulatory experiences with licensing digital I&C systems; developing a set of high-level practices for regulating digital I&C safety systems; and over the longer term, developing regulatory knowledge on the incorporation of new technologies in nuclear power plants. With regard to research needs, the OECD Halden Reactor Project and the COMPSIS Project are already carrying out several tasks in the area of digital I&C. Necessary future activities include data collection on failure modes and effects; determining acceptable diversity and defense-in-depth; improving the understanding of standards on environmental qualification; security issues and good practices; and managing the development and maintenance of digital systems over their life cycle.

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