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Contents

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The OECD Nuclear Energy Agency (NEA) is an intergovernmental organisation established in 1958. Its primary objective is to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes. It is a non-partisan, unbiased source of information, data and analyses, drawing on one of the best international networks of technical experts. The NEA has 28 member countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Norway, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission takes part in the work of the NEA. A co-operation agreement is in force with the International Atomic Energy Agency.

For more information about the NEA, see:
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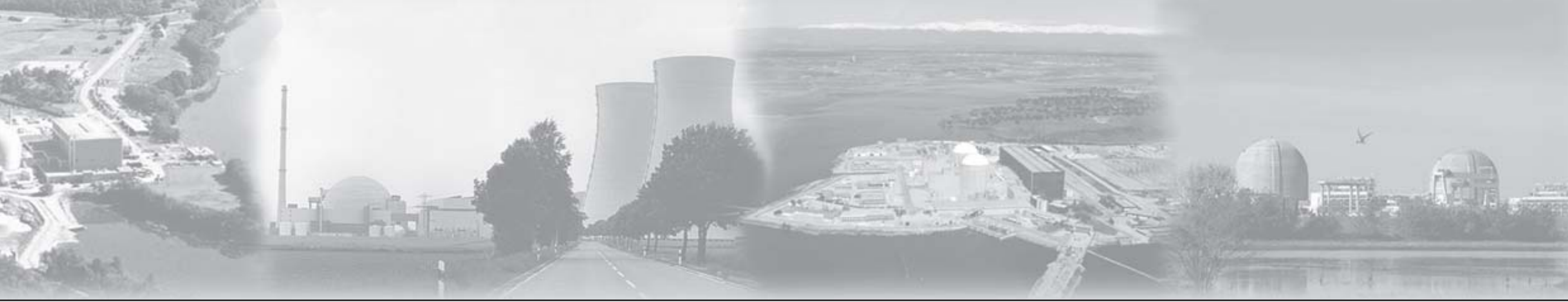
Cover page: The CROCUS research reactor (École polytechnique fédérale de Lausanne, Switzerland), water samples being collected for analyses (T. Foulon, CEA, France), water sample analyses (C. Dupont, CEA, France), seismogram (M. Stasiuk, Geological Survey of Canada).

The need for cleaner energy

At the G8 summit in Heiligendamm, heads of states from the world's leading economies unanimously agreed on the importance of combating climate change. Although consensus was not reached on binding, numerical commitments, it is worth noting that progress has been achieved. In particular, participants agreed to pursue negotiations, under UN auspices, to establish a new global agreement on climate policy by 2009. This agreement could form the basis of a more widely accepted successor to the Kyoto Protocol, which expires in 2012. Plans are also being formalised to bring together the world's largest emitting countries, including China and India, to set a series of national goals for reducing emissions.

Climate change thus appears to be receiving consideration as it never has before. Given the potential role of nuclear energy in helping to alleviate climate change, the NEA was requested to provide a written contribution to the documentation prepared for the G8 summit. Readers may access the NEA contribution at www.nea.fr/html/general/press/. The article entitled "What role for nuclear energy?" provides an overview of the main issues that policy makers should be taking into account when considering the role of nuclear energy in their energy mix.

Based on such considerations, many countries are looking either to introduce nuclear energy or to expand its current use. In such cases, NEA member countries strongly share the view that where nuclear energy is used, it must be done so responsibly, ensuring the highest levels of safety. One of the objectives of the NEA programme on nuclear safety and regulation is to identify generic issues and trends that may affect the safety of nuclear



installations, and to anticipate problems of potential safety significance. The work that the Agency is carrying out on ageing management contributes to achieving this objective. The article on page 18 describing the NEA project on stress corrosion cracking and cable ageing provides an illustration of one of the ways in which this can be done.

In terms of radioactive waste management, member countries are also very active and are paying increasing attention to the concerns and questions that the public may have in this regard. The work of the NEA Committee on Radioactive Waste Management (RWMC) and the Forum on Stakeholder Confidence (FSC) are prime examples (see pages 10 and 13 for further details).

In these ways and others, the NEA membership is doing its utmost to keep nuclear energy clean, affordable and safe. It is only in this way that nuclear will be able to contribute to the well-being of this generation and those to come.

Luis E. Echávarri
NEA Director-General

Innovation in nuclear technology

E. Bertel *

Innovation has been a driving force for the success of nuclear energy and remains essential for its future. For the continued safe and economically effective operation and maintenance of existing nuclear systems, and to meet the goals set out by projects aiming at designing and implementing advanced systems for the future, efficient innovation systems are needed. Consequently, analysing innovation systems is essential to understand their characteristics and enhance their performance in the nuclear sector.

Many studies on international and national innovation processes have been performed, in particular in OECD countries, as many governments are interested in building on feedback from experience for strengthening their innovation systems. However, until now innovation in the nuclear energy sector had not been investigated in detail, and aspects specific to the nuclear sector had not been thoroughly analysed. The new NEA study on *Innovation in Nuclear Energy Technology* published by the OECD early in 2007 presents a review and analysis of innovation systems in the nuclear sector based on country reports and case studies.

Scope and approach

The scope of the study focuses on analysing the performance of innovation systems applied in the nuclear sector as described in a series of country reports and case studies. Innovation is defined as a process spanning from research to widespread dissemination of an output through demonstration and early deployment. The output of innovation is a new or significantly improved product or process introduced successfully on the market and bringing economic and/or social benefits.

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The feedback from experience provided by 11 country reports and 23 case studies was analysed in a systematic manner according to ten elements, or indicators, selected in the light of their relevance to assessing the performance of innovation systems. Those key elements are:

- demands from the market for innovative products;
- human resources available in support of innovation programmes;
- finances that can be allocated to innovation programmes;
- physical inputs, such as materials, services and equipment, dedicated to innovation;
- innovators' access to science, technology and business best practice;
- ability and propensity of the entity pursuing an innovation programme to innovate;
- availability of institutional and support mechanisms adapted to innovation;
- networks, collaboration and clusters at the disposal of innovators;
- effectiveness of market processes for widespread distribution of the outputs from innovation;
- business environment framing the deployment of outputs from innovation.

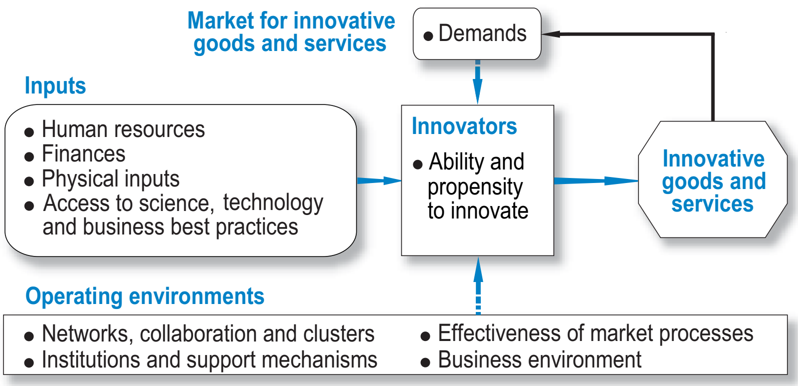
The figure illustrates the links and relationships between those ten elements. The evaluation of the respective contributions of each element to the success or failure of the innovation processes assessed helps identify best practices and provides insights into the reasons why some routes were not successful.

Nuclear innovation programmes

Research and development (R&D) programmes in the field of nuclear energy cover not only the design of new concepts and systems, but also the improvement of current nuclear power plants and fuel cycle facilities. Both domains may include innovation efforts.

Generally, R&D programmes dedicated to enhancing the performance of existing technologies and facilities are undertaken under industry leadership. The role of innovation in such programmes focuses, for example, on improving material characteristics in

Elements determining innovation performance



hostile environments, enhancing process efficiencies or adapting modelling capabilities.

Innovation programmes aiming at the development of evolutionary reactors and fuel cycles, achieving stepwise improvements over existing nuclear systems, may be undertaken jointly by industry and governmental institutes or laboratories. Innovation in that case relates mainly to technology adaptation but may require basic research to identify alternative technical solutions leading, for instance, to better economics or improved resource utilisation.

R&D programmes devoted to the design and development of a new and innovative generation of reactors are more likely to be undertaken in multinational frameworks under the leadership of governmental bodies. Recently, several countries have launched national or international efforts to define goals and roadmaps aimed specifically at the development of innovative nuclear technologies. The Generation IV International Forum (GIF) and the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) are examples of such endeavours.

Innovation is a key element in programmes that have very ambitious objectives requiring the development of entirely new concepts and systems. Innovative solutions will be needed, for example, to improve natural resource utilisation and to minimise waste streams, to eliminate the risk of off-site impacts even in the case of a severe accident, to enhance the competitive margin of nuclear systems, to penetrate non-electricity markets, to reduce the risk of nuclear weapons proliferation and to improve the physical protection of nuclear facilities.

Characteristics of innovation in the nuclear sector

The specific characteristics of the nuclear energy sector have influenced the patterns of nuclear energy development and the innovation systems adopted in various countries for R&D in the field. Nuclear energy characteristics can be grouped under four main headings: high reliance on scientific knowledge and technology know-how; low-volume/high-value market; high financial risk but low marginal production costs; and need for a stable legal and regulatory framework as well as a predictable political context.

While the innovation systems adopted in different countries vary according to their nuclear development patterns – autonomous, relying on technology transfer and adaptation, or relying mainly on foreign supply – all are based to some extent on government support and international co-operation, at least in their initial phases.

The principal driving forces of innovation identified by analysing country reports and case studies may be summarised as follows:

- market drivers, including striving for competitiveness and increasing market shares;
- policy drivers, including responding to global objectives such as environmental protection and social acceptance; and
- technical drivers, including development of enhanced materials, new computer tools and better equipment, increased efficiency and more effective management techniques.

The main actors in nuclear innovation are governmental bodies and institutes or laboratories performing research programmes, and suppliers of materials, equipment and services. Final users of the outputs, in particular utilities, also play an important role.

Governmental bodies are involved in nuclear innovation directly through national R&D policy decisions and support to basic research, and indirectly through national energy policy priority setting and the establishment of infrastructures and regulatory frameworks. In the nuclear energy field, safety authorities and agencies in charge of radiological protection and radioactive waste management, for example, have an important role in setting up the framework for innovation.

Those who perform R&D carry the most responsibility in terms of implementing innovation programmes. For a mature technology like nuclear energy, research centres involved in R&D include a mixture of public and private entities ranging from university laboratories to branches of industrial companies. Co-operation and co-ordination between the various actors are essential for effectiveness, as well as for the ultimate success of the innovation processes.

Suppliers, ranging from small local enterprises providing specific products or technologies to large multinational companies, play an essential role in the innovation process by providing innovative solutions to specific problems and by linking the R&D performed to commercial market realities. The constraints of competitive markets and intellectual property rights are important factors for suppliers that may limit the scope of co-operation between the various actors within an innovation programme.

Although they are the end users of innovation in nuclear energy technology, utilities are not automatically supportive of innovation. In liberalised markets, in particular, utilities tend to favour proven systems that offer guarantees of demonstrated performance. They have nevertheless contributed to certain innovation programmes, in the field of plant-life management for example. Initiatives such as issuing utility requirements provide guidance to innovators on the desired characteristics of end products.

Reasons for the success or failure of innovation processes

Although nuclear energy development and deployment can globally be considered as a successful innovation process, specific approaches to innovation in the nuclear energy sector have been more or less successful. Many reasons for the variable performance of innovation programmes are common to nuclear and other technologies, but some are specific to the nuclear sector.

The economics of the end product of the innovation process is a key element of success. A lack of competitiveness with other products already available on the market is bound to lead to a failure at the dissemination stage. In the case of nuclear technology, this might result from the process itself or from the context, for example, low fossil fuel prices.

Responding to market demand is a prerequisite for the successful deployment of an innovative product. Early analysis of market requirements and potential competitors is essential to assess the opportunities for the product to be adopted by users.

Project management is very important at all stages of an innovation programme to ensure that the objectives and scope of the project are well-defined and kept under control, that the expected budget and schedules are met, and that adequate down-selection of options are completed when needed.

Drastic changes in the overall political and economic context may be very detrimental to the successful completion of innovation programmes, especially in the nuclear energy sector where lead times for the design and development of new products or processes usually exceed a decade.

Concluding remarks

Innovation is essential for the safe and effective operation of nuclear power plants and fuel cycle facilities in service, as well as for the successful development and deployment of the next generations of nuclear systems. In most countries interested in the nuclear option, nuclear R&D programmes are being pursued and dynamic innovation systems are in place to design and eventually deploy innovative reactors and fuel cycles.

Policy makers' renewed interest in the nuclear energy option as a means to address security of supply and climate change threats creates favourable conditions for launching innovation programmes. Taking advantage of past experience, those programmes have the potential to succeed in designing, developing and deploying nuclear energy systems responding to sustainable development goals.

Lessons learnt from innovation programmes that have already been completed can help enhance the effectiveness of future programmes. The analysis of past experience provides a means for identifying causes of failure as well as best practices. Although national and local conditions are important factors, the main drivers for the success of innovative endeavours are common to all countries.

Co-operation and co-ordination among the various actors are major elements promoting success. All interested stakeholders, including research organisations, industrial actors, regulators and civil society, have a role to play in supporting the success of innovation, but governments are an essential trigger, especially for projects with long durations and very ambitious objectives.

Governments have a major role to play in promoting innovation because they are responsible for the overall national energy policy which sets the stage for the eventual deployment of innovative products and processes. Moreover, only governments can create the stable legal and regulatory framework favourable to the undertaking and successful completion of innovation programmes.

International organisations such as the NEA may help enhance the effectiveness of national policies and innovation programmes by providing a forum for exchanging information, facilitating multilateral collaboration and joint endeavours, and offering technical support for the management of innovative programmes. The NEA role as Technical Secretariat of multinational programmes such as GIF is an example of its specific contribution to innovation in nuclear energy technology. ■

Radiological protection and the environment

G. Brownless *

The radiological protection world is roughly divided into two camps when it comes to the issue of environmental protection: those who believe that nothing more need be done in terms of radiological protection of the environment and those who do. Yet both camps can more or less agree that the environment is well-protected, so why all the debate?

Radiological protection of the environment is based on the recommendations of the International Commission on Radiological Protection (ICRP), whose current view is that measures to protect humans from radiation will give sufficient protection to the rest of the environment, since humans live in the environment and ingest things that have grown in it. Hence, contamination in one part of the environment would impact on humans and therefore be controlled.

This approach has been increasingly debated over the last ten years, including at an NEA workshop (NEA, 2003), and there is a feeling that the issue should be revisited by the radiological protection community. There are basically two arguments for developing the system of radiological protection in the area of environmental protection:

i) At present it is not easy to demonstrate that it works because it does not directly assess harm other than to humans.

ii) Some parts of the environment may be isolated from humans. So contamination may not affect human exposure and therefore these areas would be, in effect, excluded from the system of protection. For example, this might apply to contamination that built up at the bottom of a large, deep lake.

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It would be fair to point out here that usually at least some humans live in the vicinity of nuclear installations, since installations are not usually remote from civilisation. Accordingly, "unprotected" parts of the environment are rare (and possibly non-existent?), even though radioactivity can travel long distances and be persistent. This last observation helps to explain the paradox described above whereby there is reasonable agreement that the environment is well-protected from anthropogenic sources of radiation, yet a divergence of views on whether more should be done.

All NEA member countries have legislation in place for protection of the environment. Given interest expressed, however, the ICRP has set up a committee to address the issue, the European Commission has funded large research projects (EC, 2004; EC, 2007), the IAEA is active in the area (for example, see IAEA, 2002) and several NEA member countries have been developing their own assessment approaches. To date, this work has broadly looked at the ethical basis for protection and building toolboxes for assessing harm to the environment. The NEA has also been busy in the area of environmental protection. In addition to the workshop already mentioned, its Committee on Radiation Protection and Public Health (CRPPH) has completed a study on current legal approaches and trends (NEA, 2007) and at the annual meeting of the CRPPH in May 2007, the latter debated the topic with the support of two discussion papers: one looking at the policy issues, and a second comparing chemical and radioactive substances regulation.

Strategic issues: what does protecting the environment mean?

This section looks at what "protecting the environment" means and shows how this apparently abstract question is important. Intuitively, the question of what protecting the environment means may seem straightforward, but in fact, the recent NEA study on radiological environmental protection has found that there is no clear view of what actually constitutes protection of the environment (NEA, 2007).

For example, the United Nations Convention on the Law of the Sea stipulates that countries shall take "all measures... that are necessary to prevent, reduce and control pollution of the marine environment from any source", which seems an uncompromising statement. Yet this should be seen in the context of a Convention that establishes the right of nations to exploit marine resources and fisheries. Further reading of the Convention shows that pollution is defined as something that causes harm. But what is harm? Is it the presence of a substance in the environment, or is it the substance(s) at a level that, say, kills fish? So the apparently abstract question in the section heading is in fact very important. In this example, it might mean the difference between breaching an international convention or not.

The NEA concluded that the key approach to protecting the environment was a trade-off, balancing environmental (and human) harm against the benefits of an activity. Depending on where the balance point is, a certain level of spending to protect humans and the environment would be expected, and in some cases an activity might be banned. The figure illustrates this schematically, with some of the commonly used protection terms added (albeit somewhat subjectively). It also shows that increasing concern over the environment in past decades has moved the balance point, in effect shifting the burden of proof from "need to show harm" to stop an activity to "need to show little/no harm" to carry out an activity. The CRPPH discussion paper comparing chemical versus radioactive substances regulation draws similar conclusions.

Current developments in environmental radiological protection have to some extent sidestepped this issue of "what is environmental protection?" by focusing on harm to non-human biota. This topic is the subject of the next section, where developments and issues in this area of radiological protection are described.

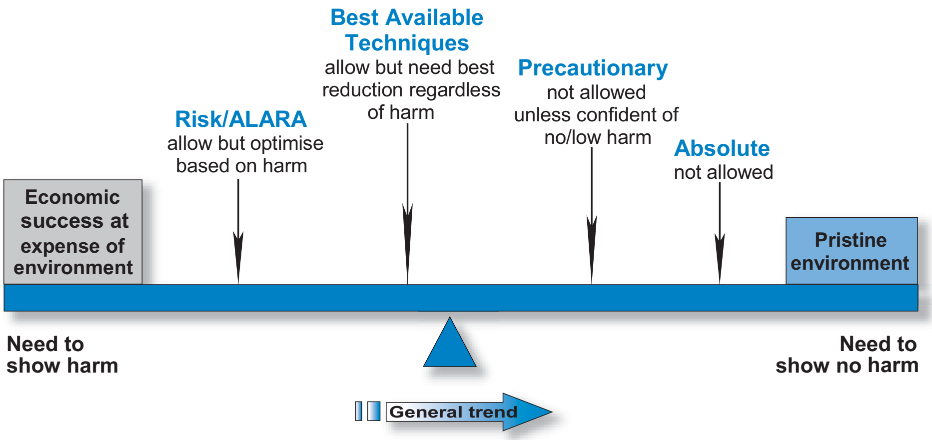
Protection of non-human biota

There are essentially two challenges associated with protection of non-human biota:

i) the level of protection that should be given (a similar question to that in the previous section); and
ii) the availability of tools to assess harm.

The general (but not unanimous) view is that, in most cases, a holistic level of protection, such as protection of an ecosystem, is appropriate, rather than protection of an individual animal or plant. The NEA study broadly supported this holistic view, insofar as laws defined environmental protection. However, ecosystems are very complicated, non-linear systems. This is why most, if not all, proposed approaches to radiological protection of non-human biota use reference animals and plants. Essentially, a practical methodology to assess harm to an ecosystem will have to look at selected parts of the ecosystem in the belief that protecting these parts will protect the whole. But what are these parts? Which biota are the critical ones? Should these be protected at the individual, community or population level? What is the critical stage of their life cycle? There are in fact a wide range of possible endpoints from which to choose. Although much work has been done to address these questions through UNSCEAR and the European

Progressive trade-offs and environmental protection



The general trend will probably stop and even reverse slightly for nuclear energy as concerns mount over climate change and security of energy supply. Pressures from globalisation may also affect priorities. Sustainable development is not shown: it is currently used in a flexible way and so its position varies.[1]

Commission, for example, this is probably the most contentious area in the radiological protection of non-human biota and one that the ICRP is examining.

Thanks to recent work in NEA member countries as well as under EC auspices, the situation is a much happier one when it comes to assessment tools. Ten or fifteen years ago, it would have been very difficult to link the concentration of a radioactive substance in environmental media to the radiation dose to an animal or plant, since the necessary models were not readily available. This is not the case today, as downloadable software applications exist that can perform these calculations, for instance the ERICA assessment tool (EC, 2007). Clearly, a large number of assumptions are used, but this is not unusual in environmental modelling. Probably the major weakness in using these tools lies in correlating dose to effect,[2] since some species will have a much greater sensitivity to radiation than others, and available databases (for example EC, 2004 and EC, 2007) will show that there are gaps and uncertainties in experimental results, which provide the link between dose and harm.

Next steps

The ICRP Committee 5 on environmental protection is examining protection of non-human biota and will produce documents over the next four years (the NEA has been granted observer status on this Committee). In parallel, a project sponsored by the European Commission, called "PROTECT" is seeking to develop standards for environmental radiological protection; the International Atomic Energy Agency has a co-ordination group on the subject; and the NEA Secretariat will participate in both. The NEA Committee on Radiation Protection and Public Health may also organise a workshop on possible policy approaches to the issue or establish an expert group to liaise with the ICRP.

In practice, several member countries will be building new nuclear power stations over the coming years. Therefore, environmental impact assessments (required in most, if not all, member countries) will need to be carried out. Thinking back to the figure, it is likely that the priority given to environmental protection will not change in the next few years: the burden of proof regarding harm to the environment will be on the proponents of a new plant. What is the best way to satisfy this burden of proof? Although tools now exist to help, the current system is not well-equipped to answer this demand, since even if it protects the environment, it does not have the tools and structure to demonstrate that it does. Hence, serious consideration should be given to developing the system to make it easy to show that the environment is protected, because the question will certainly be asked. As any material deficiencies in the current system seem small, adoption of a cost-effective solution should be a priority, and consensual development of such an approach may be best tackled by an open debate of the topic, a process which should only help strengthen the final conclusion. ■

Notes

1. This is recognised and discussed in a paper by Greenpeace Research Laboratories and co-workers, see Johnston (2007).
2. Dose is necessary at some stage since, for example, an animal living in a burrow is not likely to have the same exposure as an animal living in a tree. However, in principle dose can be "hidden" in a computer model, with the user only putting activity concentrations in and getting effects out.

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Fostering a durable relationship between a waste management facility and its host community

Adding value through design and process

C. Mays, C. Pescatore *

Ensuring the safety of radioactive waste management over the long term has special challenges. The greatest challenge may be to create a local operating facility to fulfil that mission over generations. Several conditions are needed: scientific knowledge and technical competency, resources for implementing an agreed approach, and continued willingness to live with and maintain the facility. Both the ongoing quality of life in the host community and society's future capacity to watch over the waste depend on building a sustainable relationship between the host community and the site installation.

Because a radioactive waste management facility and site will be present in a host community for a very long time, a fruitful, positive relationship must be established with those residing there, now and in the future. Simply put, designers have to make the radioactive waste management facility and site to suit people's present needs, ambitions and likings, and to provide for evolutions to match at reasonable cost the needs and desires of future generations. A facility that upsets or repels residents or visitors will only be tolerated and will remain a stranger or an unwelcome presence in the community. The challenge is to design and implement a facility (with its surroundings) that is not only accepted, but in fact becomes a part of the fabric of local life and even something of which the community can be proud.

The NEA Forum on Stakeholder Confidence (FSC) has issued a report exploring how a facility and its site may be better integrated with its host community, and be made attractive across generations. The FSC investigated design features that would provide added value to the community and region in both the short and long term.

Traditionally, local benefits to be drawn from a radioactive waste management facility are discussed in terms of hosting fees and socio-economic development packages (accompanying employment, infrastructure, etc.). Beyond traditional benefits and land use compensations, however, there has been little exploration of how else the presence of the installation may help increase local and regional quality of life. Yet this may be as straightforward and relatively inexpensive as providing a special coat of paint (as at the Vandellós I site in Spain in order to allow the facility to better blend into the landscape – see photo), or as complex and rich as engaging community processes to design an integrated radioactive waste management project (as in the "local partnership" approach created in Belgium).

Cultural and amenity value

In the 1st century BC, the classical Roman architect Vitruvius outlined what good architecture should achieve. He stated that a structure must exhibit the three qualities of *firmitas, utilitas* and *venustas:* it must be strong or durable, useful and beautiful. These are qualities that can also be sought for a radioactive

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waste management installation, for both the physical building structures and for what the installation can bring to the community.

The FSC has looked into designing and implementing facilities in ways that provide added cultural and amenity value to the local community and beyond. Cultural and amenity value has been interpreted here as meaning: agreeable additions to the quality of life, through such features as distinctiveness, aesthetic quality, convenience and meaningfulness; through providing opportunities for residents and visitors to meet, learn, relax and enjoy; and through fostering community improvements in areas such as educational level, image definition or problem-solving capacity.

A number of basic design elements to foster a durable relationship between the facility and its host community have been identified, based on the analysis of input from 32 stakeholder contexts (interviews, questionnaires) and FSC experience. Such design elements include functional, cultural and physical features. These features tend to maximise the potential of a facility to be "adopted" by the members of the host community, by fitting in, adapting to and, moreover, contributing directly to their preferred way of life. The report includes tables to summarise design features and characteristics, the value that each may add to the community, and possible strategies to achieve each feature.

ENRESA, Spain.

Spain's Vandellós-I reactor was shut down in 1990 (the site now provides interim storage for contaminated graphite). Buildings were restructured and re-styled in order to be better integrated in the local landscape. The host city is a beach resort and it is important that the site not be intrusive to the view. The reactor building was reduced from 90 to 60 meters in height, and a special paint design was adopted that will allow it to blend into the natural setting by matching the green of the forest line, and the blue of the sea and the sky when viewed from afar.

Adding value through functional, cultural and physical design features

Functions concern the uses to which an installation may be put. The radioactive waste management facility must serve the primary purpose of ensuring the safe and secure long-term management of radioactive waste. Careful *multi-functional* design can then add value by allowing appropriate parallel uses that are of direct interest to residents and visitors (for example, public gardens with recreation opportunities). In the same vein, parallel uses of radioactive waste management installations may add scientific value. Zero-gravity experiments are being carried out at Japan's Tono Mine underground laboratory. Laboratory facilities at Spain's El Cabril and the US WIPP facilities are available for regional environmental analysis or monitoring. Additionally, when creating a new facility, it is necessary to foresee the end of its useful life. If future needs are not anticipated, there is a risk that the facility will become a liability for the community. An adaptable, flexible facility can provide service and enjoyment during its operation, and also make possible at reasonable cost the transition to a full community facility when its industrial use is no longer needed. Along with careful planning for radiological safety on-site, adaptability and flexibility will leave development pathways open.

The UNESCO Universal Declaration on Cultural Diversity defines culture as "the set of distinctive spiritual, material, intellectual and emotional features of society or a social group, encompassing, in addition to art and literature, lifestyles, ways of living together, value systems, traditions and beliefs". In this way, culture may be assimilated to shared meaning and practices. Cultural value is found in arrangements that reflect and strengthen a given society's knowledge, tastes, aspirations, ethical views or beliefs. It lies in all that is meant to help transmit an honoured legacy, to communicate symbolic meaning or to advance ideals. Amongst the cultural design features, distinctiveness may be mentioned, indicating that the facility or site is attractive and like no other, and has the potential of becoming an icon, lending a positive reputation and drawing visitors. Other cultural features include aesthetic quality and understandability, whereby the installation can be tied in with existing knowledge and related to everyday life. Memorialisation is another cultural feature, meaning that both physical and cultural markers identify the site and tell its story, so that people will grasp and remember what is there.

Technical features will provide the agreed level of protection (the primary condition set by the stakeholders consulted for the FSC study). Physical design elements will help create the feeling of security (another part of what community and regional stakeholders expect). Physical design features can be combined to create harmonious integration of the installation into its geographic setting, and increase overall amenity: enhancing attractiveness and overall satisfaction. Accessibility means that the site and facility are not barricaded, but are open and welcoming. Potential host communities have pointed out that if a site that is licensed to operate can be freely visited, walked through, or enjoyed for other uses, it clearly must be safe. It no longer seems to impose restraints on the user, nor shuts people out in an alarming way. It accomplishes its goal of protection without emphasising danger.

Certainly each and every area of a radioactive waste management facility cannot be made open to the public. Areas restricted for the necessities of safety and security need not benefit from the same degree of functional, cultural and physical design input. Still, the radioactive waste management facility and site should be considered in a holistic manner, in order to maximise the added value that it is possible to achieve with reasonable effort.

Adding value through the planning and implementation process

Local stakeholders who take an active role in site investigations, or who participate with implementers in formal partnerships, report that the very process of working out the desired features of a radioactive waste management facility and site can bring added value to the community. Social capital – networks, norms and trust – is built up, equipping the community to face other decisions and issues. Local stakeholders may also focus their work on community identity, image and profile. Even when not favourable to hosting a radioactive waste management facility, communities can use the opportunity to develop quality-of-life indicators and reflect on the direction they want to take in coming years. Other benefits that may be accrued are an enhanced educational level in the host community related to the influx of highly skilled workers. Not least important, when host communities demand training and participate in the monitoring of site development and operations, they are building their capacity to act as guardians and therefore ensure another layer of defence-in-depth (see the article on the next page).

Early reflection is best

It takes time to work out new ideas, new possibilities and where the communities' own interests lie. Integrative reflection on technical and socio-economic aspects, and on cultural and amenity value that could be added by a radioactive waste management facility, is best started from the very first planning stages even before final siting agreement is reached. The information, concepts and ideas gained from this reflection will form a part of the basis on which a local community may agree to become a candidate and then actively engage in the final siting stages.

Institutions generally cannot commit to the final form of a radioactive waste management facility before a specific site is agreed, nor to the ultimate fate of the facility and site. In addition, the relationship between a community and a facility or site will depend in part upon external events (for instance, safety performance in the nuclear or radioactive waste management realm, attitudes and statements by political actors, etc.). Still, feasibility studies and social science investigations early in the decision-making process can provide meaningful preparation. Such an approach is coherent with the Aarhus Convention, which has given many European citizens formal rights to participate in decision making about their environment.

Conclusions

Different countries and regions are likely to have different socio-political realities and therefore best practices for one place may not be best for another. The exact definition of "added value" will be specific to each site, and more importantly to each community, and will have to be developed in consultation with local stakeholders. The FSC report hopes to provide input to that debate and provides many examples of initiatives from various countries and industrial contexts, but a "one-size-fits-all" solution cannot be offered.

Added cultural and amenity value brings direct improvement to the quality of life in the host community. It can foster socio-economic gains by making a place more attractive to visitors or future residents. In the best of cases, added cultural and amenity value will start a virtuous circle, bringing benefits now, encouraging an ongoing relationship with the facility, and strengthening the community such that in future years it can face challenges and continue to improve its quality of life. These benefits to the local quality of life also support the long-term safety of the facility by building the capacity and the commitment of the host community to remain invested in the facility and its site, and to act as its guardians for generations into the future.

The FSC report on *Fostering a Durable Relationship between a Waste Management Facility and its Host Community* can be downloaded at www.nea.fr/html/rwm/fsc.html, or a paper copy may be requested from claudio.pescatore@oecd.org. ■

Regional development and community support in radioactive waste management

A national workshop and community visit in Hungary

J. Kotra, E. Atherton, C. Pescatore *

The NEA Forum on Stakeholder Confidence (FSC) held its sixth national workshop on 14-17 November 2006 in Tengelic, Hungary. The workshop focused on those factors that contribute either to the success or failure of a repository siting process. Experience gained in Hungary over the past two decades provided the context for the discussions. In particular, the workshop highlighted the role and operation of local public oversight and information associations.

Hosted by the Hungarian national waste management agency PURAM, major institutional authorities, local residents and stakeholders, 11 mayors, and more than 30 FSC delegates from 12 countries learned about Hungary's management initiatives. Overall, some 40 volunteer local residents responded to PURAM's invitation to attend the workshop, taking time away from their working lives to engage with interest in the discussions with the FSC delegates. The workshop included a visit to the community of Bátaapáti, where PURAM is developing an underground repository for short-lived, low- and intermediate-level radioactive waste (L/ILW).

The safety and management of radioactive waste in Hungary is governed by the Act on Atomic Energy. According to this law, the licensee of a nuclear facility must support the establishment of a public oversight and information association and grant assistance to its activities. The purpose of establishing such associations is to facilitate the provision of regular information to the population of the neighbouring communities. The law also establishes the legal basis for providing financial incentives to groups of local municipalities. Associations may use part of the funding provided for regional development purposes.

Four public oversight and information associations are active in Hungary. These include associations near: the existing near-surface repository for medical and research waste at Püspökszilágy; the repository for L/ILW generated by nuclear power production, under construction in Bátaapáti; the interim storage facility for spent fuel at Paks; and the candidate siting area for a high-level waste (HLW) repository at Boda. These associations bring together members of the host community as well as neighbouring communities for discussions with implementers about issues affecting the local area. They provide a forum for airing differences and for identifying common objectives, and have been instrumental in fostering agreement among the relevant actors.

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PURAM, Hungary.

During the workshop hosted by the Hungarian national waste management agency PURAM, major institutional authorities, local residents and stakeholders, 11 mayors, and more than 30 FSC delegates from 12 countries learned about Hungary's management initiatives.

The FSC national workshop and community visit

The workshop's first day served to inform delegates about the history and status of the Hungarian radioactive waste management programme. Representatives of the Hungarian Atomic Energy Authority spoke, as did sociologists and the Mayor of Boda. Delegates then visited the community of Bátaapáti (as described below). Over the next two days, delegates listened to presentations by a wide range of Hungarian stakeholders and experts on issues relevant to the workshop theme. Round-table discussions took place after each session. Here, small groups of foreign delegates and Hungarian stakeholders had in-depth exchanges with the help of translators. One FSC member from each round table then summarised in plenary the results of that table's discussions.

Workshop participants first examined the means for implementing a regional development plan in concert with facility development. Researchers, an NGO representative and a local mayor gave insight into the interests and views of different stakeholders: national, regional and local. The mayor of Kisnémedi, near Püspökszilágy, where the institutional waste repository has operated since 1976, highlighted political changes and their effect on decision making. Before the 1990 regime change in Hungary, authorities simply announced decisions and made no efforts to learn whether local people accepted them. After 1990, a decision to begin storing low-level waste from the Paks nuclear power plant (NPP) implied the need to ask for residents' agreement. The local governments received the authorisation to do so, and the new tradition of "social control" commenced at this time. A control group was set up to inspect and check the data concerning the radioactive waste delivered. This was the first point of contact where civil society organisations and state-managed organisations responsible for nuclear activities met each other under the terms of partnership. The mayor found that, as a result, a positive relationship between local communities and nuclear companies emerged that continues to develop to this day.

Workshop discussions then centred on local participation and regional development. A representative of the Paks NPP explained the process according to which affected regions were defined and public associations established. A mayor and experts outlined regional development needs and initiatives. A delegate from the South Transdanubian Regional Development Agency explained exchanges between his international organisation and the Hungarian utility. In 2005, the Agency concluded a contract with Paks NPP to create opportunities for future participation in European Union projects favouring economic development and innovation. The Agency is permanently invited to Paks activities and reciprocates with full information to the plant management about projects and ideas to be supported.

Finally, participants discussed aspects of building a sustainable facility. Mayors told the FSC about local expectations of a long-term relationship with the implementer, the regulator and the waste management installations themselves. Here issues of local development, information needs and expectations concerning citizen oversight and monitoring of arriving waste were discussed. Plans for the PURAM visitors' centre at Bátaapáti were shared. The FSC report on fostering a sustainable relationship between a waste management facility and its host community was also presented.

Lessons learnt about confidence

The community visit included a tour of the existing underground facility in Bátaapáti and a meeting with the village mayor, the school principal and the vice-president of the local oversight association. Bátaapáti is a small village with about 500 residents, of which 30% are under the age of 18 years. While rural, the village benefits from water, electricity, gas and sewerage. It used to be a village of about 1 000 residents, of which 800 were German-speaking. In 1946, the germanophone population left. The village itself struggled, but over time, families came from all over the country into the area. During this period the village was joined with another village in the area, but in 1990 a new history started when it became independent again and had its own leadership. The village decided that it would repair its roads and reopen the school because it wanted to keep young people in the area. The primary school, closed for many years, reopened. This allowed village children to attend school near their home and to avoid a daily 15-km journey to school. Many people in the village work in the winery or find jobs directly or indirectly related to the construction of the repository. While Bátaapáti is small, it has two shops and four civil organisations. Cable television gives residents access not only to entertainment, but also to detailed information on waste management activities. The FSC found many reasons that contribute to the community's confidence in accepting the facility.

There is a very good working relationship between PURAM and the community, which has grown over almost two decades. The fact that members of the community work in the facility gives the most confidence to the population, as these people interact with their neighbours daily. There is an agreement between PURAM and the village that the facility will employ local people. This provides added confidence in the long-term stability of employment in the area and prospects for a continuing relationship of trust with facility operators.

Safety is the key concern for the community, who has confidence in the regulatory and licensing process, in part, because of the multiple agencies involved. The community believes that the repository will receive a license only if it is safe. The community recognises that technical issues are not their area of expertise and have brought in independent technical support. Additional confidence comes from the active involvement of the Hungarian Academy of Sciences on behalf of the community.

The community believes there is a benefit from hosting the facility. At the same time, it also recognises that there will be impacts. One key impact, identified by the community, is the increased traffic associated with building the L/ILW facility. This results in increased noise, vibration and dust in the area. Discussions continue about mechanisms that would minimise or eliminate these impacts altogether. A new ringroad has been proposed. In addition, an Environmental Impact Assessment will be prepared for the facility and will address these issues.

Another factor that builds confidence is the role the community will have as a guardian of the future safety of the repository. Members of the community will receive training to monitor both the waste coming into the facility and the facility's operations. The training will take a year and will give members of the community expertise to be able to scrutinise the facility. The community thus has a role in the working of the facility and the means to reassure themselves that everything is working as planned.

Community representatives advocate on behalf of local young people, recognising that they will need job opportunities, and will need to develop corresponding skills and qualifications for those jobs. The community looks for assurances that its youth will receive job and training opportunities to enable them to benefit from the presence of the facility.

Finally, the local oversight association is active in involving both the community and its neighbours in discussing issues with PURAM and raising their concerns. The association is instrumental in fostering agreement between PURAM and the local communities.

Conclusions

The FSC workshops have become known for their capacity to provide a platform for both national and international participants to learn from each other's experience. The FSC will document the workshop so that lessons learnt today may be shared with others now and in the future. As for the Hungarian stakeholders, overall there appear to be many reasons to be optimistic about the waste management facility under construction in Bátaapáti. The facility will bring employment, an increase in money spent in the area and an assurance of long-term employment stability in the region. The village will go on developing from a small rural location. Family tourism in the area is expected to increase once the visitors' centre opens to provide both scientific and historic information, as well as the opportunity to enjoy a barbecue or picnic. Other important measures will help place Hungary's projected waste management facilities in a productive regional context. Amendments to legislation have made it possible for the successful local oversight associations to participate in planning and to administer funds for development. The Transdanubian Regional Development Agency has signed accords with the Paks NPP that allow for a strong synergism between planning competence and the major economic presence in the region. Co-ordinated foresight is possible; for instance, consideration is being given to making this area of the country better connected with other regions and the capital by improving road infrastructure. Overall, the success of dialogue among stakeholders, thus far, bodes well for continuing to move forward. ■

Safety cases for the deep disposal of radioactive waste: where do we stand?

B. Forinash, C. Pescatore, H. Umeki *

The last few years have witnessed a resurgence in the prospects for nuclear power as part of the worldwide energy mix, with decisions on nuclear phase-out being reconsidered and new build being contemplated in several countries. In this rejuvenated environment, however, one of the challenges remains to manage and permanently dispose of the resulting radioactive wastes, especially the most long-lived ones.

The NEA hosted an international symposium on "Safety Cases for the Deep Disposal of Radioactive Waste: Where Do We Stand?" on 23-25 January 2007 in Paris, France. The symposium, organised in co-operation with the European Commission and the International Atomic Energy Agency, provided the opportunity to take stock of recent progress and remaining challenges in evaluating and supporting the safety of long-term disposal of radioactive waste.

The NEA Radioactive Waste Management Committee (RWMC) has for many years provided leadership to assist member countries by focusing on the development of strategies for the safe, sustainable and broadly accepted management of radioactive waste. The Committee has provided important contributions to the now widely accepted position that geological disposal represents an ethical, appropriate and technically feasible solution to the long-term management and disposal of spent fuel and long-lived radioactive waste (NEA, 1995). Central to successfully implementing geological disposal is the ability to evaluate and to illustrate the safety of a disposal system after closure and far into the future in a manner that is clear, scientifically sound and persuasive to decision makers and the public: namely, the safety case. The RWMC Integration Group for the Safety Case (IGSC) is dedicated to supporting the elaboration and implementation of the safety case for disposal of radioactive waste.

A safety case is the synthesis of evidence, analyses and arguments that is presented by the implementers at specific points in repository development to quantify and substantiate a claim that the repository will be able to meet its intended function, namely to provide for safety after closure and beyond the time of control of the facility (NEA, 2004). A safety case is typically used to support a decision to move to the next stage of repository development, but it could also be prepared to help review the current status of the project, or in view of testing the methodology for performing a safety case. The key function of the safety case is thus to provide a platform for informed discussions whereby interested parties can express and test their own level of confidence in the project at a given stage, as well as identify the issues on which further work is warranted. The safety case – and its supporting arguments and data – evolves during repository development and is debated, updated and reviewed at various stages in the process. This continuing process of review and development is expected to result in increasingly comprehensive and cogent safety cases and in high, shared confidence in the quality of the decision it was meant to support.

Progress in the past decade

Over 15 years ago, the NEA sponsored an international symposium on the topic of "Safety Assessment of Radioactive Waste Disposal Repositories". The symposium's conclusions showed that there was wide consensus on the general approach to safety assessment for geological disposal. A variety of well-developed tools and methodologies were also available for undertaking the task of safety assessment including, for example, for scenario development, data collection, model development and probabilistic analysis (NEA, 1989). The outcomes of the symposium provided the basis for the 1991 Collective Opinion that the technical basis and methods existed to evaluate adequately the potential impacts of geological disposal systems, and to provide a basis for decision making on such disposal sites (NEA, 1991).

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Since that time, the concept of the safety case has continued to evolve beyond simple safety assessment and numerical calculations to encompass other arguments and evidence that can support an evaluation of safety. In addition, important advances have been made in terms of a much-expanded pool of scientific and experimental data; improved understanding of processes at various spatial and temporal scales; advancement of modelling techniques; and better appreciation of the importance of openness, communication and stakeholder involvement in developing and presenting safety cases.

The 2007 symposium gave participants the opportunity to review progress and to identify emerging trends and challenges. It brought together experts in the field of radioactive waste disposal from 16 NEA member countries, international organisations and the Russian Federation. Among the participants were representatives from implementing agencies, regulatory agencies, scientific support organisations, international agencies and private sector consultants. Over three days, the symposium programme offered nearly 40 presentations and posters covering topics such as the status of the national programme in France, the host country; the safety case concept and its evolution; practical experience in implementing and communicating safety cases in national programmes; and the role of safety cases in societal dialogue and decision making. Several panel discussions allowed in-depth discussions of key topics.

There is a good, shared understanding of what a safety case is and what comprises its main elements. The symposium supported the observation that safety cases have evolved into tools to both assess safety and aid in decision making. Key aspects of this evolution in the past decade include:

- improved and structured documentation to favour clarity and traceability of the argumentation;
- evidence and arguments that showcase the knowledge basis (and scientific understanding) built up by the project;
- the development of more sophisticated analytical tools and databases;
- the introduction of new conceptual tools such as the concept of the safety function;
- the utilisation of a breadth of performance and safety indicators besides the traditional dose and risk indicators;
- the open discussion, in the safety case itself, of extant issues of concern and the identification of a path forward to their resolution.

Examples of recent, successful uses of safety cases for national decision making include Switzerland and France.

The symposium underscored the contributions and value of international organisations and dialogue in formulating the concept of a safety case and in developing methodologies and scientific information that support it. The leading role of the NEA in this area was recognised. Additional lessons learnt are:

- Bringing together dedicated experts from multiple disciplines and their integration into stable teams is of paramount importance.
- Technical aspects of the safety case can be discussed and refined with the help of local stakeholders. Notably, if the repository host locality is large enough, there are likely to be citizens who have knowledge to competently review and comment on the technical aspects of the safety case.
- Given that successive safety cases may span several decades (at least), the preservation of data – and the information supporting the quality of data – is a key challenge.
- While there is a good, shared understanding of what a safety case is, the term "safety case" is difficult to translate from English into other languages. Similar difficulties are encountered with other terms such as "confidence" versus "trust", "safety" versus "security", "safeguards" or "uncertainty". There may be benefit in clarifying and defining certain key terms.
- Important initiatives are under way to further improve the conceptual and technical bases of the long-term disposal safety case.

The proceedings of the symposium are expected to be available to the public in summer 2007.

Conclusion

The 2007 symposium was the first one in many years to focus on the specific subject of the safety case for disposal. It served the community of specialists to verify the state of the art in the area, and afforded additional verification that the current, shared understanding of the purpose and contents of a safety case allows for better discussions and exchange of experience. A final lesson learnt, to this effect, is that a higher frequency of symposia is required to reach out to both specialists and non-specialists.

Given the foreseeable, undiminished importance of the disposal safety case for future decision making in national programmes, the NEA and its Integration Group for the Safety Case are well-poised to continue to provide a key service to the international radioactive waste management community for many years to come. ■

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SCAP: the NEA project on stress corrosion cracking and cable ageing

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The number of ageing nuclear power plants is increasing in OECD/NEA member countries. Accordingly, all those concerned have implemented maintenance programmes, in-service inspection and testing of structures, systems and components important to safety to ensure that levels of reliability and effectiveness remain in accordance with the design assumptions. This is being done using an integrated ageing management strategy based on state-of-the-art technology.

Ageing effects, especially material degradation, have been experienced worldwide and progressively since the start of nuclear power plant operation. Material degradation is expected to continue as plants age and operating licenses are extended. It is clear that an unanticipated and unmanaged structural degradation could result in significant loss of safety margins, undermining public confidence and straining the resources of both the regulatory authority and the operator. For regulatory authorities, it is important to verify the adequacy of the ageing management methods applied by the licensees, based on reliable technical evidence.

Two subjects – stress corrosion cracking (SCC) and degradation of cable insulation – were selected as the focus of the SCC and Cable Ageing Project (SCAP) due to their relevance for plant ageing assessments and their implication on inspection practices. Fourteen NEA member countries[1] agreed to contribute to the project. The International Atomic Energy Agency (IAEA) and the European Commission also participate as observers.

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The project is being financed through a Japanese voluntary contribution. Japanese technical institutions are also actively co-operating in the project under the co-ordination of the Nuclear and Industrial Safety Agency (NISA) of Japan.

Objectives of the SCAP Project

The main SCAP objectives are to:

- establish a complete database with regard to major ageing phenomena for SCC and degradation of cable insulation through collective efforts by OECD/NEA members;
- establish a knowledge base in these areas by compiling and evaluating the collected data and information systematically;
- perform an assessment of the data and identify the basis for commendable practices which would help regulators and operators to enhance ageing management.

The project is scheduled to last four years. It is anticipated that the database definition and the collection of data from member countries will take approximately two years. The subsequent assessment and the commendable practices report are expected to take one year each.

Project organisation

SCAP participants are experts in the SCC and cable fields and come from regulatory bodies, industry, research institutions and academia. They provide the relevant information and perform the assessments needed for the proper execution of the programme.

The SCAP Management Board (MB) runs the project with assistance from the NEA Project Secretariat. The MB responsibilities include, but are not limited to: approving the programme of work to be carried out by the working groups on SCC and cable insulation; monitoring the project's progress

The first meeting of the SCAP Management Board, in June 2006.

in terms of results and timeliness; and supervising reporting within and outside the project.

There are two working groups, one dealing with SCC and the other with cable insulation degradation. The working groups are responsible for carrying out the programme of work and ensuring the quality and timeliness of the reporting within and outside the project.

The Clearinghouses work to ensure the consistency of the data contributed by the participating countries. They verify whether the information provided complies with the SCAP Coding Guidelines. They also verify the completeness and accuracy of the data, and maintain and distribute copies of the database. There is one Clearinghouse for the SCC database and one for the cable insulation database.

The Management Board held its first meeting in June 2006 and Prof. Sekimura from Japan was elected chairman. During that meeting, the Terms of Reference of the project were approved as was the reporting and data access policy proposed by the NEA. The SCC and the cable working groups have met twice, in late 2006 and early 2007. During those meetings, the format and content for the SCC and cable insulation degradation databases were agreed, and member countries started providing preliminary data to facilitate setting up the databases.

Scope of the SCAP databases

Based on differences in the fundamental knowledge concerning the SCC and cable insulation degradation mechanism, as well as the operating experience associated with SCC and cable insulation degradation events, it is expected that the scope and focus of the databases will be different. The SCC database will be mainly based on event occurrences, including piping or component failures. On the other hand, since cable failure or event occurrences are rare, the cable database will focus on cable material and condition monitoring methodology and validation.

The SCAP SCC database addresses passive components degradation or failure attributed to stress corrosion cracking (SCC) occurring at nuclear power plants in participating countries. The scope of the database includes class 1 and 2 pressure boundary components[2], reactor pressure vessel internals and other components with significant operational impact, excluding steam generator tubing. The following mechanisms are considered in the database: external chloride SCC, irradiated-assisted SCC, inter-granular SCC in austenitic stainless steel and nickel-based material, primary water SCC and transgranular SCC.

The cable database covers safety-related cables (including those supporting emergency core cooling), cables important to safety (cables that are desirable for preventing and mitigating any design basis event) and cables important to plant operation (cables whose failure could cause a plant trip or reduction in plant power). The scope of the database includes cables with voltage levels up to 15 kV AC and 500 V DC, including instrumentation and control (I&C) cables.

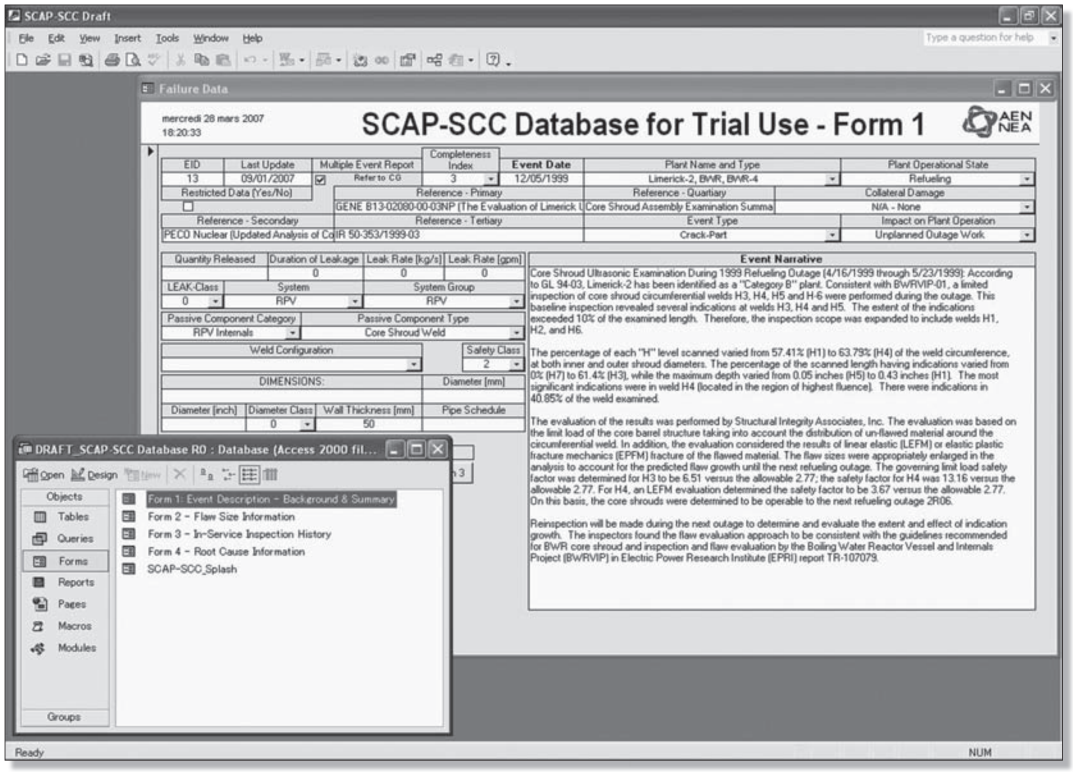
SCAP database structures

The SCC and cable preliminary database structures were defined based on the participating experts' experience, NEA experience in handling different international databases, such as the OECD Piping Failure Data Exchange Project (OPDE) and the OECD Computer-based Systems Important to Safety (COMPSIS), and the R&D information provided by the member countries.

SCC database structure

The SCAP SCC database is a relational database using Microsoft® Access software. The data entry is managed via input forms, tables, roll-down menus and database relationships. Database searches and applications are performed through user-defined queries that utilise the tables and built-in data relationships. The data entry forms are organised to capture essential passive component failure information together with supporting information. The four data entry forms are described below.

Failure data input. This form defines the minimum data requirements. All data entry starts from here. It contains 39 fields, including the plant's name and the plant's operational state at the time of discovery of the event. This allows differentiating between events with an operational impact, e.g. forced shutdown, and those events discovered through scheduled or augmented inspections. It also contains information regarding the event type, with a roll-down menu proposing options such as a through-wall crack without active leakage, a partial through-wall crack and different types of leaks. Information regarding collateral damage related to operational events involving active through-wall



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leakage is included. A menu defines the different corrective actions taken at the plant. A detailed description of plant conditions prior to the event and plant response during the event, the method of detection, and the corrective action plan are included in the event narrative field. All the relevant information that characterises the degraded component is also included such as code class, diameter for piping components, dimensions, base metal and weld metal material designation, mechanical properties, for example yield strength and hardness, and the type of process medium at the time of detection.

Flaw characterisation. This form contains 28 fields with information that characterises the flaw (description, information about size and further details according to the type of flaw).

ISI history. This form consists of 3 fields. While primarily intended for recording in-service inspection (ISI) programme weaknesses, the free-format field may be used to document any information pertaining to the ISI of the affected component, or ISI history such as the time of most recent inspection.

Root-cause information. This form consists of 25 fields and includes information regarding the estimated age of the component, i.e. the in-service life at the time of failure. If the affected component has a repair or replacement history this is to be taken into consideration. A free-format field is provided to describe the location of failure, i.e. line or weld number or using a piping and instrumentation (P&I) reference. Roll-down menus present different options for choosing the method of detection, the apparent cause and contributing factors. Finally, a free-format field is included to provide information relevant to the root-cause analysis and cause-consequence relationship.

Cable database structure

Data entry in the SCAP cable database is managed via tables and roll-down menus. Database searches and applications will be performed through user-defined queries that will be defined at the next meeting of the working group. The data entry tables are organised to capture essential cable insulation failure events along with information regarding environmental qualification and condition monitoring. Data entry tables currently include:

Cable technical data. This table contains 40 fields used to describe the technical data of the cables. There are fields to describe the cable specifications in terms of insulation material, conductor size and rated voltage, among others. Information related to cable type and manufacture is also included. There is a detailed description of the operating environmental conditions including information such as location, design pressure, temperature, humidity and dose rate. This table also considers the information related to the environmental qualification and the code or standard used for such purpose.

Cable maintenance data. This table is organised in different subtables covering aspects such as cable inspection and in-service condition monitoring methods, cable sampling and cable repairing. The cable inspection information considers the description of the monitoring techniques, the assumed ageing mechanisms and the frequency of inspections.

Data for the cable failure events. This table collects information regarding the real cable failures. There is a free-format field for the narrative description of the event. This is followed by fields for collecting data such as the date of occurrence of the event and the age of the cable. A detailed description of the countermeasures taken at the plant is also included.

Cable environmental qualification data. This table presents information regarding the environmental qualification of the cables. Fields are provided to describe the main results of the qualification test report including the environmental conditions and the test and measurements sequence.

Regulatory information. This table presents information regarding regulatory requirements for cable ageing management, regulatory guides and results of previous safety evaluations. It also includes the industry standards implemented according to the regulatory requirements.

Cable condition monitoring. This table includes 10 fields used to describe the condition monitoring of cables. A field is used for describing the condition monitoring method used, the principle of monitoring, a description of the monitoring device, and a description of any correlation between ageing indicators, such as elongation at break and the monitoring data, along with the acceptance criteria used and its basis.

The SCAP knowledge base

The aim of the knowledge base is to provide a state-of-the-art description of the degradation mechanisms, the main influencing factors, the most susceptible materials and locations, and common strategies available for mitigation and repair. The knowledge base would complement the SCC and cable databases, and cross-references will be implemented between event data and knowledge base data to enhance the usability of the information. The working groups will soon discuss the steps to follow in order to develop the knowledge base performance requirements, as well as to define the range of applications and the platform tools to be used once the databases are populated.

Future steps and intended outcomes

The SCAP project is currently in the development phase, defining and refining the database performance requirements, data format and coding guidelines. Some preliminary data have already been provided by the member countries and used to test the adequacy of the database format and structure. The working groups' members will soon develop a pilot set of data to verify the applicability of the format and the coding. Once the format and coding guidelines are finalised, the SCAP member countries will focus on populating the databases.

An assessment report will be published at the end of the SCAP project and provide the technical basis for commendable practices in support of regulatory activities in the fields of SCC and cable insulation. However, the exact scope of the assessment will depend on the amount and quality of the information gathered, and will be defined though participants' discussions.

It is envisaged that the project's outcomes will be used by the NEA member countries to evaluate how operating experience and state-of-the-art technology are incorporated into plant operating practices, and to support regulatory authorities' reviews of ageing management programmes.

The utility of the database obviously grows as member countries continue to enlarge and update it. Consideration will therefore be given to maintaining the database beyond the time frame of the project.

The project has brought together SCC and cable experts from regulatory bodies, industry, research institutions and academia. It is expected that this expert network will facilitate the sharing of knowledge as well as increase co-operation among experts outside the project. ■

Notes

1. There are currently 14 participating countries in the SCAP project: Belgium, Canada, the Czech Republic, Finland, France, Germany, Japan, Mexico, Norway, the Republic of Korea, Spain, Sweden, the Slovak Republic and the United States.
2. Class 1 and 2 pressure boundary components are defined by the American Society of Mechanical Engineers (ASME) as follows: class 1 includes all reactor coolant pressure boundary (RCPB) components; class 2 generally includes systems or portions of systems important to safety that are designed for post-accident containment and removal of heat and fission products.

Seismic probabilistic safety assessment (PSA): An update

P. Pyy, A. Murphy, B. Budnitz, A. Huerta *

Earthquakes are without doubt one of the most devastating events of nature that any society may encounter. The significance of their inclusion in risk assessment of nuclear installations has consequently been self-evident from the very beginning of the development of probabilistic safety assessment (PSA). The methodology of seismic probabilistic safety assessment (SPSA) for nuclear installations was first developed in the late 1970s in the United States but, over time, applications and refinements have been made throughout the world.

Given international interest and the importance of the issue, the NEA sponsored several activities in the field. A Workshop on Seismic Risk was organised in Tokyo in August 1999 to discuss SPSA and seismic margin assessment (SMA) methodologies for nuclear installations.[1] The workshop itself benefited from a state-of-the-art report on the same topic.[2] In 2002, the NEA Committee on the Safety of Nuclear Installations (CSNI) issued a brief technical opinion paper on seismic PSA.[3]

Since the 1999 workshop, SPSA has been applied widely at many nuclear power plants around the world. There have also been technical advances in several aspects of the overall methodology. Today, SPSA is judged to be a mature technology for assessing the risk to nuclear installations from earthquakes. Related methodologies, notably the probabilistic seismic hazard analysis (PSHA) assessing the seismicity hazard and its uncertainties, and the SMA assessing the safety margin against seismic events, are also in widespread use.

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The IAEA is currently updating its guidance in the field. Two other important recent developments are the American Nuclear Society's 2003 standard for SPSA and SMA, and the new methodology standard by the Atomic Energy Society of Japan in 2006.

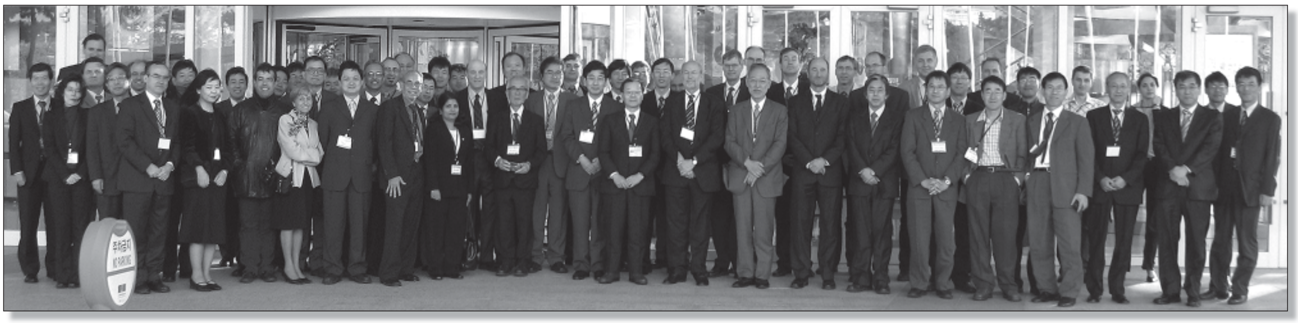
2006 specialists' meeting

In light of these developments, the NEA Committee on the Safety of Nuclear Installations (CSNI) decided to organise a Specialists' Meeting on Seismic Probabilistic Safety Assessment of Nuclear Facilities. The Korea Atomic Energy Research Institute (KAERI) and the Korea Institute of Nuclear Safety (KINS) kindly agreed to host the meeting, which took place on Jeju Island, Republic of Korea on 6-8 November 2006. The meeting was held in co-operation with the International Atomic Energy Agency (IAEA).

The main objectives of the meeting were to review recent advances in SPSA methodology, to discuss practical applications, to review the current state of the art, and to identify methodology issues on which further research would be beneficial. One specific objective was to compare the situation today with the situation in 1999, and to develop a set of findings and recommendations that would update the previous ones. Ample time was allotted to discussing the current situation and developments in SPSA, PSHA and SMA. About 75 specialists from 15 countries participated, providing a large amount of technical material and information that form the basis for this article.

Where do we stand now with SPSA?

SPSA is now in widespread use throughout the nuclear power industry: nuclear power plant (NPP) operators, national regulatory agencies and the designers of new NPPs use it. There is also



75 specialists from 15 countries attended the specialists' meeting in Korea.

broad agreement that SPSA can systematically accomplish several very important objectives, for example to aid in understanding the seismic risk to NPPs, in understanding the safety significance of seismic design shortfalls, in prioritising seismic safety improvements, in evaluating and improving seismic regulations, and in modifying the seismic regulatory/licensing basis of an individual NPP. Compared to the situation in 1999, there has been a significant expansion in the use of SPSA. The most important of the new uses are related to designing advanced NPPs, revising regulations, studying the risk at multiple-unit sites, post-earthquake evacuation and emergency planning issues, and the impact of aftershocks.

The expansion in applications has led to guidance documents to assist the designers, plant owners and regulatory bodies that use SPSA. In almost all cases, information obtained from SPSAs on sequences leading to core damage is used for identifying weaknesses and for evaluating the effectiveness of proposed plant improvements. In several countries, the regulatory requirements concerning seismic design include probabilistic requirements for determining design basis earthquakes, or requirements based on annual frequencies of ground motions that exceed the design basis. In at least two countries (the US and Switzerland), SPSA is now being used in many areas of rule making, risk-informed decisions and guidance for seismic siting and design of NPPs. Several design certifications for standard NPPs have been issued by the US Nuclear Regulatory Commission (NRC) which have used the seismic margin assessment methodology to demonstrate acceptable seismic margin and to identify system-level seismic vulnerabilities. The Finnish regulatory agency STUK has required SPSAs at the design and construction phases of the new Olkiluoto EPR reactor under construction. In addition, a full-scale probabilistic seismic hazard analysis (PSHA) of nuclear power plant sites in Switzerland, sponsored by the Swiss utilities and called the PEGASOS Project, has been conducted.

What still needs to be done?

During the Jeju meeting, a small number of important methodology issues regarding SPSA and its uncertainties were identified. None of these are new, all having been widely recognised for many years by SPSA practitioners. However, for some of the issues, extensive discussions during the meeting provided insights into how to improve matters. The most important questions have to do with PSHA, human action modelling and correlations.

PSHA: Results of properly conducted PSHA studies for regions with low to moderate seismicity, such as Switzerland and Scandinavia, typically exhibit large uncertainty. One source of large uncertainty is that there are very few strong-motion earthquakes in such regions, so that attenuation relationships must start with those taken from other regions with available strong motions (e.g. Japan and coastal California in the United States). Analysts typically seek to select regions with analogous tectonics and structure, and may also rely on simulations using seismological models based on regional geophysical features. This can lead to inconsistencies or to large uncertainties, depending on experts' choices. A proper PSHA in such cases should reflect the uncertainty due to insufficient knowledge of the regional ground motions and attenuation, and it requires expert judgement to a significant extent. Much discussion took place on this topic during the meeting. Naturally, PSHA must be performed as realistically as possible, in order to include all of the uncertainties and all of the variability observed in nature. Adequate consideration of dependencies and factors governing them is also necessary.

Human action modelling: One major area of continuing uncertainty is in quantifying the response of the NPP operating crew and emergency organisations after earthquakes. The problem is partly generic, as with all human reliability analysis where uncertainties remain and there is a lack of data on human and organisational behaviour. However, there are also specific characteristics of earthquakes that make post-earthquake actions more difficult to analyse and to quantify. Among these characteristics are the physical and mental consequences of a seismic shock. Such consequences are due in part to the damage and accessibility to equipment, consequential events such as fires likely to increase the workload, problems with multiple units potentially experiencing different consequences, conflicting goals of the government authorities, accessibility to the site and personnel worrying about their families.

Correlations: Finally, starting with the very first SPSAs in the early 1980s, analysts have struggled with the problem of how to quantify the correlations in the failures of similar equipment or similar structures due to earthquakes. Correlations certainly exist, for example in the response of two identical pumps located near each other, or arising from the identical design and construction of two identical shear walls. Yet the analysis is complex. Testing has produced ambiguous insights at best, and the experience database from real earthquakes is difficult to interpret. The analysts have usually used sensitivity studies to identify where the numerical results are sensitive, but they have also usually assigned large uncertainties to the numbers. On the other hand, the experience with existing plants in the US is that the seismic core damage risk is usually dominated by one or a very few vulnerabilities. In these cases, therefore, the impact of correlations is judged small. The situation may be different for more advanced plant designs in situations where the design basis against earthquakes will lead to even fewer failures. Assuming high dependence between co-located components may be too conservative in such cases.

Where to go from here?

Participants at the Jeju meeting concluded that there are some areas in which follow-up work would be highly desirable on an international level. One of them would be a comparison of seismic hazard studies from countries with high, medium and low seismicity. The PSHA results should be compared to all available observations, especially for return periods where records are available, in order to improve the confidence in the results. Any PSHA activity would benefit from review by all stakeholders: plant owners, regulators, PSA managers, systems analysts and fragility analysts, since bias in the seismic hazard values may have significant effect on cost, risk and licensing effort.

Moreover, because of the rapid progress in using SPSA, it may be necessary to revisit the ten-year-old NEA/CSNI state-of-the-art report on SPSA. Collecting information from conventional industrial sites after large earthquakes may be a good way to increase current knowledge about operator and emergency organisation responses after seismic events, and it provides a means for cross-industry co-operation.

The general consensus of the meeting participants, based on the discussion during the closing session, was that this meeting fully met its objectives and was extremely useful in providing them with new information in the field. The participants also suggested that the NEA should organise similar events in this field more frequently.

To date, no nuclear power plant has ever been challenged by an earthquake large enough to cause damage. Therefore, confidence in NPP safety against earthquake hazards arises from using very robust designs and performing analyses like SPSAs to confirm the adequacy of the designs, in addition to using test data and real-world earthquake data from non-nuclear facilities. Indeed, it is worth noting that other types of infrastructure in society have suffered from earthquakes, but not the NPPs. At the same time, it has been found that not even countries with rather stable bedrock may exclude the possibility of a tremor. A robust seismic design and realistic SPSA are thus beneficial everywhere for preventing the potentially grave consequences of an earthquake. ■

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News briefs

International Reactor Physics Experiment Evaluation (IRPhE) Project

Since the beginning of the nuclear power industry, numerous experiments concerned with nuclear energy and technology have been performed at various research laboratories worldwide. These experiments have required a large investment in terms of infrastructure, expertise and cost; however, many have been performed without considerable attention to archiving results for future use. The results and techniques developed from these measurements remain of great value today and in the future. They provide the basis for recording, developing and validating methods, and represent a significant collection of data for present and future research. This valuable asset is, however, in jeopardy of being lost. If the data are compromised, it is unlikely that any of these measurements will be repeated in the future.

At present, there is an urgent need to preserve integral reactor physics experimental data including separate or special effects data for nuclear energy and technology applications, and the knowledge and competence contained therein. The International Reactor Physics Experiment Evaluation (IRPhE) Project was initiated by the NEA in May 2000 to this end.

Participants in the IRPhE Project currently include: Belgium, Brazil, Canada, France, Germany, Hungary, Japan, Korea (Republic of), Slovenia, the Russian Federation, the United Kingdom and the United States. Much of the work realised thus far by the IRPhE Project, in particular, the evaluation and review of selected benchmark experiments, was possible thanks to substantial funding provided by the Government of Japan. Other countries have contributed evaluations, reviews and data at their own expense.

Purpose

The purpose of the IRPhE Project is to provide an extensively peer-reviewed set of integral data related to reactor physics that can be used by reactor designers and safety analysts to validate the analytical tools used to design next-generation reactors and to establish the safety basis for the operation of these reactors. This work of the IRPhE Project is formally documented in the International Handbook of Evaluated Reactor Physics Benchmark Experiments, a single source of verified and extensively peer-reviewed reactor physics benchmark measurements data.

The evaluation process entails the following steps:

- identify a comprehensive set of reactor physics experimental measurements data;
- evaluate the data and quantify overall uncertainties through various types of sensitivity analysis to the extent possible, and verify the data by reviewing original and subsequently revised documentation and by talking with the experimenters or individuals who are familiar with the experimental facility;
- compile the data into a standardised format;
- perform calculations of each experiment with standard reactor physics codes where it would add information;
- formally document the work into a single source of verified and peer-reviewed reactor physics benchmark measurements data.

Benefits

The benefits from the IRPhE Project are multiple. They include:

- preservation of valuable reactor data and technology;
- support of advanced generation reactors;
- access to data from different countries;
- significant cost savings. (It is well-documented how the utilisation of integral experiments in final design analyses greatly reduces calculation uncertainties, thereby reducing design margins and producing significant cost savings. In addition, if a new research reactor can be designed and built using only IRPhE Project data, the cost of construction of a separate critical facility will be offset.)

Handbook

The International Handbook of Evaluated Reactor Physics Benchmark Experiments was prepared by a working party comprised of experienced reactor physics personnel from Belgium, Brazil, Canada, China, France, Hungary, Japan, the Republic of Korea, the Russian Federation, the United Kingdom and the United States. The handbook contains reactor physics benchmark specifications that have been derived from experiments that were performed at various nuclear experimental facilities around the world. The benchmark specifications are intended for use by reactor physics personnel to validate calculation techniques.

The 2007 edition of the International Handbook of Evaluated Reactor Physics Experiments spans over 15 000 pages and contains data from 21 experimental series performed at 13 reactor facilities. The handbook is organised in a manner that allows easy inclusion of additional evaluations, as they become available. Further evaluations are in progress and will be added to the handbook annually.

Further information can be found at www.nea.fr/html/dbprog/IRPhE-latest.htm and http://irphep.inl.gov. ■

Legislative update: United States

The US Senate consented to the ratification of the Convention on Supplementary Compensation for Nuclear Damage (CSC) on 4 August 2006. Both the House of Representatives and the Senate are now in the process of drafting legislation to implement the CSC before the State Department will deposit the necessary instrument of US ratification with the International Atomic Energy Agency. The US is optimistic that its ratification of this "new" Convention, adopted in 1997 under the auspices of the IAEA in Vienna, will lead to its entry into force within a short time frame. The Convention provides for its entry into force on the 90th day following the date on which at least five states with a minimum total of 400 000 units of installed nuclear capacity[1] have deposited an instrument of ratification, acceptance, approval or accession. At the time of writing, three countries (Argentina, Morocco and Romania) with a combined nuclear power generating capacity of approximately 1 586 MWe[2] (or 4 750 MWth) have ratified the CSC. After US ratification, it will therefore be necessary for one or more states with a capacity of approximately 100 000 MWth to ratify this instrument for it to enter into force.

The entry into force of the Convention on Supplementary Compensation will substantially change the face of the international nuclear liability regime. Up until now, there have been two regimes existing in parallel: the Paris/Brussels Convention regime and the Vienna Convention regime. These systems are linked to each other through a "bridge" convention – the Joint Protocol – which provides for the extension of the benefits of one regime to victims in countries party to the other regime, under certain conditions. The CSC is a free-standing instrument, open to all states. This means that countries can become party to a new global regime providing for liability and compensation for victims of a nuclear incident, without also having to become a contracting party to the Paris Convention or the Vienna Convention. This is certainly a major step forward given that at the present time, over half of the world's reactors in operation or under construction are not covered by any of the international nuclear third party liability conventions.

It is important to point out that the CSC will be of interest not only to states that do not currently participate in any of the nuclear liability conventions, but also to Paris and Vienna Convention states. Efforts to link Paris states and Vienna states through the Joint Protocol and to create a global regime through the CSC are compatible since a Paris state or a Vienna state can be a party to both the Joint Protocol and the Convention on Supplementary Compensation.

So what will the CSC actually do? The CSC creates an instrument by which states can ensure that more money will be made available to compensate more victims for a broader range of damage than ever before. A global nuclear liability regime, in order to be efficient, needs to be "attractive" both to nuclear-power-generating states and non-nuclear-power-generating states. The CSC was designed to do just that, by focusing on providing legal certainty with regard to the treatment of legal liability for nuclear damage resulting from a nuclear incident, and ensuring, in the unlikely event of a nuclear incident, the prompt availability of meaningful compensation with a minimum of litigation and other burdens.

The CSC achieves legal certainty by requiring each contracting party to have national nuclear liability law that is based on the Paris Convention, the Vienna Convention or the Annex to the CSC, and that incorporates the provisions contained in the CSC on jurisdiction, compensation and the definition of nuclear damage. This means that the national law of each participating state will reflect the basic principles of nuclear liability law which include a) legal channelling of all liability for nuclear damage exclusively to the nuclear operator; b) strict liability of the operator with very limited exonerations; c) exclusive jurisdiction of the courts in the country where a nuclear incident occurs; d) permitting liability to be limited in amount and time; and e) no discrimination based on nationality, domicile or residence. Special provisions were introduced into the CSC to ensure that the US, which has a legal system[3] providing for "economic" rather than "legal" channelling of liability, is able to participate in the regime.[4]

The CSC provides for two tiers of compensation. The first tier, fixed at 300 million Special Drawing Rights,[5] is to be provided by the liable operator. If the operator's funds are insufficient, the Installation State (contracting party in whose territory the installation of the liable operator is located) is required to cover the difference. This tier is to be distributed on a non-discriminatory basis to victims both inside and outside of the Installation State. If 300 million SDRs are insufficient to compensate all damage, then contracting parties will be required to contribute to the second tier (the international fund). The amount of this second tier is not fixed, but rather will depend on the number of operating nuclear power plants in contracting parties, and is designed to increase as the number of such plants increases. A contribution formula is established pursuant to which more than 90% of the contributions come from nuclear-power-generating countries on the basis of their installed nuclear capacity, while the remaining portion comes from all contracting parties on the basis of their United Nations rate of assessment. Half of this international fund is to be allocated to victims both in the Installation State and outside the Installation State (transboundary damage), and the other half is allotted exclusively to cover any transboundary damage not already compensated under the first tier. This represents an important incentive to non-nuclear-power-generating countries to join the CSC.

The scope of application of the Convention is determined by reference to the two different compensation tiers. As regards the first tier, the law of the Installation State determines to what extent damage suffered in non-contracting parties will be covered. With regard to the second (international) tier, the Convention provides that funds may not be used to compensate damage suffered in non-contracting parties. This restriction is in keeping with the philosophy that a fund comprising "public" money should be distributed only to victims in states which contribute to that fund.

The Convention does not require its contracting parties to set aside funds in advance in order to compensate damage which may exceed the first tier, in the event of a future incident. Rather, they will be required to make the additional funds available, after a nuclear incident occurs, to the country whose courts have jurisdiction, and then only if and to the extent that those funds are required.

The CSC provides that its contracting parties shall adopt a broad definition of nuclear damage, covering not only personal injury and property damage but also certain categories of damage relating to impairment of the environment, preventive measures and economic loss "to the extent determined by the law of the competent court".

The Convention on Supplementary Compensation further recognises concerns of coastal states with regard to maritime shipments of nuclear material. It provides the courts of a contracting party with exclusive jurisdiction over nuclear incidents occurring within its exclusive economic zone (EEZ). The CSC makes it clear that this rule is intended simply to determine which country's courts have jurisdiction to adjudicate claims for nuclear damage resulting from a nuclear incident, and it does not permit any exercise of jurisdiction that may be contrary to the Law of the Sea.

This instrument is a welcome addition to the international nuclear third party liability conventions already in operation, and it is hoped that other countries will also ratify the Convention soon, thereby ensuring its entry into force in the near future. ■

Notes

1. 1 unit is defined as 1 MW of thermal power, i.e. 1 MWth.
2. Figures taken from the IAEA Power Reactor Information Service (PRIS) as of 4 May 2007.
3. The US national law is the Price-Anderson Act, which is section 170 of the Atomic Energy Act of 1954. The Price-Anderson Act was adopted in 1957 and currently provides the basis for liability and indemnification arrangements governing all NPPs in the United States.
4. The primary difference between US national law and the provisions of the Paris and Vienna Conventions relates to how responsibility for nuclear damage is channelled exclusively to the nuclear operator. Both the Vienna and Paris Conventions provide for legal channelling pursuant to which an operator is the only person legally liable for nuclear damage. US law provides for economic channelling under which the operator bears all the economic consequences for nuclear damage, even if other persons might be legally liable. Persons other than the liable nuclear operator can be indemnified if they incur costs because of legal liability.
5. This corresponds to approximately 454 M USD or 336 M EUR.

New publications

General information

Annual Report 2006

ISBN 978-92-64-99003-6. Free: paper or web.

Economic and technical aspects of the nuclear fuel cycle

Innovation in Nuclear Energy Technology

ISBN 978-92-64-00644-7. Price: € 45, US$ 60, £ 32, ¥ 6 200.

This report provides an overview of the state of the art in nuclear innovation systems, including their driving forces, main actors, institutional and legal frameworks, and infrastructure for knowledge and programme management. It also offers policy recommendations based on country reports and case studies supplied by participating member countries.

Management of Recyclable Fissile and Fertile Materials

ISBN 978-92-64-03255-2. Price: € 30, US$ 39, £ 21, ¥ 4 100.

This report provides an overview of recyclable fissile and fertile materials inventories which can be reused as nuclear fuel. It reviews the options available for managing those materials, through recycling and/or disposal. The potential energetic value of recyclable materials is assessed, taking into account the variability of retrievable energy contents of various materials according to technology and strategy choices made by the owners of the materials. The analyses contained in this report will be of particular interest to energy policy makers and to nuclear fuel cycle experts.

Nuclear Energy Data 2007/Données sur l'énergie nucléaire 2007

ISBN 978-92-64-03453-2. Price: € 30, US$ 39, £ 21, ¥ 4 100.

This new edition of *Nuclear Energy Data*, the OECD Nuclear Energy Agency's annual compilation of essential statistics on nuclear energy in OECD countries, offers projections lengthened to 2030 for the first time and information on the development of new centrifuge enrichment capacity in member countries. The compilation gives readers a comprehensive and easy-to-access overview of the current situation and expected trends in various sectors of the nuclear fuel cycle, providing authoritative information to policy makers, experts and academics working in the nuclear energy field.

Risks and Benefits of Nuclear Energy

ISBN 978-92-64-03551-5. Price: € 24, US$ 29, £ 17, ¥ 3 300.

In the context of sustainable development policies, decision making in the energy sector should be based on carefully designed trade-offs which take into account, insofar as feasible, all of the alternative options' advantages and drawbacks from the economic, environmental and social viewpoints. This report examines various aspects of nuclear and other energy chains for generating electricity, and provides illustrative examples of quantitative and qualitative indicators for those chains with regard to economic competitiveness, environmental burdens (such as air emissions and solid waste streams) and social aspects (including employment and health impacts). This report will be of interest to policy makers and analysts in the energy and electricity sectors. It offers authoritative data and references to published literature on energy chain analysis which can be used in support of decision making.

Nuclear safety and regulation

Benchmarking of CFD Codes for Application to Nuclear Reactor Safety

Workshop Proceedings, Garching (Munich), Germany, 5-7 September 2006

CD-ROM. Free on request.

On 5-7 September 2006, the OECD Nuclear Energy Agency organised a workshop on Benchmarking of CFD Codes for Application to Nuclear Reactor Safety (CFD4NRS) in co-operation with the International Atomic Energy Agency. The workshop was hosted in Germany by the *Gesellschaft für Anlagen und Reaktorsicherheit* (GRS). The purpose of the workshop was to provide a forum for numerical analysts and experimentalists to exchange information on nuclear reactor safety activities relevant to computational fluid dynamics (CFD) validation, with the objective of providing input to create a practical, state-of-the-art, web-based assessment matrix on the use of CFD for nuclear reactor safety applications. These proceedings contain the 39 technical papers presented at the workshop, which was attended by 100 participants.

CSNI Technical Opinion Papers – No. 9

Level-2 PSA for Nuclear Power Plants

ISBN 978-92-64-99008-1. Free: paper or web.

This technical opinion paper represents the consensus of risk analysts in NEA member countries on the current state of the art of level-2 probabilistic safety assessment (PSA) and its applications in accident management of nuclear power plants. Level-2 PSA models the phenomena that could occur following the onset of core damage that have the potential to challenge the containment integrity and lead to a release of radioactive material to the environment. The paper's objective is to present decision makers in the nuclear field with a clear technical opinion on the status as implemented in industrial PSAs. The intended audience is primarily nuclear safety regulators, researchers and industry representatives dealing with safety management and severe accidents. Government authorities and nuclear power plant operators may also be interested in the paper.

Evaluation of Uncertainties in Relation to Severe Accident and Level-2 Probabilistic Safety Analysis

Workshop Proceedings, Aix-en-Provence, France, 7-9 November 2005

CD-ROM. Free on request.

Uncertainty in relation to several severe accident phenomena plays a major role in probabilistic safety analyses involving beyond-design-basis accident scenarios for nuclear power plants. The technical papers presented herein will be valuable for nuclear safety analysts, nuclear power plant designers and R&D managers, especially with regard to unresolved severe accident issues or issues where risk uncertainty is high.

Nuclear Safety Research in OECD Countries

Support Facilities for Existing and Advanced Reactors (SFEAR)

ISBN 978-92-64-99005-0. Free: paper or web.

This report provides an overview of experimental facilities that can be used to address nuclear safety research issues in OECD member countries, and identifies priorities for organising international co-operative programmes centred on selected facilities. The information has been gathered and analysed by a Senior Group of Experts on Nuclear Safety Research, in the context of an ongoing initiative of the NEA Committee on the Safety of Nuclear Installations (CSNI) aimed at maintaining critical experimental infrastructure for nuclear safety studies in member countries.

Radiological protection

Environmental Radiological Protection in the Law

A Baseline Survey

ISBN 978-92-64-99000-5. Free: paper or web.

This publication describes a study of international, European and national legislation which protect the environment from radiation. Countries covered include Australia, Canada, France, Japan, the United Kingdom and the United States. The analysis of the legislation draws conclusions about how well the environment is protected from radiation, and identifies strengths and weaknesses of current approaches as well as trends in regulation. The book will be useful reading for regulators and policy makers in radiological protection, but also for those interested in environmental regulation more generally.

Fifty Years of Radiological Protection

The CRPPH 50th Anniversary Commemorative Review

ISBN 978-92-64-99017-3. Free: paper or web.

On 21 March 1957, the Steering Committee for Nuclear Energy of the Organisation for European Economic Co-operation established the Working Party on Public Health and Safety. From this early date onwards, radiological protection formed a central part of the work of what was to become the OECD Nuclear Energy Agency. Now, 50 years later, the Committee on Radiation Protection and Public Health (CRPPH) has commissioned this historical review of half a century of work and accomplishments. Over this period, the key topics in radiological protection have been identified, debated and addressed by the CRPPH. This report brings this history to life, presenting the major questions in the context of their time, and of the personalities who worked to address them. The developments and views of the past condition how we are able to assess and manage radiological risks today, as well as how we may adjust to challenges that will or could emerge in the coming years. This heritage is thus an important element for the CRPPH to consider as it looks forward to its next 50 years of accomplishments.

Occupational Exposures at Nuclear Power Plants

Fifteenth Annual Report of the ISOE Programme, 2005

ISBN 978-92-64-99010-4. Free: paper or web.

The Information System on Occupational Exposure (ISOE) was created by the OECD Nuclear Energy Agency in 1992 to promote and co-ordinate international co-operative undertakings in the area of worker protection at nuclear power plants. ISOE provides experts in occupational radiation protection with a forum for communication and exchange of experience. The ISOE databases enable the analysis of occupational exposure data from 480 commercial nuclear power plants participating in the programme (representing some 90% of the world's total operating commercial reactors). The Fifteenth Annual Report of the ISOE Programme summarises achievements made during 2005 and compares annual occupational exposure data. Principal developments in ISOE participating countries are also described.

Radiation Protection in Today's World: Towards Sustainability

ISBN 978-92-64-99013-5. Free: paper or web.

The science and application of radiological protection have continually evolved since the beginning of the 20th century when the health effects of radiation first began to be discovered. Given these changes, notably over the past 10 to 15 years, and considering the recent evolution of social values and judgements, the NEA Committee on Radiation Protection and Public Health (CRPPH) felt that it would be worthwhile to identify possible emerging challenges as well as ongoing challenges that will require new approaches to reach sustainable decisions. This report concisely describes the CRPPH views of the most significant challenges to radiological protection policy, regulation and application that are likely to emerge or are already emerging. While not proposing solutions to these issues, the report characterises key aspects and pressures, taking into account the evolution of science, society and experience, such that governments can better foresee these challenges and be prepared to address them appropriately.

Radioactive waste management

Engineered Barrier Systems (EBS) in the Safety Case: The Role of Modelling

Workshop Proceedings, La Coruña, Spain, 24-26 August 2005

ISBN 978-92-64-00664-5. Price: € 45, US$ 60, £ 32, ¥ 6 200.

These proceedings include the main findings and presented papers from the third NEA-EC workshop on engineered barrier systems, which focused on the role of EBS modelling in the safety case for deep disposal. Some national programmes are placing increased emphasis on EBS and, as implementation of underground repositories approaches, more realistic assessments of EBS performance are needed. The workshop examined the mod elling tools currently available and identified complex areas of assessment in which further dialogue is needed.

Fostering a Durable Relationship Between a Waste Management Facility and its Host Community

Adding Value Through Design and Process

ISBN 978-92-64-99015-9. Free: paper or web.

Any long-term radioactive waste management project is likely to last decades to centuries. It requires a physical site and will impact in a variety of ways on the surrounding community over that whole period. The societal durability of an agreed solution is essential to success. This report identifies a number of design elements (including functional, cultural and physical features) that favour a durable relationship between the facility and its host community by improving prospects for quality of life across generations.

Linkage of Geoscientific Arguments and Evidence in Supporting the Safety Case

Second AMIGO Workshop Proceedings, Toronto, Canada, 20-22 September 2005

ISBN 978-92-64-01966-9. Price: € 50, US$ 65, £ 36, ¥ 6 900.

Through a series of technical workshops, the OECD Nuclear Energy Agency (NEA) project on Approaches and Methods for Integrating Geological Information in the Safety Case (AMIGO), is devoted to defining and improving the collection and use of geological evidence that contribute to the understanding of long-term safety for radioactive waste disposal. The second AMIGO workshop was organised in Canada in September 2005. It examined how geoscientific arguments and data are compiled and linked to create a unified description of the geological setting to support a safety case. It also examined practical aspects and limitations in collecting, linking, extrapolating and communicating such information. These proceedings present the outcomes of the workshop.

The NEA Co-operative Programme on Decommissioning

A Decade of Progress

ISBN 92-64-02332-1. Free: paper or web.

The NEA Co-operative Programme for the Exchange of Scientific and Technical Information Concerning Nuclear Installation Decommissioning Projects (CPD) is a joint undertaking which functions within the framework of an agreement between 21 organisations actively executing or planning the decommissioning of nuclear facilities. The objective of the CPD is to acquire and share information from operational experience in the decommissioning of nuclear installations that is useful for future projects. This report describes the progress made and the main results obtained by the CPD during 1995-2005. Although part of the information exchanged within the CPD is confidential and restricted to programme participants, experience of general interest gained under the programme's auspices is released for broader use. Such information is brought to the attention of all NEA members through regular reports to the NEA Radioactive Waste Management Committee (RWMC), as well as through experience summary documents such as this report. The RWMC Working Party on Decommissioning and Dismantling (WPDD) is grateful to the CPD for sharing the experience from its important work.

Stakeholder Involvement in Decommissioning Nuclear Facilities

International Lessons Learnt

ISBN 978-92-64-99011-1. Free: paper or web.

Significant numbers of nuclear facilities will need to be decommissioned in the coming decades. In this context, NEA member countries are placing increasing emphasis on the involvement of stakeholders in the associated decision procedures. This study reviews decommissioning experience with a view to identifying stakeholder concerns and best practice in addressing them. The lessons learnt about the end of the facility life cycle can also contribute to better foresight in siting and building new facilities. This report will be of interest to all major players in the field of decommissioning, in particular policy makers, implementers, regulators and representatives of local host communities.

Nuclear law

Nuclear Law Bulletin

ISSN 0304-341X. Price: € 99, US$ 125, £ 68, ¥ 13 400.

Considered to be the standard reference work for both professionals and academics in the field of nuclear law, the *Nuclear Law Bulletin* is a unique international publication providing its subscribers with up-to-date information on all major developments falling within the domain of nuclear law. Published twice a year in both English and French, it covers legislative developments in almost 60 countries around the world as well as reporting on relevant jurisprudence and administrative decisions, international agreements and regulatory activities of international organisations.

Nuclear science and the Data Bank

Boiling Water Reactor Turbine Trip (TT) Benchmark

Volume III: Summary Results of Exercise 2

ISBN 92-64-02331-3. Free: paper or web.

The present volume is the third in a series of four and summarises the results of the second benchmark exercise, which identifies the key parameters and important issues concerning the coupled neutronics/thermal-hydraulic core modelling with provided core inlet and outlet boundary conditions. The transient addressed is a turbine trip in a boiling water reactor, involving pressurisation events in which the coupling between core phenomena and system dynamics plays an important role. In addition, the data made available from experiments carried out at the Peach Bottom 2 reactor (a GE-designed BWR/4) make the present benchmark particularly valuable.

Burn-up Credit Criticality Benchmark

Phase II-D: PWR-UO_2 Assembly – Study of Control Rod Effects on Spent Fuel Composition

ISBN 92-64-02316-X. Free: paper or web.

The objective of the Phase II-D Burn-up Credit Criticality Benchmark was to study the impact of control rod (CR) insertion on spent fuel composition and on reactivity for a PWR-UO_2 assembly. For this purpose, a range of CR insertion profiles during irradiation were defined, and participants were asked to calculate the spent fuel inventory and the neutron multiplication factor for each case. To assist in the evaluation of the benchmark results, the sensitivity of the neutron multiplication factor to a variation of isotope concentration was performed. The large effect of CR insertion (9 000 pcm when the CRs are inserted from 0 to 45 GWd/t) is due in part to the fact that the CRs are axially fully inserted in this benchmark. A more “typical” CR insertion profile would not consider CRs fully inserted throughout the irradiation, particularly over three cycles. An additional benchmark has been initiated to study the effect of CR insertion when considering partial axial CR insertion and an axial burn-up profile.

Handbook on Lead-bismuth Eutectic Alloy and Lead Properties, Materials Compatibility, Thermal-hydraulics and Technologies

ISBN 978-92-64-99002-9. Free: paper or web.

As part of the development of advanced nuclear systems, including accelerator-driven systems (ADS) proposed for high-level radioactive waste transmutation and generation IV reactors, heavy liquid metals such as lead (Pb) or lead-bismuth eutectic (LBE) are under evaluation as reactor core coolant and ADS neutron target material. Heavy liquid metals are also being envisaged as target materials for high-power neutron spallation sources. The objective of this handbook is to collate and publish properties and experimental results on Pb and LBE in a consistent format in order to provide designers with a single source of qualified properties and data and to guide subsequent development efforts. The handbook covers liquid Pb and LBE properties, materials compatibility and testing issues, key aspects of the thermal-hydraulics and system technologies, existing test facilities, open issues and perspectives.

Mixed-oxide (MOX) Fuel Performance Benchmark

Summary of the Results for the Halden Reactor Project MOX Rods

ISBN 978-92-64-99019-7. Free: paper or web.

Within the framework of the NEA Expert Group on Reactor-based Plutonium Disposition, a fuel modelling code benchmark test for MOX fuel was initiated, with in-pile irradiation data on two short MOX rods provided by the OECD/NEA Halden Reactor Project. This report summarises the in-pile data and fuel characteristics, and presents the calculation results provided by the contributors.

Physics of Plutonium Recycling

Volume VIII: Results of a Benchmark Considering a High-temperature Reactor (HTR) Fuelled with Reactor-grade Plutonium

ISBN 978-92-64-99007-4. Free: paper or web.

This report provides an analysis of the twelve sets of results supplied by seven experts from five countries. Participants have used nuclear data from three different evaluations having applied both Monte Carlo and deterministic methods of analysis. Participants using the same nuclear data report similar results, although some differences have been noted, particularly in relation to the fuel temperature coefficients and the whole-core xenon fission product poisoning effect. There is also evidence of good agreement between Monte Carlo and deterministic solutions for some of the participants despite the difficult nature of the problem with stochastic geometry.

Volume IX: Benchmark on Kinetic Parameters in the CROCUS Reactor

ISBN 978-92-64-99020-3. Free: paper or web.

The present report provides an evaluation and analysis of the reactor period measurements carried out in the CROCUS reactor of the *École polytechnique fédérale de Lausanne* (EPFL) for several different delayed super-critical conditions. Two types of reactivity changes were measured employing an appropriate stable period technique in each case. The first series of experiments involved increasing the water level above the critical level. The second series was carried out by inserting/removing one of the absorber rods into/out of the core. The report also provides a benchmark model and the results obtained with different computer codes. The report will be of interest to reactor physicists and designers.

Pressurised Water Reactor MOX/UO_2 Core Transient Benchmark

Final Report

ISBN 92-64-02330-5. Free: paper or web.

Computational benchmarks based on well-defined problems with a complete set of input and a unique solution are often used as a means of verifying the reliability of numerical solutions. The problems usually employ some simplifications in order to make the analysis manageable and to enable the consistent comparison of several different models, yet complex enough to make the problem applicable to actual reactor core designs. The present benchmark has been designed to provide the framework to assess the ability of modern reactor kinetic codes to predict the transient response of a core partially loaded with mixed-oxide (MOX) fuel. It is a follow-up to a pressurised water reactor (PWR) benchmark designed to assess the ability of spatial kinetics codes to model rod ejection transients in a core with uranium-dioxide (UO_2) fuel. The current problem adds the complexity of modelling a rod eject in a core fuelled partially with weapons-grade MOX. The core chosen for the simulation is based on a four-loop Westinghouse PWR power plant similar to the reactor chosen for plutonium disposition in the United States. This report provides an analysis of the results supplied by experts. The report will be of interest to reactor physicists and designers as well as to nuclear power plant utilities.

Reference Values for Nuclear Criticality Safety

ISBN 92-64-02333-X. Free: paper or web.

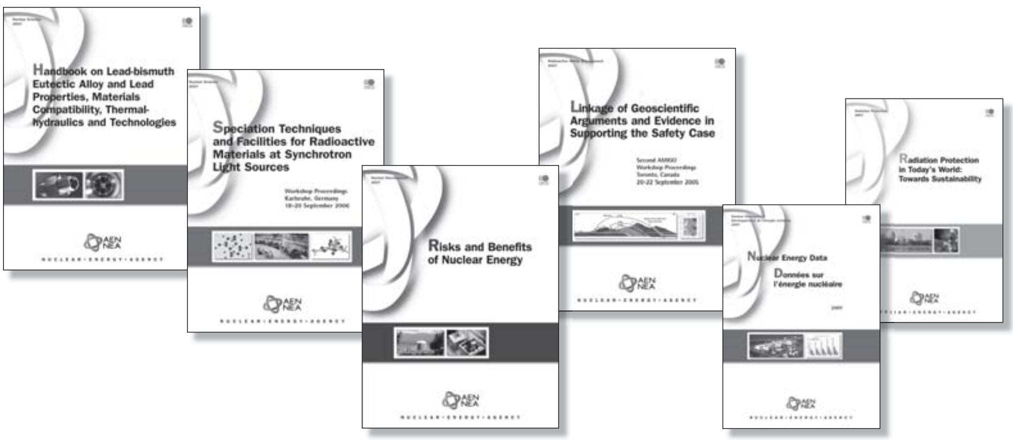
The present report represents the outcome of the NEA study and contains a compilation and evaluation of nuclear criticality safety reference values from various sources. Some of the values were taken from published reports, while others were calculated specifically for this study. Many discrepancies have been identified and resolved, thus reinforcing the importance of data verification and validation as essential tools in this field.

Speciation Techniques and Facilities for Radioactive Materials at Synchrotron Light Sources

Workshop Proceedings, Karlsruhe, Germany, 18-20 September 2006

ISBN 978-92-64-99006-7. Free: paper or web.

This workshop was the fourth in a series devoted to the application of synchrotron radiation techniques for studying actinide species. The unique properties of synchrotron radiation allow the elucidation of the molecular and electronic structure of radionuclide samples. Since 2004 when the previous workshop was held, worldwide experimental capabilities for carrying out such studies have expanded. Synergy is developing with advanced theoretical and simulation tools, and it is expected that this progress will contribute significantly to developments in areas such as radioactive waste management, site environmental remediation and separation technologies, as well as in the radiopharmaceutical industry. The Actinide-XAS-2006 workshop brought together experts in solution, co-ordination and solid state chemistry of the actinides, actinide physics and environmental and life sciences. Workshop sessions were organised on cutting-edge experimental techniques, theoretical and modelling tools and reports on experimental facilities. These proceedings contain abstracts and peer-reviewed papers for 24 presentations as well as 33 poster session contributions, representing the current state of the art in speciation techniques and facilities for radioactive materials at synchrotron light sources.



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