OECD NUCLEAR ENERGY AGENCY NUCLEAR WASTE PROGRAM

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ABSTRACT

This paper covers recent and ongoing activities of the OECD Nuclear Energy Agency in the field of radioactive waste management. As an intergovernmental body, NEA's activities in this field are mostly devoted to the disposal of various types of waste in both the marine and terrestrial environments. In addition, the emphasis of NEA's work is placed on safety evaluations, particularly concerning the long term issues involved in the disposal of high level waste and spent fuel. The most significant of NEA's activities are described, notably concerning safety issues in general, the application of ICRP recommendations, long term modeling of the behavior of disposal systems and the establishment of data bases. Through all these activities, NEA contributes to reinforcing the information at the disposal of national authorities.

As a specialized inter-governmental body, the Nuclear Energy Agency of the Organisation for Economic Cooperation and Development (NEA/OECD) promotes cooperation between its Member governments* on the safety and regulatory aspects of nuclear development and on assessing the future role of nuclear energy as a contributor to economic progress. In the area of radioactive waste management, NEA pursues three main interrelated objectives:

- The promotion of studies to improve the data base available in support of national programs.
- The support of research and development through coordination of national activities and promotion of international projects.
- An improvement in the general level of understanding of waste management issues and options, particularly in the field of waste disposal.

To achieve these broad objectives, NEA's program of work is defined and periodically reviewed by the NEA Radioactive Waste Management Committee (RWMC), which is an international body of senior governmental experts in this field. This Committee, which works in close co-operation with the NEA Committee on Radiation Protection and Public Health (CRPPH) and specialized sub-groups, draws on the best international technical expertise and oversees NEA's efforts at all levels.

This paper presents background information on NEA's recent and ongoing activities in the field of radioactive waste management, as well as a description of the current efforts of the Agency on the assessment of long term safety issues which now enjoy an increasing priority. Emphasis is placed on work associated with the assessment of the long term performance of radioactive waste disposal systems.

*Australia, Austria, Belgium, Canada, Denmark, Finland, France, the F.R. of Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States.

RECENT AND ONGOING NEA ACTIVITIES

To appreciate the role of NEA on the international scene, between the Commission of the European Communities (CEC) which runs a large R & D program at the European level, and the International Atomic Energy Agency (IAEA) which has a major information exchange function at the worldwide level, it is necessary to realize that NEA groups the most advanced countries in the world with about 80 per cent of the world nuclear generating capacity. NEA is therefore in a priviledged position for the discussion of nuclear issues in general and of radioactive waste problems in particular. The NEA Radioactive Waste Management Committee fulfils such a forum function, since its setting up in 1975, continuing a previous NEA tradition of reviewing the waste management policies and strategies of its Member countries[1,2]. More specifically, NEA has promoted many studies and activities over the last 20 years which have contributed to a better presentation and assessment of the technical and scientific issues involved, among the community of health physicists, waste managers and nuclear fuel cycle specialists, but also among policy makers and government authorities in general. The impact and value of such international studies are directly related to the depth of the technical results achieved, but may be equally attributable to the deliberate will to try to jointly progress, often further than each country can do individually. NEA's aim is to catalyse this form of cooperation at the forefront of knowledge and, in a certain way, to give a "credibility label" to radioactive waste studies when they have been the subject of intensive reviews by the best international experts.

In cooperation with the NEA CRPPH, composed of radiation protection specialists and representatives of national authorities, the RWMC has concentrated its activities on disposal issues, particularly in the long term, since, for the large part, treatment, conditioning and on-site storage of radioactive waste are solved and already commercially available on a large scale. The focus of the work was on the following main types of activity:

Discussion of the radiological acceptability of waste disposal practices, notably on the basis of the recommendations of the International Commission on Radiological Protection (ICRP);

- Coordination and promotion of R & D, essentially on sea-based disposal options and deep underground disposal;

- State-of-the-art reviews and discussion of broad policy issues, including legal, administrative and financial aspects of radioactive waste disposal.

Radiological Acceptability

While NEA promotes an individual risk approach compatible with the ICRP system of dose limitation as the most appropriate procedure to decide whether a disposal practice can be acceptable or not from a radiological standpoint in the long term, it also recognizes the value of source-related assessments and collective dose calculations in such a debate. Long term radiation protection objectives for waste disposal (LTO) have actually been published by NEA[3], placing radiological issues in a broad multi-criteria context, where other factors such as technology, availability, social, economic and political considerations are taken into account.

Radiological acceptability issues were also discussed in three specific disposal circumstances within NEA:

- On the long term management of uranium mill tailings with a relatively detailed application of the ICRP differential cost/benefit approach for ALARA, and the identification to the extent possible of cost-effective solutions for the long term stabilization of mill tailings piles in different climatic areas[4].

- On the radiological suitability of the North East Atlantic site used until 1982 by several European countries for the disposal of low level waste according to the London Dumping Convention (LDC). While the results of the NEA assessment[5] indicated clearly that the radiological impact on man and the environment was not of concern, it was nevertheless decided within the LDC to continue the suspension of dumping operations for an open-ended period of time. By and large, the results of the best international safety assessment which could be made at present on the sea dumping option were largely ignored and political attitudes prevailed.

- On the disposal of low level radioactive waste at shallow depths on land, for which acceptance criteria are being discussed for long-lived radionuclides which may be present in small concentrations in such waste. The current NEA study shows that site conditions influence the concentration limits which could be adopted, even if the intrusion risk which dominates after the end of institutional control measures is relatively generic[6]. Therefore, only ranges of possible concentration limits will be proposed. They are likely to be the following for alpha emitters (excluding radon):

  . 10 to 1000 Bq g^{-1} (averaged over the whole site) for waste placed at depths below 3 m

  . 10^3 to 10^4 Bq g^{-1} for waste placed below 3 m.

These three NEA studies have illustrated the fact that radiological criteria can, in general, be met, that most often site conditions will impose specific requirements, but also that in the end radiological acceptability is only one of the factors to be taken into account and usually not the most difficult to cope with.

Coordination and Promotion of R & D

NEA is sponsoring the three following international research and development programs.

- The Coordinated Research and Environmental Surveillance Programme (CRESP[7]), associated with the North East Atlantic Site for the dumping of low level waste. This program, covering model development, physical oceanography, geochemistry, biology and radiological surveillance, was set up in 1981. The results obtained through the program, which enjoys the participation of 14 countries and the IAEA, were used in the assessment of the continued suitability of the North East Atlantic Dump Site, as mentioned above[5]. In spite of the present suspension of dumping, it was agreed last October by the NEA Steering Committee that the CRESP program be continued for a new five-year period, with the objectives of improving the scientific data base and refining further the radiological assessment.

- The Coordinated R & D program on seabed disposal of long-lived and high level radioactive waste. This concerns the emplacement of waste canisters into the unconsolitated sediment layers below the seabed and is therefore an alternative to deep geologic disposal. The purpose of this activity, supported by eleven NEA Member countries and the CEC, is to assess the technical feasibility and long term safety of this concept. Research activities are coordinated by the NEA Seabed Working Group, assisted by a number of task groups specialized in various scientific disciplines[8]. In 1985, during a major oceanographic cruise involving the presence of some 70 international scientists on a large French research vessel, 13 long sediment cores (between 17 and 34 m length) were taken and different penetrators were tested at two different sites located in the West and East Atlantic. It is hoped that budgetary and political constraints will not endanger the current program and prevent a full assessement of this very promising disposal option.

The International Stripa Project, concerning research into the feasibility and safety of HLW disposal deep underground in crystalline rock. Starting at the old iron Stripa Mine in Sweden in 1977, under a Swedish/American program, the Project really began in May 1980 with its phase 1 (until 1985). A phase 2, initiated in 1983, is due to be completed in 1986. Under both phases, research was carried out under four main headings

  . hydrological investigations of the Stripa granite and migration within single and multiple fracture systems;

  . the hydrochemistry *of ground* waters at the site;

  . the detection and characterization of fracture zones in granite; and

  . the behavior of bentonite clay as a backfilling and sealing material under field conditions.

The latest results and current status of research were reviewed in June 1985 at the second Stripa Symposium held in Stockholm[9]. New tools and

techniques have been developed for assessing potential disposal sites in granite, such as geophysical, radar and hydraulic investigation techniques used to map the distribution and extent of fracture zones. It was confirmed that only a small percentage of the fractures in granite transmit flowing water. From the engineering design viewpoint, studies have concentrated on the validation of predicted bentonite behavior as backfill and seal material in the Stripa Buffer Mass Test. Further studies on bentonite are now under way. The review of the results achieved during phases 1 and 2 has indicated a strong interest for the application of the site investigation techniques developed at Stripa to a large undisturbed volume of granite at the site itself (125 m x 125 m x 50 m). A phase 3 of the Stripa Project is currently under discussion for this purpose. It is planned to use non-destructive cross-hole measurement techniques such as high resolution directional radar and borehole seismics, as well as a large scale tracer experiment. Comparison of the results with mathematical predictions will be made in a further validation exercise. This phase 3, which has a proposed budget of about $16 million, should therefore result in the availability of non-destructive site investigation techniques which will be fully evaluated under rigorously controlled conditions. Some further work is also planned on the use of sealing materials to restrict the migration of radionuclides from a repository.

- The Cooperative Programme for the Exchange of Scientific and Technical Information Concerning Nuclear Installation Decommissioning Projects. Under this recently launched NEA Project, seven countries have agreed to share information and experience relating to the decommissioning and dismantling of some ten large nuclear facilities, mostly reactors such as Shippingport, but also fuel cycle facilities such as the NFS plant at West Valley, NY. The exchange includes project description and plans, R & D data from each project, data from actual dismantling, and visits by experts. Special arrangements are foreseen on an ad hoc basis with regard to the availability of equipment used in decommissioning operations and components and samples from decommissioned facilities, the conduct of tests, and the secondment or exchange of personnel. The project actually started in November 1985 with a workshop, held in Tokyo, describing the JPDR reactor decommissioning program and the technologies developed for this purpose.

State of the Art Reviews and Discussion of Policy Issues

Assessing the state of the art in the different areas of radioactive waste management is an important function of international bodies, as it not only contributes to wide dissemination of information but also to the development of a common understanding and technical consensus among experts which help licensing and political authorities in their judgements and decision making processes. Some of the reviews mentioned earlier have fulfilled at least partially this role[3,4,5,8]. Two more should be cited briefly.

- An overview of the current status of understanding and development on geological disposal of radioactive waste, published jointly by NEA and the CEC in 1984[10]. This report stated clearly that early disposal of HLW and spent fuel is technically feasible, even if not really justified at present from a technical and economic standpoint. It indicated the need to move from generic to site-specific research, both for engineering development and safety assessment studies. With the necessary qualifications concerning the need for additional research, it concluded that there is no reason to doubt the feasibility and long term safety of deep underground disposal in different geologic environments. More than the nature of the geological medium, the site characteristics themselves seem to be of major importance in site selection.

- A study on the legal, administrative and financial aspects of the long term management of radioactive waste, published also in 1984 by NEA[11]. These aspects, particularly important for national regulatory authorities, were reviewed with emphasis on the scope and duration of institutional control measures, responsibilities of governments and the role of industry, third part liability issues and possible financing schemes.

These and other NEA activities have provided the foundation for the Radioactive Waste Management Committee to express, in 1985, a "collective opinion" in the form of a Technical Appraisal of the Current Situation in the Field of Radioactive Waste Management[12]. Essentially, the RWMC concluded that "a step by step approach to the application of technologies as they become viable on an industrial scale is both justifiable and safe, always keeping in mind the need for strict quality control and operating procedures, all along the chain of waste management operations". An overall impression of optimism and confidence prevails from the RWMC's appraisal, even if it is recognized that R & D will have to continue "notably to fill remaining gaps for particular options, to collect site specific data and to refine safety studies". This message was well received within NEA Member countries, and regarded as one of the best means at the disposal of international organizations in support of national programs: the preparation of "predigested" reliable and objective technical information for the benefit of national authorities and policy makers.

THE NEA PERFORMANCE ASSESSMENT PROGRAM

From the above, it is obvious that NEA has always been involved in environmental and safety evaluations concerning waste management. However, the sophistication reached for disposal systems performance assessments has led to new challenges, both at the level of the developers and at the level of those assessing the results of safety studies. The need to predict the behavior of increasingly complex disposal systems and the need to do it with a large degree of confidence in spite of the uncertainties inherent to the far future, make it more and more essential to pool resources and to rely on the advice of the best international experts. This is why NEA is now devoting the largest fraction of its work in the field of radioactive waste management to such long term safety assessments. An NEA Group has just been set up for this purpose as a result of a workshop organized in October 1985 on the various types of linkage in system performance assessments. This Group, which will periodically review the progress in this field and advise the RWMC, will ensure the coherent integration of all elements to be taken into account in systems performance assessments. The workshop discussed, in particular, various types of linkage between the output from performance assessments and the need of regulators, the link between the various mathematical models used in performance assessments and the link between model development and field/laboratory observations. The workshop proceedings will be published by NEA in 1986. Among the topics to be discussed by the Group, code development, intercomparison and validation, was regarded as a priority area. The handling of uncertainties in

systems performance assessment and methodologies for scenario identification also discussed at the workshop, will be the subject of a topical workshop in 1986 or the beginning of 1987. The suggestion for international peer reviews of performance assessment activities, upon request from national authorities, will be explored. This new Group will, in practice, help to coordinate all NEA activities in the area of systems performance assessments. In the meantime, work is proceeding in two main areas.

Predictive Modeling

NEA's main involvement in this field is through the NEA User Group for Systems Variability Analysis Codes, which was set up in 1985 for the purpose of exchanging codes, information and experience, providing mutual peer reviews, discussing specific technical issues such as code quality assurance, verification and validation, and applying the results of these discussions to SYVAC-like codes in order to increase confidence in the approach. The interest in this Group grew rapidly and it is now called the Probabilistic Systems Assessment Codes User Group to cover a wider range of probabilistic codes from a larger group of countries. The Group now includes participants from Belgium, Canada, F.R. of Germany, Sweden, Switzerland, United Kingdom and the CEC. It meets twice a year to consider the progress of its program of activities. This program falls under three main headings:

- exchanging and compiling an inventory of codes;
- code intercomparison; and
- holding topical specialist meetings.

The first activity is based on work at the NEA Data Bank and currently involves the testing of fully developed computer programs. These include SYVAC-1 and 2 from Canada, SYVAC A and C from the United Kingdom, and Lisa 1 and 2 from the CEC. It is intended that the Data Bank will establish a library of codes for exchanges between members of the User Group. The second activity involves the intercomparison of probabilistic codes via a series of benchmark exercises. This began recently with a straightforward Level 0 exercise, using simple pre-defined sub-models for the vault, geosphere and biosphere, with runs restricted to Iodine-129 and a one-member decay chain. The aim is to provide a means of intercomparison of probabilistic codes to aid their development and also for quality assurance purposes. Further Level 1 and Level 2 intercomparisons are envisaged depending on the experience gained from Level 0. The third activity involves holding very informal topical meetings in conjunction with the main meetings of the User Group. Following critical discussion of participants' experience and current problem areas, a series of guidelines are prepared and a summary of the presentations is made. To date, topical meetings have been held on: Input data acquisition and handling; Methods and procedures for sensitivity analysis; Presentation of results from SYVAC-like codes; and Statistical sampling procedures, their theory and application to SYVAC-like codes. Further meetings are planned in 1986 on Software quality assurance and validation, and Time dependent processes. Six other topics have been agreed for subsequent meetings.

NEA is also involved in the HYDROCOIN intercomparison exercise, covering hydrological codes used in system performance assessment. Started on the initiative of the Swedish authorities in May 1984, it is now a well-known international activity, with the participation of fourteen national organizations and NEA. The second Hydrocoin meeting took place in Albuquerque in May 1985 and the third one at the OECD in Paris, in October 1985. The purpose of Hydrocoin is to obtain improved knowledge of the influence of various strategies for ground water modelling. The study is conducted in three successive levels:

- Level 1 to verify the numerical accuracy of ground water flow codes. It is now complete and the results will be published in 1986.
- Level 2 on validation of models using field experiments. Preliminary results will be available in 1986.
- Level 3 on sensitivity and uncertainty analyses. The work to be done is at present under discussion.

At the NEA Data Bank, computer codes are routinely stored and tested, before distribution upon request. Two short courses have been organised by NEA in 1985 on the application of the PHREEQE code, developed by the US Geological Survey. This is a reaction-path tracking code used for chemical thermodynamic modeling.

Data Bases

Two data bases are currently being developed at the NEA Data Bank in Saclay, France. The International Sorption Information Retrieval System (ISIRS) is a data base system for the storage and handling of distribution coefficients Kds used to model retardation of the migration of radionuclides in the geosphere. The system was initially developed by Pacific Northwest Laboratories and transferred to the NEA in 1983. It is now run as a truly international project, with the participation of ten countries. The data base contains data from about 2500 Kd determinations for 18 elements on eight general classes of geologic material in a variety of physico-chemical conditions. With a growing data base, ISIRS will be increasingly valuable for:

- providing distribution coefficient data for both general and preliminary site-specific models of potential radionuclides migration from disposal facilities;
- providing experimental scientists with a readily accessible source of information about previous experimental parameters and results;
- providing a collection of data from various sources that can be used to develop and validate geochemical models of sorption behavior.

The second NEA data base concerns fundamental chemical thermodynamic data which can be used in geochemical modeling of the far-field geological barrier[13]. Such data permits the quantification of mass transfers in chemical reactions occurring in ground water and in water-rock interactions. They are increasingly used in models such as PHREEQE, which calculate aqueous speciation and mass transfers due to dissolution and precipitation processes, as well as to isotope exchange and other retardation mechanisms. The objective of the NEA in this chemical thermodynamic data base is to compile, critically review and publish recommended values of these fundamental constants for ten elements important to high level waste disposal and other nuclear technologies. These ten elements are uranium, plutonium, neptunium, americium, caesium, strontium, radium, technetium,

iodine and lead. The results of the uranium review, which is the first volume to be published, will appear in 1986. The recommended data sets will also be made available in computer-readable form from the NEA Data Bank.

With its contribution on international data bases for diffusion coefficients (ISIRS) and chemical thermodynamic data (TDB), the NEA is adressing the primary geochemical modeling needs of waste disposal systems performance assessments.

CONCLUDING REMARKS

Through all its activities in the area of waste management, NEA enjoys the participation of hundreds of scientists from some 20 countries. The results of NEA's work are therefore a reflection of truly international evaluations. As such, they carry a great deal of weight for the benefit of national authorities confronted with the need to take decisions on the definition and implementation of their own waste management policies. This is particularly true in the area of long term performance assessment of disposal systems to which most of NEA's efforts are devoted. By having defined broad long term radiation protection objectives for waste disposal, we are now aiming at the development and refinement of long term assessment methodologies. Of course, it is not the role of NEA to develop site- or country-specific solutions. It is more our function to assist in this work by providing suitable data and modeling techniques which have been thoroughly tested and, if felt desirable at the end, by organizing possible peer reviews on request. This is really the thrust of our present programme, to increase confidence in our capability to assess the long term safety of waste disposal systems, together with coordination and promotion of the associated R & D.

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