US COOPERATION WITH OTHER NATIONS IN NUCLEAR WASTE DISPOSAL

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ABSTRACT

The major areas of cooperation in high-level radioactive waste disposal between the US and other nations and international organizations are identified, focusing on those activities associated with the US Department of Energy. The various means by which activities are identified and implemented are discussed. Information and experience gained through past cooperative efforts at underground research laboratories in other nations is provided along with those activities performed to enhance the development of repository predictive response models. The benefits associated with participation in these cooperative efforts are also discussed.

INTRODUCTION

It has been US policy for many years to exchange information and to seek benefits through cooperating with other nations and international organizations in the development of waste management and disposal technology. Development in US radioactive waste management programs have much to offer for exchange with the international community. Several foreign nations and organizations are developing sophisticated waste management programs which have significant benefits and are ahead of the US programs. Thus, participation in generic and site specific cooperative activities with these nations and international organizations has been and is expected to continue to benefit US waste management programs by sharing technology, experiences and approaches.

This paper identifies and describes the major areas of cooperation on radioactive waste disposal between the US and other nations and international organizations, focusing specifically on activities associated with geologic disposal of high level radioactive waste (HLW) and spent fuel. The information presented in this paper deals primarily with cooperative activities of the US Department of Energy (DOE), which has responsibility for the disposal of HLW and spent fuel. However, important international exchange on low and intermediate level waste is occurring as well.

The exchange of technology with other nations and international organizations is fostered through various routes -- exchange of technical reports, direct correspondence between technical staff, reciprocal visits by technical staff, exchange of personnel, cooperative research studies and test programs, and participation in technical conferences and specialist workshops. To encourage the transfer of technology, the DOE has established radioactive waste management agreements with several nations and international agencies to define the scope of activities which can be freely exchanged and to establish guidelines for implementation of the exchange. To date, the DOE has established the following nine specific waste management agreements: the European Atomic Energy Community (EURATOM)-acting through and represented by the Commission of European Communities (CEC), Belgium, Canada, France, the Federal Republic of Germany, Japan, Sweden, Switzerland, and the United Kingdom. A general agreement with Spain also covers waste management. The DOE maintains a membership in the Organization for Economic Cooperation and Development/Nuclear Energy Agency (OECD/NEA), comprised of 23 western-bloc nations, and the

International Atomic Energy Agency (IAEA), maintaining a membership of over 100 countries. Interaction established by these agreements is promulgated and coordinated through officially designated "Principal Coordinators" by each party of the agreement. Identification and implementation of specific activities under each agreement is performed through officially designated "Technical Coordinators" for each party of the agreement. In all cases the official representatives for the US are DOE employees.

The DOE Office of Civilian Radioactive Waste Management (OCRWM), responsible for development of the technology for deep geologic disposal of HLW and spent fuel, is cooperating with other nations and international organizations that are actively developing technology for the disposal of HLW and spent fuel. This cooperation ranges from the exchange of technical documents to full collaboration in sharing cost for underground research laboratories (URL). Specific project agreements are prepared in which the terms and conditions of shared projects are established. OCRWM benefits from international cooperation in several ways: 1) it affords access to foreign technology, experimental data and experience; 2) it allows the sharing of extensive underground test programs; and 3) it permits access to underground facilities in which OCRWM can evaluate testing methods prior to use in future US facilities.

In order to assure that planned exchange activities are beneficial, the OCRWM policy on international cooperation requires a benefits assessment prior to engaging in any new major international activity. As a result, OCRWM is closely cooperating with those nations and international agencies working on rock technology which complements or is consistent with the US geologic repository program (i.e. salt and granite), especially those focusing on URL projects. These efforts include cooperative projects with the Atomic Energy of Canada, Limited (AECL) and the Organization for Economic and Cooperative Development/Nuclear Energy Agency (OECD/NEA) in crystalline rock URL developmental work, recently complemented by crystalline URL activities in Switzerland, and a highly successful cooperative research and development project with the Federal Republic of Germany (FRG) at a salt URL. The information and experience gained at these URL sites is of particular benefit to the US geologic repository program, since OCRWM currently does not have to construct an expensive underground research laboratory of its own. In addition, the DOE is cooperating with those nations maintaining advanced nuclear waste management programs in the development of repository predictive response models. A significant portion of this work is being achieved through membership in the OECD/NEA and a multinational effort being coordinated by Sweden.

SALT URL ACTIVITIES

The DOE and the FRG entered into a project agreement to collaborate in studies at the Asse Salt Mine in 1981. The Asse Mine, located north of the municipality of Remlingen in the county of Wolfenbuttel within the FRG, was first used for salt extraction in 1909. The DOE/FRG agreement focuses on the following technical areas: 1) migration of brine in a salt repository under the influence of heat and radiation; 2) utility of test procedures and performance of test equipment in the salt mine environment; 3) performance of waste package materials under the influence of heat, radiation and brine; and 4) temperature and stress fields associated with the mining of cavities in salt and with the emplacement of heat sources in salt. The work is being performed to establish methodology and develop tools for use in the salt site characterization activities. The major cooperative effort at the Asse Mine has been achieved through the Brine Migration Project, a large scale field test to simulate a waste repository in salt. The major objectives of the project were to: 1) obtain an understanding of the mechanism of brine migration toward heat sources; 2) obtain data to validate numerical models; 3) identify the chemical composition of the brine produced; 4) define the thermomechanical and radiation effects on the salt; and 5) qualify equipment and test methods for obtaining brine migration data. The complete experiment was composed of four heater test sites -- two nonradioactive heaters and two heaters with Co-60 as radiator sources. The tests were initiated in 1983 and completed in 1985. The results showed that: 1) the average amount of absorbed water contained in the salt is significantly lower than assumed for the pre-test calculations; 2) room closure and displacement are slightly different from predicted values; and 3) there is no significantly different behavior between non-irradiated and irradiated test sites. In addition, the acoustic monitoring systems showed extensive cracking in the heated zone after heating power reduction and shut off at the end of the heating cycle. As a result of the work performed to date, the DOE will continue with the Asse brine migration post-evaluation activities, which include salt and metal analyses in US and FRG laboratories, geo- and thermomechanical behavior of the mine, and data analysis of the brine migration test results.

Currently the FRG is constructing an underground facility at Gorleben in Lower Saxony in order to evaluate the suitability of the site for a repository. The techniques being used by the Germans are of great interest to DOE because of the potential application to the design and construction of facilities in Texas as part of the first repository siting process. On-site liaison has been established in the FRG to assure the full benefit of the German experience.

CRYSTALLINE URL ACTIVITIES

Sweden, Switzerland, Canada and France have extensive work underway in their predominately available crystalline rock formations. In June 1986 OCRWM initiated through NEA a meeting of the Directors of crystalline rock programs to exchange views on enhanced collaboration among the countries. The directors were in favor of continuing such meetings and to seek additional ways that each could benefit from closer cooperation. (See INTERNATIONAL AGENCY ACTIVITIES).

Currently, OCRWM has active technology exchange programs with Sweden (Stripa through the OECD/NEA), Canada, and Switzerland.

The Stripa Test Facility is an abandoned iron ore mine in central Sweden. Horizontal tunnels and boreholes suitable for experimental investigations at about 400 m depth have been excavated in a granite formation adjacent to the mine. The US involvement in the Stripa URL project was initiated as the Swedish American Cooperative (SAC) Program in 1977 as a result of identification of a need to develop techniques for measuring thermomechanical, hydrologic, geophysical and geochemical properties in granite. The initial program between the US and Sweden was so successful in providing information and experimental experience associated with identification of major parameters of influence for model development and repository response that in 1980 the jointly funded International Stripa Project was formulated by Canada, Finland, France, Japan, Sweden, Switzerland, the United Kingdom, the United States, and to be coordinated by the OECD/NEA. The objective of the project was to develop in-situ test techniques and procedures in an underground experimental program to assess isolation of radioactive wastes in a crystalline rock repository. Work on the project was organized under a technical advisory group to perform activities in several phases.

Phase 1, which was completed in 1984, utilized experiments designed to obtain information on logging systems or borehole hydrogeological measurements, geochemistry of groundwaters at great depth, migration rates of various elements in fractures and behavior and utility of backfill materials in a real geological environment. Phase 2, which was initiated in 1983 and expected to be completed in 1987, consists of development of single hole and cross hole radar and seismic techniques for the detection and characterization of fracture zones in the vicinity of a repository, a three-dimensional tracer migration experiment, investigations of ground water fracture flow and associated radionuclide transport, and borehole and shaft sealing tests.

To date OCRWM has obtained useful information in the area of instrumentation development, test procedure establishment requirements, and identification of which parameters are significant for model development. OCRWM is supporting Phase 3 of the project, currently expected to extend from 1986 to 1991. Phase 3 will apply Phase 1 and Phase 2 technology to an undisturbed rock mass at the Stripa Test Facility. The Phase 3 activities will focus on: 1) fracture flow and nuclide transport; and 2) groundwater flow path sealing.

OCRWM cooperation with Canada centers on performing experiments in the AECL's URL in the Lac du Bonnet granite monolith located in the Province of Manitoba. The URL has been excavated to a depth of approximately 240 m into the previously undisturbed pluton. It will contain several hundred meters of experimental drifts in which thermomechanical, excavation response, and grouting/sealing tests will be performed. The joint project provides OCRWM the unique opportunity to gain experience and knowledge at high quality research facilities in the characterization and behavior of crystalline rock, especially experience related to shaft extension through a fractured granite zone. The joint project has been structured to focus on four areas: 1) participation in experiments at the URL, including excavation response experiments, heated block tests, heated pressure chamber tests, radionuclide migration/sorption experiments, buffer/container tests and borehole shaft sealing investigations; 2) performance assessment studies, which include geosphere modeling, dissolution-precipitation kinetics, and the transfer of performance assessment computer codes; 3) field testing investigations, which include development of US characterization plan procedures and instrumentation development; and 4) shaft extension and characterization of a major fracture zone. The shaft will be extended from the current depth to approximately 440 m to allow the execution of experiments at a depth more representative of an anticipated repository. The OCRWM participation in the characterization and monitoring of a fracture zone will include instrumenting and monitoring the zone prior to and during the shaft construction. To date US involvement has included the initiation of borehole drilling as required to obtain information for shaft extension to 440 m, the implementation of general above ground testing in support of the overall URL project, and planning meetings to identify experiments to be performed at the URL.

The DOE signed a bilateral agreement on waste management with Switzerland in the Spring of 1985 and has since formulated several project agreements to perform activities considered beneficial to the OCRWM geologic disposal program. The activities, expected to complement the work being performed at both Stripa and the Canadian URL, will focus on flow and transport through fractured media and takes advantage of Switzerland's extensive experimental and data collection efforts at their Grimsel Pass URL. The laboratory was built as a branch from the main access tunnel to the Grimsel II Power Station 1150 m into the rock with approximately 450 m of rock above the test tunnel. The total length of the 3.5 m diameter test tunnels is 900 m. The purpose of the program is to develop geotechnical and geophysical investigation techniques and to further evaluate the quality of granite as a barrier for geologic disposal.

INTERNATIONAL AGENCY ACTIVITIES

The OECD/NEA promotes development of peaceful uses of nuclear energy through cooperation of member states. The NEA provides a forum for sharing common interests and experiences in disposal technology. The OCRWM geologic repository program is currently participating with the NEA in: 1) technical workshops/groups focusing on repository performance modeling; 2) cooperative efforts in underground research laboratory activities; and 3) efforts through committee/study groups to demonstrate the safe disposal of radioactive waste. OCRWM considers participation in these

efforts important to the US geologic disposal program. Participating nations are represented by delegates on the Radioactive Waste Management Committee (RWMC). The RWMC involves senior experts who meet at least annually to review proposed OECD/NEA radioactive waste management activities and to ensure the overall programmatic objectives are met. The RWMC is assisted by the Performance Assessment Advisory Group (PAAG) and In-Situ Research and Investigations Advisory Group (ISAG) on Geologic Disposal.

The NEA PAAG was organized in December 1985 with the objective to provide an international forum to consider post-closure performance assessments for the safe disposal of all radioactive waste types with emphasis on the long-term to assist in the establishment of confidence within the technical community. Two of the activities of the group include: 1) exchange of information and experience to further the development and use of performance assessment methodologies and avoid duplication of efforts; and 2) identification of initiatives for cooperation on the development and use of performance assessment methodologies, in particular in the areas of model development, data acquisition and regulatory requirements.

Within the PAAG there are several areas of specific coordination. For example, the Probabilistic Systems Assessment Codes (PSAC) Users Group, consisting of members from Belgium, Canada, the Commission of European Communities, the FRG, Japan, Sweden, Switzerland, the United Kingdom and the United States are comparing approaches for using general overall system codes as applied to the screening of sites and to indicate the general expected performance of a site. This working level group is benefiting from the operational experiences and results from comparisons of codes and models. In another effort work is proceeding on the acquisition of data on the various species of radionuclides utilized in the prediction of potential migration from a repository. Actual sorption data and theoretical thermodynamic data provide a base for calculation of source terms as well as retention of radionuclides. Last month the NEA sponsored and the US hosted an uncertainty analysis workshop in Seattle. Participating countries were able to review approaches of estimating the uncertainties in long term projection of repository performance.

The NEA ISAG was organized in December 1985 to meet the continuing need for information exchange and coordination in the field of geologic disposal concerning activities associated with in-situ experimentation, site investigation and engineering aspects of generic or potential disposal sites. In addition, the group will provide information exchange among researchers working in the field and those developing and implementing performance assessment evaluations. Thus, information exchanged in this group relates actual designs and experience gained at URL sites. Accordingly, the group is of interest to OCRWM as input to planning future US URL's during the site characterization phase of site selection for the first and second repository.

In July 1986, in response to a proposal by the US delegation to consider enhanced collaboration among crystalline rock repository projects, the OECD/NEA RWMC agreed to convene a Directors Level meeting among those countries interested in crystalline rock in order to exchange views on options for closer cooperation. The US proposed the enhanced program based on the fact that there is significant effort underway in Canada, Switzerland, France, and through the NEA (Stripa Project) in crystalline rock activities, and that the potential for increased cooperation needs to be fully evaluated. The cooperation could bring more expert focus on both the management process and technical developments. OCRWM is continuing development work on crystalline rock as a potential host for geologic repositories because of its attractive characteristics, its abundance in the US and its potential for a possible second repository in the US. In particular, the continuation of active technology development and exchange can be maintained through international cooperation even though the siting work on the second repository in the US has been postponed until the mid 1990's or later. Those participating in the meeting held late in 1986 at the OECD/NEA offices in Paris were the AECL, Canada; CEA/ANDRA, France; TVO, Finland; JAERI/PNC, Japan; JEN/ENRESA, Spain; SKB, Sweden; NAGRA, Switzerland; DOE, United Kingdom; DOE, United States; and the CEC. From the meeting it was concluded that there is value in exchanging information and pursuing personal contacts among Project Directors by using the existing mechanism within the NEA. The group agreed to meet again in about one year to review broad issues of interest to all participants, and further recognized that individual member countries may elect to work together anytime through use of existing mechanisms.

OCRWM also cooperates with the International Atomic Energy Agency (IAEA). The IAEA activities include exchange of scientific information on radioactive waste treatment disposal and spent fuel management. The principal effort involves the preparation of documents to guide the development and safety of treatment and disposal of radioactive waste. OCRWM participate in the Technical Review Committee on Underground Disposal (TRCUD), a review group to examine and make recommendations on the IAEA publications on waste management. In making such recommendations, the TRCUD looks into the need to ensure consistency between documents, quality of contents, and relevance in context of the overall objectives. Other special IAEA meetings are convened to assist the agency in preparing general criteria and standards, safety documents and technical reports in the area of waste management technology and practice. Many of the documents are important to OCRWM because they represent internationally derived guidance on waste disposal and fuel storage. Documents are currently being prepared on standards and criteria for disposal of HLW and acceptance criteria for radioactive waste.

MULTINATIONAL ACTIVITIES

In addition to participating in beneficial activities with other nations and international organizations maintaining sophisticated radioactive waste management programs, OCRWM also participates in multinational projects considered to be required for the eventual implementation of geologic disposal in the US. Most of these projects focus on predictive modeling and verification of those models for the geologic disposal system, and involve experts from many nations. Several of these projects have been originated and coordinated by Sweden, whose radioactive waste management program implementation has experienced notable success. The US has concluded that these efforts are beneficial, since associated activities assist in identifying the quality of the computer codes used to predict the response of a repository to emplaced waste relative to the surrounding environment.

In January 1984 the Swedish Nuclear Power Inspectorate (SKI) established the Hydrologic Code Intercomparison (HYDROCOIN) study to intercompare computer codes used to predict groundwater flow in relation to the performance assessment of geologic repositories. The project was established in several phases and is expected to be completed in 1988. The OCRWM involvement and interest was prompted by: 1) the need for benchmarking, verification and validation of project office codes and methods; and 2) the need for expert peer review. The US Nuclear Regulatory Commission (NRC) participates as well, thus allowing comparisons of the DOE project and NRC approaches to problem solving as the technology matures. Canada, the FRG, Finland, France, Japan, the Netherlands, Sweden, Switzerland, the United Kingdom and the United States are participants in this program.

Since 1981 the SKI has implemented the international collaboration projects dealing with verification, validation and uncertainty analysis exercises using mathematical models for the description of nuclide migration (INTRACOIN) and ground water transport (HYDROCOIN) in the geosphere. The need for extensive work on validation of geosphere models has been elucidated within these projects. As a result, SKI is establishing the INTRAVAL project to study the problem area of validation of geosphere performance assessment models in a comprehensive and systematic manner. The primary objective of the project will be establish an international group of experts -- structure and participation trend similar to that experienced by INTRACOIN and HYDROCOIN -- for the evaluation of selected mathematical models aimed at describing the transport of radioactive substances in the geosphere. OCRWM intends to participate in this project.

For several years the US has performed natural analog studies at the Morro do Ferro thorium deposit in Brazil for the purpose of obtaining experimental information by which to validate performance assessment modeling efforts. In 1985 Sweden, Switzerland, the United Kingdom and the United States met with Brazil to evaluate the region of Pocos de Caldas for a multinational effort in the area of natural analogs. Subsequent to evaluation of the benefits to be derived through participation in this multinational activity, the US decided in early 1987 to join the ongoing activities with the other participating nations.

CONCLUSIONS

The DOE has been cooperating with other nations and international agencies in the area of high-level radioactive waste disposal for over ten years to obtain information and experience in international activities. Participation in underground research laboratories and modeling of repository performance have been emphasized. Past experience indicates that the information obtained has been extremely beneficial to the development of the OCRWM geologic repository program. Current and planned efforts with foreign organizations have been developed based on the success of previous efforts. The DOE will continue to focus cooperation on those nations and international organizations maintaining underground research laboratories and generic activities which can assist in the enhancement of the OCRWM geologic repository program. These include:

-- Crystalline URL activities with the Canadian AECL, the OECD/NEA Stripa Project and the Swiss Grimsel Pass are expected to continue to contribute significant insight to the type of information and testing methods that will be required to assist in the development and characterization of a deep geologic repository in the US.

-- Salt URL activities at the Asse and Gorleben Facilities in the FRG are expected to provide experience and information useful for the development of the US geologic repository program. US Liaison staff in the FRG, cooperative workshops and seminars focusing on specific aspects of the experimental program have been established to improve information exchange.

-- Development of repository performance models considered crucial to the OCRWM program is being assisted through activities with the OECD/NEA, the IAEA, and multinational efforts being coordinated by Sweden. The continuation of directors meeting on crystalline rock repository programs between the US and those nations focusing on deep geologic disposal of spent fuel and high-level radioactive waste is expected to assist in the acquisition and exchange of information important to the conduct of the OCRWM program. Improvements in modeling are being actively pursued for use in the overall OCRWM program.

OCRWM recognizes the major benefits in continuing and enhancing international cooperation. Significant contributions to technology and experience are evolving. Approaches to institutional and regulatory issues are being developed. The exchange and support among the many countries developing geologic repositories for radioactive waste attests to its importance. The scientific "cross-check" among nations is leading to a high level of confidence that the approaches being taken are timely and appropriate to assure protection of the health and safety of this and future generations.