THE ROLE OF INTERNATIONAL COOPERATION REGARDING SAFETY ASSESSMENT DEVELOPMENT IN THE SKB RESEARCH PROGRAM

Torsten Eng and PerEric Ahlstrom
Swedish Nuclear FueL and Waste Management Co, SKB

ABSTRACT

Cooperation and exchange of information with organizations in foreign countries regarding nuclear waste management constitutes an important part of the overall research and development activities of SKB. In the safety assessment of a repository for spent nuclear fuel natural phenomena have to be described with different kinds of models based on both general and site specific data. The international cooperation efforts to achieve models and methods for this type of descriptions, and where SKB are largely part, is summarized in this paper.

BACKGROUND

The nuclear power program in Sweden consists of twelve reactors with a combined capacity of about 9650 MWe. Up to the year 2010 these units will give rise to some 7800 metric tonnes of spent nuclear fuel. The present planning foresees that the spent fuel will be stored at the existing interim fuel storage facility CLAB for about 40 years before final disposal in a geological repository. Such a repository is planned to be located in the Swedish bedrock and to be in operation from 2020. The Swedish Nuclear Fuel and Waste Management Co. SKB is responsible for all necessary measures to be taken for handling and disposal of all radioactive wastes from the Swedish nuclear power program. This responsibility includes performing the required R&D before construction of a spent fuel repository (1,2).

The research and development program of SKB is aiming at the following goals. In the early 1990s a few sites will be selected as candidate sites for the final repository for spent nuclear fuel and other longlived wastes. The detailed characterization of at least two candidate sites will start in the mid 1990s. Alternative designs of the repository barrier system will be studied and soon after the mid 1990s a specific design will be selected for optimization to the sites chosen for characterization. In parallel to these activities pertinent models for performance and safety assessment will be developed and improved. The models will be applied as required by the site and system selection process and for optimization. In order to achieve these goals the international cooperation efforts of SKB plays an important role. This paper is highlighting some of the international projects and activities which are of key importance for the safety and performance assessment developments.

INFORMATION EXCHANGE

Cooperation and exchange of information with organizations in foreign countries regarding nuclear waste management constitutes an important part of the overall research and development activities of SKB. The cooperation is made both on an international and bilateral basis. Presently SKB has formal bilateral information exchange agreements with the following organizations:

DoE	USA
JAECL	CANADA
NAGRA	SWITZERLAND
TVO, IVO	FINLAND
CEA	FRANCE
SCUAE	SOVIET UNION
EURATOM	CEC

Information exchange without formal agreements also occurs with organizations in the Federal Republic of Germany, Belgium, Great Britain, Japan and the nordic countries.

Exchange of uptodate information in the form of reports as well as through expert meetings on a bilateral basis are covered in the agreements. General reviews of existing waste programs occurs at intervals of about one and a half year. A considerable portion of the buildup of knowledge is associated with international or bilateral projects, which are conducted within the framework of the general agreements. Exchanges of personnel and direct project cooperation has turned out to be the most fruitful forms of information exchange.

RADIONUCLIDE TRANSPORT MODELLING

The safety assessment of a repository for spent nuclear fuel is based on extensive analyses and modelling of radionuclide transport. Modelling is made at several different levels eg:

a) Conceptual models. These descriptive models are based on field measurements and on the knowledge of the phenomena involved.
b) Detailed, research related mathematical models. These are models describing hydrology, geochemistry, rock mechanics, thermomechanical behavior and other coupled processes.
c) Mathematical models for radionuclide dispersal in the repository near field, the far field and the biosphere (assessment models).
d) Mathematical models for uncertainty and sensitivity analyses.

The mathematical description of transport in the geosphere including all relevant hydrologic and chemical processes would require rather complex models. One model alone can of course not perform this complicated task and different submodels in which appropriate

approximations and restrictions are made are therefore developed.

The models need data of both general and site specific nature and must also be verified and validated. In some cases it may be enough that they give bounding values. The development of verified and validated models and the compilation of relevant data for assessment of radionuclide transport is a very large effort. This is a task well suited for international cooperation. Examples of international projects in this field where SKB is actively participating are the following:

a) The collection and review of thermodynamic data for the OECD/NEA databank.
b) Transport of radionuclides by colloids, humic and fulvic acids work done in the CEC COCO Club.
c) Validation of codes used for the assessment of the release and transport of radionuclides
   the CEC CHEMVAL project
   the HYDROCOIN study
   the INTRAVAL study

The numerical modelling and validation studies of the Stripa Project phase 3

The OECD/NEA thermodynamic data bank will contain quality assured sets of selected thermodynamic data for the most important radionuclides that may occur in a HLW repository (3). Radionuclide speciation and solubilities calculated by different groups, with different geochemical computer codes and data , but for similar conditions, may now differ by orders of magnitude. The NEA effort to develop a reviewed, well documented and internationally accepted thermodynamic databank is therefore very important in order to arrive at a reliable and accepted dataset. During 1989 data for uranium are scheduled for publication in this databank, and during 1990 data for americium, technetium and neptunium should follow.

SKB supports this work. For the daily needs of geochemical and radionuclide chemistry calculations a database is used which is continuously updated with the progress of the NEA database.

The so called COCO club (Colloides and COmplexes) organized by EURATOM is working on transport of radionuclides by colloids, humic and fulvic acids. The aim is to produce basic data for such transport. Benchmark studies of various models are performed. The project also deals with analytical methods for determining colloids and organic complexes both quantitatively and qualitatively (4). SKB contributes to the work both by providing data from Swedish groundwaters and by analytical and modelling efforts.

The CHEMVAL project also organized by EURATOM is mainly aiming at verification and validation of aqueous speciation models (5). Another aim is to produce a comprehensive and consistent database for use with aqueous speciation and coupled chemical transport codes. Such codes are also reviewed by the project. SKB actively participates in the CHEMVAL project.

HYDROGEOLOGICAL MODELLING

In the HYDROCOIN project organized by the Swedish Nuclear Power Inspectorate SKI groundwater modelling strategies have been studied (6). Computer codes and their accuracy have been evaluated. The capability of the hydrological models have been tested in a set of cases, and uncertainty and sensitivity analyses have been performed. SKB analyzed several of the cases set up by HYDROCOIN.

The INTRAVAL project which also has been organized by SKI is a follow up of INTRACOIN and HYDROCOIN with the ultimate goal to validate computer programs for radionuclide transport via groundwater in various types of rock (7). Several of the test cases which are analyzed in INTRAVAL are based on experiments performed for SKB. These include studies made of a fracture zone at Finns as well as studies of natural analogues at Pocos de Caldas. SKB will also participate in the validation exercises.

In the Stripa Project phase 1 and 2 methods and technology for detailed investigation of the rock at a potential repository site have been developed as well as engineering solutions for sealing of boreholes etc. In the ongoing phase 3 of the Stripa Project the experience gained so far is applied to an undisturbed granitic rock volume (125m * 125m * 50m). The phase 3 is arranged in five stages so that data collection (Stages I and III) is followed by model prediction (Stages II and IV) in an interactive manner. The more detailed predictions of Stage IV are checked within a final period of data collection. This stage V also includes the excavation of a validation drift through the pre-investigated volume (8).

Predictions of ground water flow and tracer transport will be made by three different modelling groups. One group sponsored by the Stripa Project is the Harwell group in UK. They will apply a specially developed scholastic model for discrete fracture flow the NAPSAC code. The two other groups sponsored by the USDOE are from Lawrence Berkeley Laboratory and from Golder Ass. Co.

Another important part of phase 3 of the Stripa Project is aimed at sealing of rock fractures close to the waste positions and tunnels. Two types of grouts based on bentonite and cement respectively will be tested. Also in connection with these experiments some modelling efforts concerning near field phenomena will be tried.

In general terms, all the above mentioned modelling and validation efforts aim at the development of conceptual and mathematical models for the geohydrological and geochemical description of a potential repository site. Most of the projects are planned to be ended in the early 1990s. The results and experiences gained from the SKB program are now combined into the planning of the next major step the development of the Swedish Hard Rock Laboratory. The construction of this facility is planned for 1990 to 1993. A site for the facility has been selected on an island called sp close to CLAB (Central Storage for Spent Fuel) and the Oskarshamn nuclear power plant. The research program

for this project will include several experiments in order to verify and validate methods for prediction of ground water flow and geochemical transport similar to those conducted at Stripa but on a different scale. SKB would welcome international cooperation in this research on a similar basis as in previous projects.

NATURAL ANALOGUES

The longterm time perspective is an important aspect of the safety assessment for a radioactive waste repository. To verify the models used for prediction of longterm geochemical behavior of different components the studies of natural analogues are of special interest. Examples of such analogues are examined in the international Poos de Caldas project sponsored by organizations in Sweden, Switzerland, USA, UK and the host country Brazil. SKB is the managing participant in that project (9).

In the uranium mine (Osamu Utsumi) and the nearby unexploited thorium and rare-earth deposit (Morro do Ferro) the following investigations are made:

1) Determination of speciation and chemical transport of natural radionuclides and rare-earth metals in a fracture flow system in crystalline rock under both oxidizing and reducing conditions.
2) Measurements of the formation and mobility of colloid-borne radionuclides in natural groundwaters.
3) Study of the thermal influence on the transport of natural radionuclides and rare earth elements.

The results from the Poos de Caldas project will contribute to the validation of equilibrium models for water-mineral systems, increased understanding of dissolution and precipitation of uranium and rare earth elements at a redox front and increased understanding of transport of thorium and rare earths elements by colloids and organic complexes. Thorium and rare earth elements are used as chemical analogues for other actinides and fission products. Most of the analyses and field work has been completed during 1988 and the work in 1989 will be concentrated on interpretation and evaluation.

SCENARIO ANALYSIS

To ensure that all relevant cases are evaluated in a safety analysis, a proper method for analyzing scenarios has to be developed. SKB is participating in the work of OECD/NEA PAAG (Performance Assessment Advisory Group) to develop means and methods for performance and safety analyses of final disposal systems. SKB and SKI (Swedish Nuclear Power Inspectorate) are also conducting a joint study on scenario analysis focussing on the possibility to use a method developed by Sandia National Laboratory in USA (10). The work started in 1988 with a relatively large internationally composed group, which assembled an extensive list of features and events that might influence a final repository in the future. A working group is now writing definitions for each item on the list and sorting them into groups. For each item an attempt is made to define if the feature or event should belong to what is called a reference case i.e. a case that always not to be considered in model calculations. This work will be reported during the summer 1989.

PROBALISTIC SAFETY ASSESSMENT CODES

The uncertainty and sensitivity analyses part of a safety assessment can be considerably facilitated by using probalistic techniques. For this purpose SKB has developed the PROPER code package. It applies the same general idea as the Canadian SYVAC code. The PROPER Monitor links a number of submodels selected from a library and carries out an analysis on the desired system. Postprocessing codes treat the results statistically or graphically. The code package uses the Monte Carlo sampling method. To keep the calculation times at reasonable levels the submodels must not be too complicated. The present code version is mainly applicable to the disposal concept described in the KBS3 report (11) but can easily be adapted to other systems.

SKB takes part in the efforts of NEAs PSAC-group aiming at verification and inter-comparison of models like SYVAC or PROPER on an international basis (3).

INTEGRATED SAFETY ASSESSMENTS

The safety assessment of a final repository will be an integrated effort. Fig.1 tries to give a generalized scheme of the major components in this process.

Throughout the development of a repository system safety and performance evaluations will be done at several stages as has already been indicated in the introductory paragraphs. Such evaluations play a large role in assigning research priorities, in demonstrating feasibility of candidate sites and system designs, in licensing sites and finally in getting construction and operating licenses.

CONCLUSION

The examples above illustrate how international projects are integrated in the SKB research program and how the results are used in safety assessments. For acceptance of a repository licence application it is important that all applied scientific results have been scrutinized on a recognized international level. This is particularly so in a small country like Sweden where the scientific community in a particular subject may be very limited. SKB therefore puts a strong emphasize on developing its international network of contacts. The next important test on the progress of our ability to make a comprehensive safety assessment is now in the planning stage under the working name SKB91. This safety assessment is intended to support the site selection process and should be completed in 1991. The SKB91 study will for the first time try to apply many of the new methodologies developed since KBS3 in 1983, of which some have been touched upon in this paper.

REFERENCES

1.SKB R&D Program 86J Handling and final disposal of nuclear waste. Program for research development and other measures. SKB, September 1986
2.SKB Technical Report 8733. SKB Annual Report 1987 May 1988
3. Nuclear Waste Bulletin.J No 1 July 1987 "Update on waste management Policies and Programs"

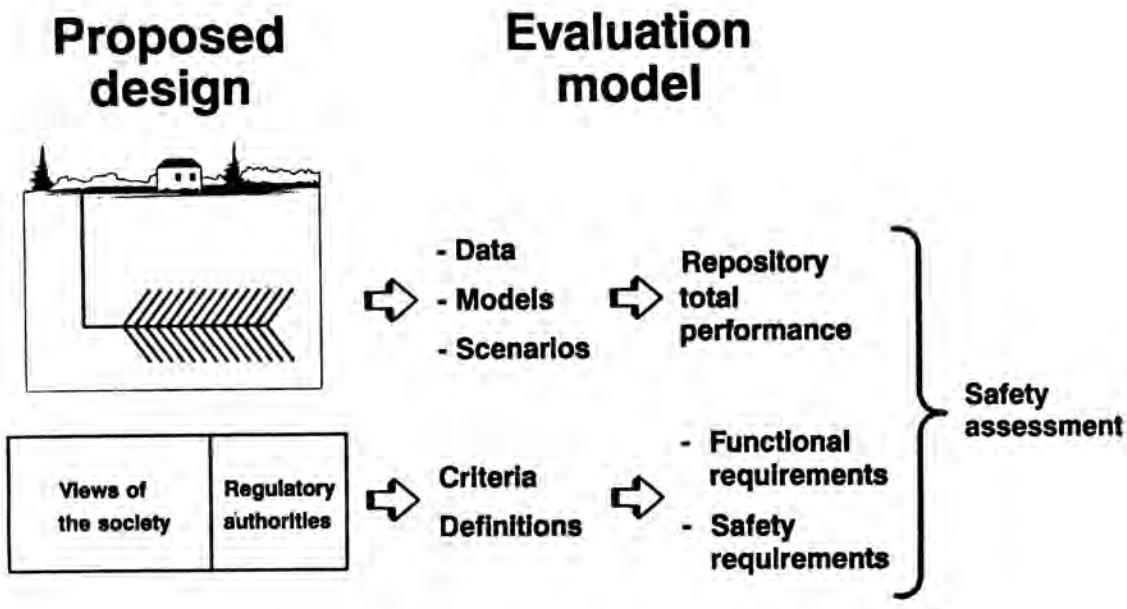

Fig. 1. General Scheme for Safety Assessment.

4.CEC Project Mirage Second Phase First Summary Progress Report (Work Period 19861987) EUR 11589
5.Project CHEMVAL Comparison of thermodynamic databases used in geochemical modelling DOE Report No: DOE/RW/88.074
6.The International HYDROCOIN Project Level 1: Code Verification OECD. 1988
7.INTRAVAL Progress Report October 1987 January 1988
8.Stripa Project Annual Report 1987 88 06 June 1988
9.Poos de Caldas Project Second Year Final Report June 1987 May 1988
10. Risk methodology for Geologic Disposal of Radioactive Waste: Scenario Selection Procedure R.M Cranwell, R.V. Guzowski, J.E. Campbell, N.R. Ortiz NUREG/CR1667, SAND801429, Draft1982
11.SKBF/KBS. Final Storage of Spent Nuclear Fuel KBS3Volumes IIVSKBF/KBS, May 1983