STARTING WITH BUILDING OF CONFIDENCE FOR LILW REPOSITORY IN SLOVENIA

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ABSTRACT

In nineties Slovenian Agency for Radwaste (ARAO) management has written in its strategy the intention to dispose off all of its LILW waste into Slovenian repository. Accordingly, an expert team was formed in 1997 to continuously follow all activities in this field by preparing successive PA/SA reports at each stage of the project life. The current stage is the PA report at generic stage, since the location of repository is not yet selected. Accordingly, a lot of work has been done on methodology of preparing such a document and on its main constraint: to build confidence into the work done. The team believes that this goal has been achieved by systematical application of the ISAM methodology into the PA procedure, strictly holding the developed QA procedures and standards, uncertainty treatment on the base of the "good science and engineering" and good communication activities with national and international technical audiences. Last, but certainly not least, other communication techniques and programs have been developed by ARAO in which the so called combined procedure in siting process through mediator is playing the key role in communication with local communities. Information and communication activities are spread over the whole Slovene population with the emphasis on two-way communication with all stakeholders. Special workshops and presentations are organized for special public groups, journalists and interested environmentalists. Research activities are set to obtain the understanding of public opinion regarding radioactive waste. It is hoped that also through building of confidence in technological projects the site will be selected by the year 2008 and that LILW repository will be constructed by the end of 2010.

INTRODUCTION

In accordance with the strategy for Slovenian management of low and intermediate level radioactive waste, the Slovenian Agency for Radwaste management formed in 1997 a PA/SA team. This expert team from different Slovenian organizations (ARAO, National Slovenian Civil Engineering Institute – ZAG, Geological Survey of Slovenia and Polytechnic Nova Gorica) has prepared several basic studies based on experiences gained in the international project ISAM led by IAEA since 1997. At the beginning the efforts have been directed towards framing the objectives of the performance and safety assessment (PA/SA) procedure: the assessment context, the input parameters for the assessment and the time frames for the assessment. These studies were followed by research of radionuclide influence on the different materials, which compose waste-form, and migration processes through engineered barriers and geological surroundings, together with their time dependence.

Within the time the teamwork became more and more complex. Starting with generic location and performing some radionuclide transport calculations through the repository nearfield, the geosphere and the biosphere, the team went through calculating exercises. At later stages, the calculations became more comprehensive, and the quality assurance program was developed to assure the transparency and repeatability of the process. Reports became more systematic and elaborated in more detail, including assessment context, disposal system description, scenario development, model development, calculations,

sensitivity analysis and the quality assurance program. Within the last stage, a real site in Slovenia was taken as performance assessment case, though the site selection process has not yet been finished. All inputs were taken from bibliographical data. The PA study has been made for two repository types: for the surface and for the near surface facility, up to 70 m beneath the surface. Results showed a good compliance with the regulatory constraints and with international ICRP recommendations.

CURRENT STATUS ON THE SAFETY ASSESSMENT ACTIVITIES

The work on the performance assessment for LILW repository safety case followed the methodology proposed by the ISAM program, which is shown in Figure 1. All key elements of the PA/SA model (assessment context, disposal system with radioactive waste identification, scenarios generation, conceptual and mathematical models identification) were defined having in mind the purpose of the assessment which has been limited to the site/disposal concept selection phase, and restrictions resulting from that stage. The characteristics for individual disposal system were taken from the earlier prepared basic conceptual designs for both, a surface and an underground repository.

The safety case has been assessed in compliance with the international praxis. A systematic, generic list of all possible features, events and processes predictable for surface or underground LILW disposal in Slovenia was prepared. Using the experience from the IAEA international ISAM project, the possible FEPs have been screened in a well documented and transparent way, and finally the FEPs which could significantly influence the performance or the safety of the proposed disposal system have been selected.
Apart from the normal evolution scenario, four alternative evolution scenarios and related conceptual models have been built for the surface and three for the underground repository. They were related to the engineered barrier system degradation, gas migration and human intrusion into repository with its consequences on intruder and on the member of critical population.

The different scenarios have further been developed by modeling and consequences analyzed by transport calculation.

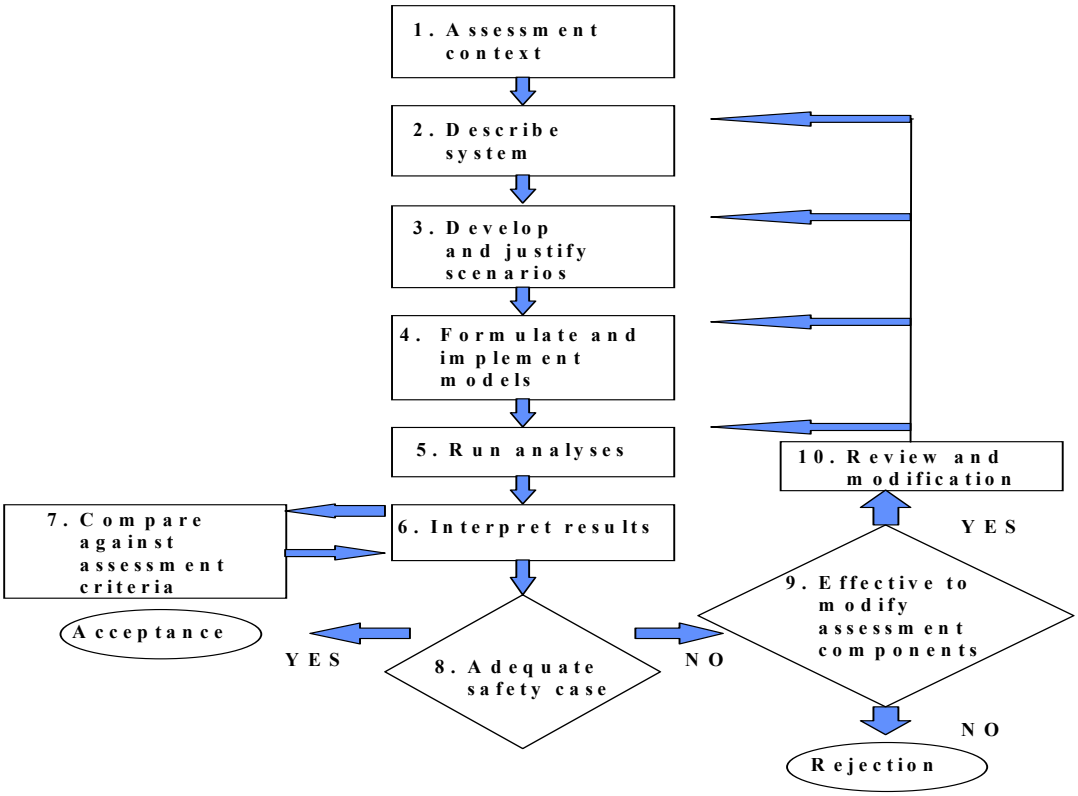

Fig. 1 The PA/SA approach in compliance with the ISAM practice

Modeling and calculation of the whole disposal system, together with its environment, has been divided into three subsystems:

1. The near field, or the repository itself with its engineered barriers,

2. The far field or geosphere; the hydraulic and geochemical conditions of the natural barriers define migration of the radioisotopes, and

3. For the biosphere - where all different pathways from the groundwater to human population (water pumping, crops irrigation, animal and fish consumption) were taken into consideration.

Deterministic calculations of radionuclide transport have been performed by means of selected and powerful computer codes:

- For the near field calculations the PORFLOW [9] and HYDRUS 1D and 2D codes were used, giving the flow paths and the transport time as well as the radionuclide concentrations leaving the near field,

- For the geosphere calculations, the GMS computer code [10] was applied, first for the hydraulic field calculations and later on for particle tracking and transport calculations for the radionuclides entering the geosphere through the near field;

- For the biosphere calculations, the AMBER code [11] helped the team to evaluate the different paths of radionuclides through the biosphere. The starting point for these calculations was the

surface water or the ground water (well scenario) radionuclide concentrations, and the ending point was the dose to a member of the critical group. In addition, some parallel calculations with three different computer codes were done and results compared showed on a good agreement.

The input parameters for calculation were chosen on the basis of data from literature, since no site investigation has been realized; the material properties which were not yet available, have been subjected to expert judgment.

The results for both generic cases (surface and underground type of LILW repository) under normal and most of the altered evolution scenarios showed that there was a negligible dose influence on members of the critical population due to the migration of radionuclides from the LILW repository.

The sensitivity and uncertainty calculations undertaken have rather been sporadic at this step and will further be used more systematically within the next steps of the PA procedure.

By IAEA expert's opinion, the team has made a substantial progress within the last few years. By our belief, the main reasons for the progress of Slovenian performance assessment program are:

- The very active participation of the Slovenian representatives in the IAEA ISAM program,
- ARAO's strong decision to develop the expertise in PA/SA,
- A very productive co-operation with the Belgian research institute SCK-CEN and
- The IAEA financial and technical support to the Slovene PA/SA team.

CONFIDENCE BUILDING IN PA ACTIVITIES

As part of the PA/SA, and the site selection process, ARAO carries out different communication and information activities, to enhance confidence and improve the acceptability of near surface LILW repository among the general public, local communities, public opinion makers and decision makers.

According to the ISAM methodology there are at least 4 major topics which are associated with confidence building in PA activities: confidence in the performance/safety assessment, quality assurance for performance/safety assessment, sensitivity and uncertainty analysis and communication activities to support the development of the safety case. All these topics are correlated and must assure that performance or safety assessment for certain safety case is transparent, repeatable, documented and is communicating to different stakeholder at the level that is appropriate for each individual group of audiences. Slovenian PA approach has developed special program for all topics, with more or less details, which depend mainly on the level of current safety case.

Confidence in PA/SA

The main objective of building confidence in PA/SA is to establish confidence in the long-term safety radioactive waste disposal facilities and to effectively communicate such confidence through development of a safety case. All involved stakeholders should, according to establishing confidence, understand the philosophy, the approach and the general principles associated with the development of the safety case and gaining and demonstrating confidence in overall safety of waste disposal facilities.
Confidence in safety assessment should be established in two levels. The first level involves establishing confidence within each stage of the safety assessment process (internal confidence). The second level

involves gaining an overall confidence, which involves gaining confidence in the overall safety assessment methodology, safety assessment approach and the safety assessment findings.

Confidence building in the safety assessment is a process that needs to be addressed through all stages of the safety assessment, which is clearly defined within the assessment context, in the way of good science and engineering.

According to BNFL definition of the terms 'good science and engineering' contains the following various elements and their combination:

1. All relevant FEP's systematically identified and assessed
2. All relevant assumptions and simplifications in the safety case, modeling and data identified, justified and supported by appropriate references
3. All relevant uncertainties identified and assessed
4. An appropriate quality assurance system governing all aspects of the assessment
5. Documentation of peer reviews with all peer reviewers addressed
6. Publication in the open scientific literature
7. Awareness of similar radioactive waste disposal research programs/safety cases from other countries
8. Awareness of and involvement in international collaborative programs
9. Awareness of speculative or innovation developments in science which may be included in future iterations of the assessment.

Slovenian team responded to these assignments in our safety case in the following way:
Request under point 1 was fulfilled within description of reasons for the screening of FEPs within scenario generation procedure.

Point 2: All relevant assumptions and decisions at this generic stage of the PA/SA we have taken after consultancy with the relevant foreign or Slovenian experts. Simplifications have been used only in the case that calculations and comparison of results showed that they gave more conservative solutions. All data were collected on the base of the Data work instructions for data collection forms**.** All computer codes have been verified and validated. According to the stage of the performance assessment and its assessment context, there is yet no data available from the site investigation or its characterization.

Point 3: All relevant uncertainties have been identified through the process. Their treatment is described in one of the following chapters.

Point 4: The projects' quality assurance program was led in conformity with main contractor Quality Assurance Program (ISO/IEC 17025) [12], which has been overviewed by the QA administrator from the ARAO and enriched by the elements of Belgian (SCK/CEN) Quality Assurance system. The work instructions for data transmition between partners were followed**.** Testing, verification and archival instructions were included into the Quality manual.

Point 5: Peer reviews of our studies have been made on national and international level.

Point 6: Until now, we have not accomplished any scientific work on data from the site, since the site has not yet been selected, thus we have not published any scientific literature on work done.

Point 7: The team is aware of similar running safety cases in Belgium, Swiss, Romania, Czech Republic as well as it is in current with solutions used in France and Spain. First through the ISAM and lately through the ASAM - IAEA coordinated projects, the team got contacts with other foreign experience and guidelines for its further PA work.

Point 8 and 9: The team leader and one of co-workers from the contractor side of the assessment team were taking part in an International EU project (FW5: Bentonite barriers in integrated performance assessment – BENIPA project [13]) and are applying the methodology and some relevant results into our safety case. The team is collecting experience and literature from similar PA cases all over the world, which can be proven by cited bibliography.

QA Program

Today, the PA/SA project combines four different parties, under the guidance of ARAO agency. The main contractor, ZAG, Slovenian National Building and Civil Engineering Institute, which is also the main performer of the PA/SA report, has developed his own QA standards, in accordance with ARAO requests. The other two contractors, Polytechnics University and Geological survey of Slovenia, are bound into the main contractor QA program. All activities in PA are properly planned, data and methods are properly documented and an auditable trail has been developed.

The PA/SA team also emphasis the importance of use of Quality assurance procedures as an aid to generating confidence in the assessment tools and data. At the present stage of performance assessment the team was trying to achieve goal of traceability of input parameters, methods and assumptions by attentive description and clear documentation of the sources and methods used.

For this reason, several working procedures and instructions have been prepared that include:

- Parameter Data collection forms with instructions on all relevant parameters which are used in PA/SA calculations,
- Relation Parameter Data Base as a special tool for handling the parameters in near field, far field and biosphere,
- Special instruction for input and output files coordination due to the special organization of Slovenian PA team,
- Procedures for verification, validation and documentation of all computer codes used in PA calculations.

Uncertainty Treatment

Uncertainty is one of the key problems in performance and safety assessment of nuclear structures at all stages of their life, therefore approaches to managing uncertainties are well developed in safety assessment methods.

Uncertainties are categorized into four main groups such as **Future (scenario) uncertainty**, which addresses incomplete knowledge of the future behavior of people or evolution of the disposal system, **Model uncertainty,** which arises from incomplete knowledge/ability to represent the FEP's relating the limits, controls or criteria to safety standards, **Data/parameter uncertainty**, which arises from lack of data, inadequate measurements or human errors and last **Subjective uncertainty**, which is usually incomplete knowledge of the expert judgment.
The management of uncertainties can be considered to have four elements such as **Awareness, Importance, Reduction** and **Quantification.**

Scenario uncertainty we addressed by developing alternative evolution scenarios.
Model uncertainty was addressed at different levels, by calculating:

- Conceptual model: 2 alternative cap types, 2 different backfills, varying thickness of the unsaturated zone, 2 different locations for the underground repository several different pathways through the geosphere

- Mathematical model: sensitivity analysis was made on: grid density for the near-field and geosphere calculations, constant versus time dependent flux from the repository as input for the geosphere calculations, 2D to 1D transport calculations through the near field, calculations of the numerical dispersion versus physical dispersion in the geosphere model, calculations of radionuclide concentrations, taking into account of the decay and without it.

- Computer code: numerical dispersion for the geosphere, parallel computations with different computer codes: HYDRUS / PORFLOW, AMBER / RESRAD / BIOPHARE; also: code verification and code references for all computer codes used is supplied. For the GMS: comparison between computed results, analytical solutions and experimental data was made (for slug injection test).

To overcome the **Parameter uncertainty**, we generated a calibrated flow field model of the Krško plain, which required a lot of variation of different input parameters and boundary conditions to match the model with in-situ measured values. Also: Calibration of the near-field model from 2D to 1D has been done. In addition: variation of precipitation in the near-field modeling and variation of the hydraulic conductivity in the near-field modeling was performed within this frame.

Subjective uncertainty was addressed through the confrontation of different expert judgments (Belgian, IAEA, Slovene experts). Two independent revisions of our report were made (temporary and final reports), and the application of the QA procedure into the performance assessment to ensure transparency, repeatability and sufficient documentation of subjective judgments.

Communication activities in PA/SA

Regarding confidence building to different stakeholders, ARAO has also been developing different programs for different stakeholders such as competent authorities – regulatory bodies, technical, expert public, governmental organizations, local communities, general public, media - journalists and non-governmental organizations.

At this stage of PA progress the main activities of communication programme are focused into demonstration of proper methodology of PA/SA activities to regulatory bodies, to different experts and competent authorities. Therefore, several workshops have been organized in which the methodology of PA for LILW repository was described and the results were analyzed. Each year PA team presents the achieved work in papers which are than submitted to the national and international conferences, where the

technical public is informed about the PA/SA project and different opinions and experiences are exchanged. In this way the PA approach, the results as well as perceived difficulties are discussed among expert public.

All PA reports are available also in libraries and could be delivered on request of the interest party. The approach to the performance and safety assessment for LILW repository is included in general presentations of Slovenian work regarding site selection in different workshops for local communities representatives, ARAO's newspaper, annual reports and brochures. Those are than distributed to libraries, parliament, journalists, local communities and special public groups such as NGO's.

Recently, in October 2003, a 3-day national seminar on development of PA for future LILW repository has been held for different Slovenian stakeholders (competent regulatory bodies, involved authorized institutions, NPP representatives, participants from different Slovenian enterprises, international experts, IAEA representatives,…) in which approach, methodology and results have been discussed and distributed among participants. A special issue of ARAO's newspaper RAOPIS which is under preparation will be dedicated to safety assessment and to the results of the work performed by PA team. Each issue of the newspaper is broadly distributed to all libraries, schools, parliament, local communities, and to special publics (NGO's, experts, media,..).

OTHER COMMUNICATION PROGRAMS

ARAO is aware that good communication is necessary in any siting and licensing of risky facilities such as a repository for radioactive waste for all stakeholders. It was decided to implement the so-called combined procedure in siting process, taking into account the environmental and technical conditions as well as the public opinion and social acceptability. Communication with the public as early as possible is very important, especially with the local community on the potential sites for the repository. If strong rejection occurred very early in the process it would be most impossible to continue the communication. ARAO supports and produces continuing source of information in order to increase the general functional knowledge and understanding of phenomena related to the radiation and nuclear technology. The final objective of these activities is to alleviate the potential conflicts between the public and the governmental interests in the field of radioactive waste management.

Because of the considerably small area of the country and very scattered population, and because of the opinion that radioactive waste represents a great risk and danger, Slovenian citizens feel they should have the opportunity to express their opinion about the location for the radioactive waste repository (Figure 2). The information and communication activities are therefore not focused on a specific local community, geographical area or social group, but rather on the whole population, using a variety of media.

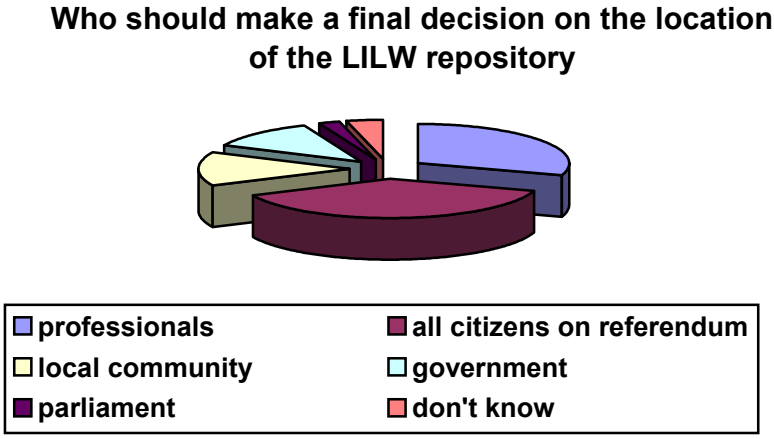

Fig. 2 Public opinion poll in Slovenia showed that people mostly think that the public acceptability of the radioactive waste repository is very important.

The most important stakeholders regarding construction of LILW repository are competent local authorities, technical public, ministries and government of Slovenia and general public. ARAO is developing different approaches and communications activities for all involved stakeholders. Basically ARAO communication channels address all groups of stakeholders. Communication strategies that provide two-way communication are preferred, but also educational materials that mainly provide information in one direction are also applied. Educational publications prepared for the secondary school population, which are distributed free of charge, are also well accepted by the adults who wish to learn more about radioactivity and radioactive waste management and disposal. ARAO web pages are an important source of information including the possibility to communicate to ARAO personnel by the e-mail service.

Some of the communication activities are concentrated in the localities having the natural potential for hosting a repository or are already hosting the nuclear facility. Supporting the local newspaper together with preparing articles on the radioactive waste management issues is an additional ARAO activity focused mainly on adult population. ARAO also supports study circles engaged in radioactivity studies and discussion. Special workshops and presentations are organized for local leadership, journalists and interested environmentalists. Due to better and more direct communication between ARAO and local communities in the present site selection process, the mediator was selected for this job. Mediator represents connection between public interests in local environmental protection and the governmental interests to safely dispose of the radioactive waste. The mediator is continuing to inform the local communities and to discuss all the conflict issues with the stakeholders on both sides.

One of the target populations is teen-age pupils from elementary and secondary school. With the objective to increase the knowledge and hence the rational component of decision making, ARAO publishes information materials that can be used as additional learning sources in the educational process, mainly in science classes. Leaflets, posters, CD-ROM, books, the yearly magazine and videotapes on radioactive waste management and general issues on radiation are available on request to individuals. One issue of each publication is sent free of charge to all primary and secondary schools and to public libraries. The educational material is also presented at the conference of Slovenian science teachers. The publications are also available in the Visitors' Center, which was established to disseminate information on nuclear technology including radioactive waste management.

ARAO, with cooperation with Philosophical Faculty and Social Sciences Faculty at the University of Ljubljana, is also involved in research activities, mostly with general public. The research activities are set to obtain public opinion about rad-waste, future repository and after all general knowledge of the public about radiation and waste. A special mental model approach is used with the objective to understand the perception of the public, it believes and concerns and to improve communication activities which should be adopt to the public need.

THE WAY FORWARD

ARAO is constantly looking to improve its methods of work, QA standards and meet international standards and requirements. ARAO has been also developing for several years (2001-2004) performance assessment activities for LILW repository through the technical cooperation with IAEA. Performance assessment for Slovenian LILW repository for generic site will be done with international assistance, which is implemented by high technical standards, particularly on the field of design development, inventory description, generic characterization of the site, optimization of engineered barriers and safety assessment process.

Future work will focus on two main activities. First, a more detailed performance assessment will be made for our disposal concept, taking into consideration more details on waste stream, waste packaging and other engineered barriers in saturated and unsaturated conditions. As long as the location of the future repository remains unknown, the systematic sensitivity analyses with variations of each parameter will be performed in order to evaluate the importance of different factors and parameters. The work in 2004 will proceed towards evaluation of the non-radiological influence of the repository. As part of the iterative process of PA calculation it is also planned to derive the waste acceptance criteria for future LILW repository.

Secondly, the methods for building confidence among all interested parties will further be explored and developed. It is important that all procedures, methods, partial and final results are carefully and systematically documented, providing the traceability and possibility of independent verification by repeating the whole procedure.

ARAO will also after the period of present IAEA technical cooperation continue with development of activities in the field of performance assessment and safety assessment. The emphasis in the year 2005-2006 should be run in parallel with the site selection and will focus on:

- Performance of the PA/SA to judge the suitability of different selected sites and/or disposal concepts,
- Development of the site specific performance assessment for LILW repository,
- Development of site specific field investigation programme,
- Preparation of safety analyses report, covering both operational and post closure safety aspect of future repository,
- Development of non radiological safety assessment in order to prepare Environmental Impact Report as part of the EIA process.

Other communication activities to enhance public participation and their involvement in the site selection process as well in even more technical issues such as performance and safety assessment will represent

crucial precondition in gaining public acceptance to build LILW repository. Therefore ARAO will continue to develop new approaches and tools to enhance confidence among the general public, local communities and other stakeholders in Slovenia in the near future. It is hoped that the site will be selected by the year 2008 and that LILW repository will be constructed by the end of 2010.

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