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Preparing for Construction and Operation of Geological Repositories – Challenges to the Regulator and the Implementer

Proceedings of the
Joint RF/IGSC Workshop
Issy-les-Moulineaux, France
25-27 January 2012

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Radioactive Waste Management Committee

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NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Foreword

More radioactive waste management programmes are advancing to a new repository development phase and are preparing for the application of their construction license of a deep geological disposal facility. Such developmental progress brought along significant changes to repository development affecting both the waste management programme implementers and the regulators. New issues impacting both the regulatory authorities and the future facility operators include operational safety and reliability, increased demands on human resources, activities to ensure quality assurance, the additional requirements on information management system and management plans for construction work.

To respond to new arising issues, the Radioactive Waste Management Committee (RWMC) of the OECD Nuclear Energy Agency (NEA) has agreed, as stated in the 2011-2016 Strategic Plan, that the Committee will focus on constituencies for the preparation of the construction and operation license of future deep geological repositories. In addition, the Committee will consider operational aspects of repository implementation, both connected to the operational safety and the impact on the post-closure long-term safety. In particular, the RWMC has approved the RWMC Regulator's Forum (RWMC-RF) and the Integration Group for the Safety Case (IGSC) to hold a joint workshop to explore challenging issues and practices in preparing for the application of the construction license of a geological repository.

The joint workshop titled "Preparing for Construction and Operation of Geological Repositories – Challenges to the Regulator and the Implementer" was held on January 25-27, 2012 at the NEA premises in Issy-les-Moulineaux, France. The key objective of the workshop was to identify, and exchange experience on, the current and future challenges faced by the implementers and the regulators when preparing for their application of a construction license of a geological repository.

The workshop gave a diverse reflection of the various developmental levels of the different geological disposal programmes, ranging from general information on organisations and their licensing regimes, to specific information on technical, regulatory, managerial, administrative and procedural issues.

This document synthesizes the workshop presentations and discussion findings of the round table sessions.

Acknowledgments

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The NEA also would like to thank the speakers for their informative and stimulating, presentations, as well as all participants for their valuable inputs and contributions.

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Introduction

The workshop "Preparing for Construction and Operation of Geological Repositories – Challenges to the Regulator and the Implementer" was opened by Mr. Uichiro Yoshimura, Deputy Director General for Safety and Regulation of the NEA. Mr. Yoshimura welcomed the participants and noted the importance of the topic of this workshop. This joint workshop, organised by the RWMC Regulator's Forum (RWMC-RF) and the Integration Group for the Safety Case (IGSC), was attended by a balanced mix of implementers and regulators from 14 countries and international organisations (e.g. IAEA, EU). The objectives and the structure of the workshop were then explained by Mr. Georg Arens, the RF Chair.

Following the introductory session (Session 1), implementers and regulators from various national programmes (e.g. Finland, Sweden, Canada, Switzerland, etc.) presented their experiences and viewpoints on issues related to construction and operation of geological disposal facilities in Session 2. Session 3 of the workshop focused on industrial feasibility of construction in which key safety issues that must be addressed were presented and discussed. Session 4 continued to explore the issue of industrial feasibility but with the focus switched to the operation of geological repositories. Main operational issues and how to address accidents and disturbances in the design of the various disposal systems were presented. The impact of retrievability on the design and operation of a repository was also examined. The last session of the workshop, Session 5, evaluated various licensing aspects during repository development. Specifically, this session looked into how a licensing process affects the implementation of a repository and also the effect of optimization on late design modifications. To engage participants in more in-depth discussions on the presented topics and also to encourage professional exchange, 3 round table discussions were carried out in Sessions 3-5, to discuss the targeted questions. Results of the group discussions were reported by the rapporteurs.

A synthesis of all presentations and conclusions of each session is provided in this document.

Main findings

1. *Licensing regimes*

Licensing regimes vary from country to country. When the license regime involves several regulators and several licenses, this may lead to complex situations. Identifying a leading organisation in charge of overall coordination including preparation of the licensing decision is a useful practice. Also, if a stepwise licensing process is implemented, it is important to fix in legislation decisions and/or time points and to identify the relevant actors.

It was recognized during the workshop that the number and level of licences to be granted vary among countries. Depending on the national legislation, a licensing process implies to deal with one license combined with several regulatory permissions to a number of licenses, all of them taken at the highest level. It may be granted by different regulators and require the production of a large number of supporting documents. In particular it was stressed that mining regulations are often not applicable and specific regulations for underground activities involving nuclear operations may have to be elaborated.

The licensing process may be quite complex. A typical example was given by Sweden where the license application is addressed by two different legislative acts: the Environmental Code and the Nuclear Activities Act. The license application is thus being reviewed in parallel by two regulators: the Environmental Court and the Swedish Radiation and Safety Authority (SSM). Municipalities are involved as well since they have right of veto and should give statements to the Government on the project. At the same time both regulators will define conditions associated to the permits. On the basis of these statements and statements by the regulators, the final licensing authority, i.e. the Government, will make a decision. A similar kind of licensing process is foreseen in the United Kingdom.

In Finland and France, the Parliament is strongly involved in the licensing process. In Finland, a Decision in Principle had to be rendered by Parliament in 2000 before the construction of Onkalo. The construction license of the repository facility will be granted by the Government. The actual construction will be regulated by STUK, the nuclear regulator. It will include several reviews and approval steps, holdpoints and viewpoints. In France, the submission by ANDRA of the license application for construction will be followed by a review led by the nuclear regulator, ASN. On this basis, the Government will present a bill in Parliament in order to define the conditions of reversibility for the repository. The creation decree will be signed by the Government. It will include licensing conditions defined by ASN.

Lessons learned, with respect to licensing regimes, from the discussions at the round tables include:

(i) when several regulators are involved in assessing an application, there is a need that the law or a governmental decree designates a lead regulator. In many cases, it was noticed that the nuclear regulator is the leading regulator. An example was given by the United Kingdom where ONR will be the licensing body even though the Environmental Agency will play a major role in reviewing the assessment of post-closure safety.

(ii) when preparing for a licence application it is important that the licensee identifies all the necessary permits early in the process. Overlapping and/or conflicting requirements and relationships as specified in different permits must be clarified. In this respect it is important that one organization be in charge of overall coordination including preparation of the licensing decision. Many programmes have agreed that the final decision on licensing conditions lies with the leading regulator who should make sure that there are no conflicting or irreconcilable regimes. Possibly due to time constraints this difficulty was not highlighted in presentations during the workshop.

(iii) in countries that have adopted a stepwise process for implementing geological repositories, it is agreed that decision and timeframe to progress to the next step shall be indicated in the legislation. If time takes precedence over everything else, this may have implication on the quality of the project. Conversely, if there are no deadlines and/or stated requirements for the decision cannot be met in a reasonable period, local communities and the stakeholders may lose confidence and knowledge, both may have detrimental effects on the project.

It was made clear, during the workshop, that depending on whether the licensing authority is the main regulator or the government/parliament, the situation can be very different. When the licensing authority is also the main regulator (USA, Canada, UK) the project is less sensitive to the political situation (the fate of the Yucca Mountain Project is an exception in this respect). However there can still be possible conflict between the regulator and local government, which could imply judicial actions as it was the case for WIPP in the USA. Complex situations may also arise in the case of multiple licensing authorities, and they have risen in the past in the UK. When the Government is the final licensing authority, which is the case in most European countries (Sweden, Finland, France, Germany), the Government has responsibility in coordinating the procedure for granting the necessary permits.

The different roles devoted to the regulator(s) consist of:

- defining technical regulation, developing guidance,
- reviewing the license application,
- sending statements to the Government and setting up the licensing conditions and hold points,
- inspecting and reviewing construction, operation and closure,
- making decisions at the different hold points and, in some cases, submitting those too to government,
- providing information to political authorities and the public.

2. Challenges for construction (implementer)

There is considerable experience in civil and mining engineering that can be applied when constructing a deep geological disposal facility. Specific challenges are, however, the minimization of disturbances to the host rock and the understanding of its long-term behavior. Construction activities may affect the geohydraulic and geochemical properties of the various system components which are important safety features of the repository system. Clearly defined technical specifications and an effective quality management plan are important in ensuring successful repository implementation which is consistent with safety requirements. Monitoring plan should also be defined in advance.

There is a general agreement that, in the license application for constructing a repository, the implementer should demonstrate the industrial feasibility of construction. The safety case presented by the implementer before the construction of the facility should show that all subsequent activities that may be carried out, will not compromise safety.

It was recognized that there is significant experience in the construction of railway and motorway tunnels. Much experience, more than one hundred years, in the construction of large underground cavities also exists as well as experience in building underground laboratories for RD&D research in waste disposal. The implementer should utilize and apply the relevant information to the construction of deep geological repositories (DGRs). Specific challenges for DGRs are the minimization of disturbances to the host rock and the behavior in the long term.

During the workshop the conditions for preparing the application for the construction phase were discussed. It was acknowledged that before construction begins the implementer should substantiate an adequate level of site characterization and make sure that construction plans take the findings of site characterization into account. On this basis, the implementer adapts the conceptual design to the site properties, specifies and substantiates the reference design of the disposal facility, sets out detailed techniques for excavation and construction.

Site characterization may be performed in several ways. It may be performed in an independent underground laboratory in the same host rock formation as the one planned for the disposal facility but in a different location (e.g. Bure underground laboratory in France) or a characterization facility constructed after the access to the final disposal facility is excavated (e.g. a specific URL such as the Onkalo facility in Finland). In the later case the construction work of the access pathway to the facility should comply with nuclear and environmental regulations.

There was consensus among participants that the safety case, to support the implementer's application to construct the facility, should cover all subsequent activities, including later operation, closure and post-closure of the facility. The implementer also selects the main options for the operational phase and develops technical proposals for the closure of the facility. The demonstration of feasibility implies that a credible solution should exist in principle for all steps in the project even if this initial solution is not the final one. This means that sufficient flexibility should be maintained when granting a license to accommodate possible future developments and needs.

Identification of construction factors that may disturb safety functions and compromise long term safety is of major importance. It was recognized that construction affects site characteristics and that the implementer has to set requirements on construction work. In general, the most important features for safety that could be either created or influenced by construction activities are related to geohydraulic or geochemical disturbances. The focus of monitoring should be placed on these features. Geohydraulic changes are brought about by the inflow of groundwater to the open tunnels and shafts, and especially so in crystalline rock; boreholes drilled from the facility or in its neighborhood could add to these effects. The effect of main stress directions in hard rock is important to consider. The hydraulic changes could entail geochemical effects, but further geochemical effects could also be caused by the man-made materials used in the construction, e.g., grouting or tunnel lining, and investigations activities. There should be limitation on materials that might induce unwanted chemical interactions. A special type of disturbance to the host rock is the excavation damage zone (EDZ) created around the tunnels and shafts.

These constraints should lead the implementer to demonstrate that they are able to ensure that the engineered components will be built according to nuclear specifications at an industrial level and in a way that the characteristics of the host rock important for long-term safety will not be compromised by construction activities. It is therefore important to establish criteria and specifications – e.g., through safety function indicators – and define QA rules so that it can be judged if the «product» meets the requirements.

3. Challenges for construction (regulator)

The regulatory organization should prepare itself to the licensing review before construction by allocating sufficient resources. It should increase its competence, e.g., by interacting early with the implementer and through its own R&D. This will allow the regulator to define appropriate technical conditions associated to the construction license and to elaborate a relevant inspection plan of the construction work.

It was agreed in the workshop that regulators should increase their experience through dialogue with implementers, particularly early in the process but avoiding co-conception. Examples were given from France and Sweden. In France a stepwise approach was set up by the 1991 Act. The application decrees leading to the construction of the Bure underground laboratory and the subsequent 2006 Act defined the steps toward the application for construction in 2015. This shows a good example of a stepwise process. Another example is the review of the RD&D programs of SKB by the regulator every third year in Sweden. R&D requirements to the implementer should be substantiated by experience from regulatory R&D.

The regulatory organization should prepare itself for the licensing review. This point was detailed by the USNRC when describing the organization for reviewing the Yucca Mountain Project. It was pointed that the review was planned to last three years, including hearings, examination of 3 million pages and 299 contentions. It needed the elaboration of a detailed project plan and allocation of adequate resources, including the creation of a safety integration review team with work break-down structure and experienced staff who are familiar with legal terminology.

It was also agreed that as part of the authorization process, regulators should impose conditions and requirements on the implementers to ensure regulatory compliance during the construction phase. These conditions may specify:

- hold points in the construction for regulatory involvement or interaction,
- requirements for documentation and substantiation to be provided to the regulator before authorization to operate the facility,
- if not already established in the regulatory framework, definition, in discussion with stakeholders, the detailed procedures and expected conditions for delivering the authorization for closure of the disposal.

As detailed in the Finnish presentations, the regulator requires from the implementer : the description of constructing organization, staff competences, the regulations, codes and standards to be used in the construction, the management system (especially safety and quality management), design data, drawings, construction documentation, in-service inspection plan, etc.

Regulators should also outline their expectations. The long-term safety related rules and instructions on the design and construction should be put in place before construction begins. This requires all systems, structures, components and activities to be clearly classified, based on their safety functions, and the implementation of a quality management system for resource controls.

Regulators' inspection activities shall cover all areas of the regulator's responsibilities. Inspections shall be carried out to ensure that the implementers' full compliance with regulations, and conditions as stated in all approvals granted by the regulator. In Finland, during the construction of Onkalo, inspection activities have been divided into three areas:

- Construction Inspection Program (CIP) on management system, on main operations and concerning functions and activities ;
- Inspections concerning the readiness to begin excavation and other work phases ; and

- Inspection concerning construction works on site (once every two weeks).

4. *Challenges for operation (implementer and regulator)*

After construction, obtaining the operational license is the most important and crucial step. Main challenges include (a) establishing sufficient confidence so that the methods for closing the individual disposal units comply with the safety objectives and (b) addressing the issue of ageing of materials during a 50-100 years operational period. This latter challenge is amplified when reversibility/retrievability is required. Managing concomitant construction of new galleries with continuing operation and/or closure in the existing galleries remains as another challenge.

General context

The implementer will typically submit an application for licensing the operation of the underground and surface facilities under the nuclear safety regime, after construction of the surface facilities, excavation of ramp and/or sinking of shafts to access the repository level and the excavation, construction and equipping the first fraction of disposal modules. Since entering the nuclear regime is not easily reversible, the workshop identified the operational license as the most important and crucial step in a project and both the implementer and the regulator should make adequate preparations for it ahead of time. Subject to regulatory approval, construction of extensions to the disposal facility may continue after the operational licence has been granted.

The regulatory process shall lead to the commissioning of the disposal facility, so that waste emplacement in the facility can begin, and shall include a formal review of the updated safety case. At this stage the safety case should be at its broadest and should demonstrate that there is a high degree of confidence in the feasibility of the project and that the facility, once constructed and operated in accordance with the approved plans, will meet the safety requirements during both the operational period and the period after closure.

The workshop suggested that the major technical challenge to be faced by the implementer in advance of the operational licensing process is to create sufficient confidence in the technical feasibility of the methods for closing the individual disposal units and in their compliance with the safety objectives. Demonstrations tests will be needed to that effect. Another challenge is the ageing of materials during a 50-100 years operational period. This challenge is amplified when reservability/retrievability requirements have to be taken into account. Another important issue that the implementer and the regulator are to address in the safety case and in the license conditions is the concomitant operation of the underground facility and construction of new parts, the periodic re-certification and permit renewal, and the mechanisms to allow for changes in the design and in the operating procedures.

Preparation for the operational license

The implementer prepares early for the operational licence and interacts with the regulator on this subject. This is usually done through elaborating generic/interim operational safety reports starting before construction. The initial assessment of operational safety is useful with respect to identification of key accident scenarios, and therefore leading to design optimization or update of guidance if needed.

The Swedish regulator (SSM) stressed that an important component for the preparation before the operational licence is the elaboration of norms for underground nuclear activities. For conventional non-nuclear facilities, the corresponding norms and standards are applicable. They include requirements relative to rock excavation, mining, concrete structures, worker safety, fire safety, ventilation, electrical installations etc. For any nuclear facility additional requirements apply with regards to operational nuclear safety and radiation protection. Those additional requirements can be described as imposing restriction on conventional non-nuclear facilities, i.e. the same type of activity that is performed in a conventional non-nuclear facility may be subject to stricter control and less flexibility when performed in a nuclear facility.

For a spent fuel and/or high level waste repository designed to provide both pre- and post-closure containment and isolation, additional restrictions apply due to the risk for potential negative impacts on post-closure safety. These additional requirements impose even stricter restrictions on the construction and operations of a repository compared to conventional nuclear facilities.

In France, in view of the license application, ANDRA identified in Dossier 2009 challenging issues during both operational and post-closure phases such as: containment systems, fire, co-activity and explosion risks, improvement in the understanding of the rock damage around the major underground structures and sealing of the repository. As an illustration, some requirements on fire risk were identified in order to take into account the combined constraints of "conventional" underground facilities (tunnel, mine) and nuclear facilities. After the review in 2010 by IRSN and the Standing Group of Experts on waste management (GPD) it was concluded that ANDRA had to introduce specific safety provisions on handling fire risk for the underground nuclear facility, as no current such guidance exists for this type of facility.

To ensure operational safety, undesirable events have to be prevented or the likelihood of their occurrence shall be kept sufficiently small. The consequences (e.g. release of radionuclides to the environment) have to be limited if such events ever occur. This implies provisions shall be provided through (i) design, e.g., the design of handling devices/transport containers and shielding, (ii) organizational/administrative procedures, e.g. appropriate operating schemes and emergency preparedness, and (iii) waste acceptance criteria in order to ensure the robustness of the waste packages (nuclide inventory, properties of waste matrix, properties of waste package, etc.).

Contents of operational license application

The discussion in the round tables addressed the content of the safety case to be prepared for the licence application. The updating of the preliminary safety case developed for the construction licence will be based on the description of the facility « as built », on more detailed information gained during construction, on a possible updated design and on demonstration tests of appropriate duration. The safety case will provide assurance that design and safety principles developed in previous phases have been followed and that safety requirements are met. The implementer should address all the subsequent phases of geological disposal and, as a minimum, present the overall approach for operation, partial closure of the disposal units and final closure of the disposal facility (updated as appropriate based on construction experience). A detailed description and substantiation of the suitability for safe operation of the operational facilities and structures, systems and components, in the context of planned operations and the proposed management system should be defined.

Waste acceptance criteria should be finalized and procedures in case of lack of compliance should be defined. All the activities associated with waste emplacement will need to be appropriately covered in the operational aspects of the safety case. They include receipt of the waste packages on site, handling and storage of the packages on the surface, transport of the packages underground and to the locations where they will be emplaced, as well as emplacement itself.

A safety operation envelope should be defined. As part of the operating rules a number of provisions should exist including those for worker protection against both radiological and non-radiological hazards, description of the procedures and rules for proper response to an accident or emergency during waste emplacement operations, procedures for site security and safeguards controls, procedures for the monitoring and surveillance of the facility and its surrounding surface environment.

The "operational phase" encompasses activities being carried out in parallel, i.e. characterization, excavation, construction, disposal, as well as partial backfilling and closure of disposal tunnels occurs simultaneously in different parts of the disposal facility. Thus, construction and closure are on-going, same time activities within a repository over a period of roughly of 50-100 years. A specific challenge is thus to make sure that excavation/construction/disposal/backfilling activities are carried out such as not to jeopardise the anticipated initial state for the passive post-closure development ("operation") of a sealed and closed repository.

The position of individual countries on retrievability is very diverse. When retrievabilily is imposed by law or regulation, specific studies (France, Germany) show that it may be implemented without compromising long term safety. However, it was suggested in the round tables that it is more difficult to demonstrate that retrievability will be possible with respect to operational safety.

Monitoring

During the operational phase, the implementer should put in place a monitoring programme to monitor the evolution of the components important for safety. The monitoring programme should be brought up to date based on experience from site characterization and from construction. The implementer should provide a description of the monitoring programme for the operational phase including the continued monitoring of host rock evolution due to construction and operation, confirmation of barrier system performance (type of parameters to be measured and how they are related to the performance of components that provide the safety functions) as well as radiation monitoring for operational safety. A description of the environmental monitoring programme should also be presented. There is a necessity to perform early planning of monitoring. The monitoring plan should be reviewed by the regulator. The issue of independent monitoring by the regulator was raised. It was concluded that this is best accomplished through inspection.

5. *Optimisation*

There is a need, during the project, to address targets very different in nature and which may potentially compete with each other. Alternative solutions are typically compared and evaluated with a view to lower potential impacts and risks to workers, people and the environment in the short and the long term to as low as reasonably practicable. This is often called "radiological optimisation". In repository development, the set of target functions can be much broader, blurring the meaning of "optimisation". The visibility and importance to optimisation for licensing varies from country to country, and it may take different names.

There is no single straightforward definition of optimisation, and not all regulatory guidelines use this term. The regulatory documents that provide guidance on what and how to optimise define constraints that must be considered in the optimisation process. Typical factors to be considered in optimisation include nuclear safety and security; radiation protection (operational phase with normal operation and incidents/accidents; post-closure safety with expected/unlikely evolution); worker health and safety; technological issues including "robustness"; environmental aspects during construction, operation and post-closure phase; cost; societal expectations; etc.

The variety of the remarks and views on this subject reflected the diversity of optimisation goals that may be pursued in the framework of a geological disposal programme. While optimisation of protection, as defined by ICRP, is regarded as a process to keep the magnitude of individual doses, the number of people exposed, and the likelihood of potential exposure as low as reasonably achievable with economic and social factors being taken into account, optimisation can also be seen as a way of increasing the technical quality and robustness of the whole waste management process. An "optimal solution" in a wider sense may also mean addressing safety requirements whilst balancing other factors such as the need to use resources efficiently, political and acceptance issues and any other boundary conditions imposed by society. It was noted that optimisation variables are often not well defined and could be quite programme-specific.

Examples of optimisation issues addressed during the workshop included site selection (Germany), location of disposal facility in a selected zone (France), design of the engineered barrier system (Sweden, Finland). Optimisation is a forward-looking activity and continues as well during the operational phase, e.g. in the framework of re-licensing, and it may concern working procedures, installations, equipment (USA, WIPP).

There was general agreement on a series of statements on the subject. Namely: the endpoint of optimisation should represent a balance between the different factors considered in the optimisation process while respecting the constraints. Optimisation is normally forward oriented rather than directed on re-examining past decisions (except for situations that require remedial action) and should focus on those issues where (residual) flexibility is available. Optimisation should be taken at several levels, from the overall waste management system (including waste treatment, interim storage, final disposal, etc.) down to individual elements of the repository system. Optimisation also has to find a balance on how long to keep options open and when to take decisions and narrow down the number of options; optimisation, however, should not be used as an excuse to take no decisions and not to move forward. For optimisation, not only the endpoint counts; equally important is the process of optimisation that should be conducted in a transparent manner and relies on a structured interaction between regulator and implementer. In this respect regulators need to be clear about their requirements and these requirements become constraints on the optimisation process, together with any societal constraints that may be applied in certain programmes. Once the safety objectives (dose/risk targets and other constraints) have been met, further optimisation should be aimed at moving the project forward as efficiently as possible, and this could largely be described as "cost optimisation".

Conclusions

The workshop was considered a success as there was a vast amount of interest in the topics covered with active participation of both regulators and implementers. Informative programme overviews and project details were delivered in the given presentations by many participants.

It was acknowledged, during the workshop, that many repository projects are at different developmental levels and therefore different concerns were noted among countries and/or waste management programmes. Due to this reason, the experience in dealing with the preparation or review of a license application is diverse.

Despite the various developmental levels, commonalities among the waste management programmes or countries can be drawn. The most apparent consensus was on the role of the stepwise process which, in many countries, is inscribed in their legislation. In this context, early interaction with a competent regulator is considered important in order to communicate effectively on issues related to the construction and operational licence. It is recognized that the early identification of challenges associated with construction, with long term safety, and with risk management related to repository operation are also crucial in development. In this respect, and at specific steps before the license application, the implementer often produces generic/interim reports that are reviewed by the regulator.

Many commonalities are also found to be necessary information in the safety case. The European Pilot Study[1] had identified the need to describe, in the license application, all subsequent activities leading to a given decision, including later operation, closure and post-closure. This implies that feasibility of a technical solution shall exist in principle for all phases of the repository although this technical option may not be used in the final design. It is inevitable that techniques will evolve; hence, implementers shall be allowed to have some level of flexibility in the license for their repository implementation. This, nevertheless, remains to be a challenge for the regulator when stipulating licensing conditions.

Many advanced programmes recognize the importance of a quality management system including the planning of required resources. Competent and experienced implementers and the regulators are also keys in advancing repository development. This is especially important when the implementer has to be prepared for the industrial phase and supervise large contracting companies. In this respect a monitoring plan and proper documentation to monitor and record construction and operational progresses are very important. The quality management process shall be reviewed by regulators and an inspection programme put in place.

Main differences between countries are observed in the licensing regimes or in the licensing process. The need of developing specific regulations is noted as well. In some countries, a license or a license application may be regulated or assessed by more than one regulating body. Such situation can be complex as different regulating authorities may stipulate different license conditions. In such situation, it is often the government who has the responsibility to deliver the final decisions on the license conditions. Another difficult situation faced by the implementers is to account for potential political changes in the planning of the essential resources for the industrial phase.

Finally, the workshop concluded that many others areas of this subject: “Challenges faced by implementers and regulators in the industrial phase of repository development” need to be further explored in the future. Aspects such as (i) the need to introduce enough flexibility in the project within the limits set by the licensing conditions, (ii) the need to comply with competing targets in the framework of an optimisation process and the obligation to address a series of operational issues including the constraints associated with concomitant operation and construction, (iii) aging of disposal system components, (iv) the application of retrievability constraints, if required, (iv) the different roles of monitoring in the different phases of the project, and (v) the identification of events / scenarios to be considered when assessing operational safety. These and other issues will be taken up in the programme of work of the RWMC’s RF and the IGSC in the future.

1. Report on the European Pilot Study on the Regulatory Review of a Safety Case for Geological Disposal of Radioactive Waste *Version for consultation @ 26.11.2010 distributed to IGSC members on 13.07.2011*

Day 1 – National Case Studies

The Finnish Experience with the Construction of Onkalo

Licensing of a repository for nuclear waste in Finland - J. Avolahti (MEE)

Pursuant to the Nuclear Energy Act (990/1987), a license holder whose operations result, or have resulted, in the generation of nuclear waste must perform all measures included in the management of nuclear waste and preparation thereof and bear all the costs of nuclear waste management. Under law, spent nuclear fuel is regarded as nuclear waste. According to the amendment made to the Nuclear Energy Act in 1994, nuclear waste generated in Finland must be handled, stored and permanently disposed of in Finland. Nuclear waste generated elsewhere may not be handled, stored and permanently disposed of in Finland.

The Finnish nuclear legislation defines spent fuel as nuclear waste and requires that it has to be disposed of in the Finnish bedrock. Over 30 years of systematic R&D has been carried out to develop the repository concept, site selection, technologies, safety assessment and the regulatory approach. Activities are based on the Finnish Government's long term strategies since 1983. The stepwise development and future plans for disposal are presented in Table 1.

The licensing procedure for a disposal facility has several steps that are similar to all nuclear facilities in Finland and are defined in Nuclear Energy Act (990/1987) and Decree (161/1988). These licensing steps are:

Table 1. Main phases and steps in the program for spent fuel disposal from Loviisa and Olkiluoto nuclear power plants in Finland.

Period	Implementation	Regulatory oversight
1983-1999	-Conceptual design, research and development -Site selection process: 100 > 5 > 3 -Detailed site investigations	-Government's policy of 1983 -STUK's safety reviews of 1987, 1994 and 1997
1997-2001	-EIA program and report -DiP application for a disposal facility at Olkiluoto	-Safety regulations 1997 -EIA hearings and judgement -STUK's preliminary safety appraisal as part of DiP process
2000-2012	-Confirming site investigations, including underground rock characterization facility ("Onkalo") -Research and technical development, start detailed design	-Updated safety regulations 2008 -Oversight of site investigations and construction of "Onkalo" -Review of the state and plans of research and technical development, in three year periods
2012-2020	-Construction licence application -Construction of the facilities	-Review of licence application -Oversight of construction
2019-	-Operating licence application -Operation of the facilities	-Review of licence application -Oversight of operation

- Decision in Principle (DiP) is required for a nuclear facility having considerable general significance. This is essentially a political decision: the government decides if the construction project is in line with the overall good of society. The decision can be applied for one or more sites, the host municipality has a veto right and the parliament has the choice of ratifying or not ratifying the decision.

- Construction License is granted by the Government and authorizes the construction of the disposal facility. The actual construction is regulated by STUK and includes several review and approval steps, hold points and viewpoints.

- Operational License is granted by the Government and authorizes the operation of the facility for a certain period. The operation license is needed before nuclear waste can be disposed.

An Environmental Impact Assessment (EIA) shall be conducted prior to the first authorization step of a major nuclear waste facility. The EIA procedure for the final disposal of spent nuclear fuel from three units of the Olkiluoto nuclear power plant and two units of the Loviisa nuclear power plant was carried out in 1998–1999 and extended to one more unit at Olkiluoto in 2008-2009.

Pursuant to the Nuclear Energy Act, before making the DiP the Government shall ascertain whether the municipality planned as the location of the nuclear facility is in favour of the facility, and ensure that no facts indicating a lack of sufficient prerequisites for constructing and using a nuclear facility in a safe manner without causing injury to people, or damage to the environment or property, have arisen in the statement from Radiation and Nuclear Safety Authority STUK or elsewhere during the processing of the application. The Government's decision-in-principle shall be forwarded, without delay, to Parliament for perusal. Parliament may reject the decision-in-principle or decide that it shall remain in force as it stands.

In 2000, the Government made a DiP on the disposal of spent fuel from Loviisa and Olkiluoto nuclear power plants in Olkiluoto bedrock. The DiP also stated that the project is allowed to proceed to the construction of the ONKALO underground rock characterization facility in Olkiluoto. From a legal standpoint, the DiP thus included a permit to start a limited construction of the repository. ONKALO may be later used as a part of the actual repository and therefore the regulatory approach to ONKALO construction is the same as is for the rest of the repository.

The activities of Posiva, the implementing organisation, to fulfill the DiP are regulated by the Ministry of Employment and Economy (MEE) and Radiation and Nuclear Safety Authority (STUK). The regulatory oversight of Posiva's spent fuel disposal project (including the construction of ONKALO), consists of review and assessment and inspection. Other functions, such as establishing, updating or adopting safety principles, regulations and regulatory guides, are developed in parallel with the RD&D work.

Pursuant to the Nuclear Energy Act, the decision-making and licensing system of nuclear facilities is based on a principle whereby safety is continuously reviewed, the assessments being further defined throughout the procedure so that the final safety assessments are only performed at the operating licensing stage.

The actual licensing procedure starts after the Government's decision-in-principle. The construction of a final disposal repository is subject to a construction license granted by the Government. Prerequisites for granting the construction license include the requirement that the plans concerning the facility be sufficient in terms of safety, that the protection of workers and the population's safety have been taken into account appropriately when planning the operations, that the location is appropriate with respect to the planned operations, and that environmental protection measures have been taken into consideration in an appropriate manner in the planning of operations.

In addition, the construction of a final disposal repository and an encapsulation plant requires a number of other permits and licenses, such as permits in accordance with the Environmental Protection Act and the Water Act, and a municipal building permit.

A construction license for the final disposal repository of spent nuclear fuel must be applied for by the end of the year 2012. A hearing procedure involving municipalities, authorities and citizens will be established during the application process for the construction license.

The operation of a nuclear facility requires an operating license issued by the Government. In order to receive a license, it must be ensured that the protection of workers, safety and environmental protection have been taken into account as appropriate. Furthermore, for instance, licenses in accordance with the legislation regulating the transport of hazardous substances are required for the purpose of transporting spent nuclear fuel. The operating license will be granted only for a fixed term. A hearing procedure involving municipalities, authorities and citizens will be established during the operating license application process.

Design and Construction of Onkalo - J. Vira (Posiva)

Design premises

The idea of underground characterization as a final, confirming phase of the site selection process is included in Teollisuuden Voima's and later Posiva's plans since the early 1980's and the construction of an investigations facility was one of the main objectives set in the long-term RTD program Posiva published in 2000. The idea was presented in IAEA's early guidelines for repository siting, but how the characterization facility would be related to the actual repository, was not, perhaps, made all clear in them. At the time Posiva started its design of the ONKALO a separate characterization facility in the actual host rock looked like a potential source of hydraulic and geochemical disturbances that, in general, should be avoided. For the efficient use of both rock resources and manpower it was considered natural to design the ONKALO in a way that it could later be used as an access way to the repository as well. Of course, it was understood that this would cause additional complexity in the actual construction work, since the design and construction of the facility should, in this case, comply with nuclear regulations.

The principal objectives set to the ONKALO design were

- to enable the underground characterization of the actual host rock of the repository, and, barring unexpected negative results, the final confirmation of the site suitability;
- to enable in situ testing and demonstration of repository technologies and work processes in realistic conditions

with the main constraints that

- it should be built in a way that the characteristics of the host rock important for long-term safety were not compromised, and

- it should be built as if it were a nuclear facility.

The first of the constraints came directly from the regulations. The second constraint had particular implications to

- quality management,
- safety classification of systems and structures,
- application of safeguards.

Posiva had applied an ISO 9001 quality assurance system for all its previous R&Dwork, but now the QA system needed to be extended to the design and construction work and it should comply with the regulatory QA requirements. However, on the details of QA the existing YVL Guide on quality assurance largely referred to IAEA's safety guides. What came up handy at that time was a comparison, made by IAEA, between ISO based QA and IAEA's safety guides. It showed that the differences were actually small and comprised mainly of the graded approach based on safety meaning, and the role of a responsible facility manager, which were not included in the ISO 9001 based QA system. Posiva decided to continue with the ISO based quality management revamped with additional features from IAEA safety guidelines.

Management of ONKALO design and construction

In many respects the QA system for the ONKALO was a straight-forward application of the ISO 9001 and 10006 guidelines. The main new challenges were

- how to manage and coordinate the parallel design, construction and investigations activities
- how to formulate the QA system in a way that meets the IAEA requirements on graded approach and focus on safety-critical aspects.

Since there would be no radioactive substances handled in the ONKALO and most of the structures and systems would not have any bearing on nuclear operational safety of the repository, the main nuclear and radiation related safety issues would be concerned with long-term safety and, particularly the issue of how to minimize the negative disturbances to the host rock. In addition, there should be a system through which the potential disturbances could be monitored and the necessary corrective actions could be taken.

In general, for the purpose of long-term safety assessment modeling, it would be worthwhile to try and keep the host rock as close to the natural state as possible. However, some disturbances would be unavoidable, and for this reason a survey was made to identify the FEPs that could be affected by the construction activities and would be important for long-term safety. The focus of monitoring should be placed on these FEPs. However, some of the potential changes that were considered as interesting from the long-term safety point of view were found very difficult if not completely impossible to monitor. Mineralogical changes were of this nature.

In general, the most important FEPs that could be either created or influenced by construction activities were related to geohydraulic or geochemical disturbances. Geohydraulic changes would be brought about by the inflow of groundwater to the open tunnels and shafts; boreholes drilled in the ONKALO or its neighborhood could add to these effects. The hydraulic changes could entail geochemical effects, but further geochemical effects could also be caused by the "foreign" materials used in the construction and investigations activities. A special type of disturbance to the host rock would also be the excavation damage zone (EDZ) created around the tunnels and shafts.

The first approach to limit the disturbances was to select the type and location of the underground characterization facility in a way that would minimize the negative effects on the host rock. The first ideas of the ONKALO comprised only one or two shafts, but for the rock characterization and for the intended use as an access way to the repository the shaft designs were considered less flexible than a combination of an access tunnel and one or several shafts. The combination alternative was chosen, but as it was expected to lead to larger hydraulic disturbances than one or two shafts, special attention was called to the location of the underground access routes: they should be located close to each other to avoid hydraulic pressure differences between the openings and in the part of the host rock that was known to be relatively dry. A number of possible locations were compared on this basis until the present location was selected in the southern part of the Olkiluoto Island. The choice received criticism from some geologists, but could well be defended on the basis of its expected geohydraulic properties.

The further control of potential long-term safety implications of the ONKALO construction was based on the safety classification developed. The current regulatory advice on safety classification was at that time only for nuclear power plants and hardly applicable for long-term safety issues. Therefore, Posiva decided to develop its own classification system for long-term safety issues and defined three safety classes:

A. activities that had known effects on the host rock characteristics important for long-term safety

B. activities that had potential effects on the host rock characteristics important for long-term safety

C. other activities.

On the basis of an assessment four critical issues were identified that required attention according to the highest (long-term) safety class A:

- the groundwater inflow to the ONKALO
- the rock damage resulting from the excavations (EDZ)
- the use of harmful foreign materials
- the drilling of boreholes in the ONKALO area.

Special QA rules and instructions were developed for activities that could have direct effects or indirect couplings to these issues. The most challenging issues turned out to be the groundwater inflow management and the control of EDZ.

The problem with groundwater inflow constraints was that - after the selection of the location of the facility - the inflow could only be controlled through grouting injections, and grouting implied using foreign materials that should be avoided. In the early 2000's opinions on the use of cement-based materials in the high-level waste repositories were strongly divided: some experts would totally ban the use of all cement-based materials, whereas some others claimed that it would not be possible to construct any repository without concrete. Posiva concurred to the latter opinion, but carried out two specific development programs to minimize the potential harmful effects of the cement-based materials.

In general, the safety meaning of EDZ was not considered to be significant in the safety assessments made earlier for KBS-3, but, of course, it was agreed that its nature and extent should be known and controlled in the excavations. The main issue has been said to be the question whether excavations could bring about new connected fracturing along the tunnel direction, and in this way create new flow channels. However, the characterization of the real EDZ arisen has turned out to be difficult. The current guidance is still based mainly on the control of the thickness of the EDZ and some bulk measurements of its hydraulic properties.

The long-term safety related rules and instructions on the design and construction were in place at the time of start of the excavations. However, a further challenge was how to control the compliance with these rules and how to react to new information gained during the construction process. For this purpose a so called CEIC procedure was established (Coordination of Engineering Design, Investigations and Excavations), but a number of iterations turned out to be needed until a satisfactory feedback, learning and decision-making procedure was defined.

Current experience

The construction of the ONKALO has reached the final stage and the next step is to apply for a license to construct the actual repository tunnels. The project is lagging behind its original time schedule, but the main reason for this is the changes in design that have been made since the start of construction: two more shafts have been made to ensure safe and healthy work conditions, and the tunnel layout was modified to avoid intersections of tunnels with some potentially well-conductive fracture zones.

After some difficulties in the early phase of the construction, the coordination of the investigations, design and construction has made it possible to proceed fairly smoothly, without major unplanned interruptions in the work processes. Most of the important geological and geohydraulical features that were crossed were predicted by the models developed in advance of the excavation and few surprises were encountered. The total amount of groundwater inflow has been kept in the prescribed limits.

Unfortunately, one serious accident took place: in the early 2011 a falling rock block caused the death of a person who was scaling the rock walls at the end of the access tunnel. After the accident new measures were taken to improve the safety of tunnel working. These measures also stressed the importance of rock mechanics observations for the prediction of risk levels.

Some of the control procedures implemented for long-term safety grounds have been modified on the basis of the experience gained. Most of the changes have been small, but some requirements and related working procedures are still subject to discussion and fine-tuning. Grouting has still turned out to be more an art than a mature technology, and at times, difficult decisions have been required to cope with the requirements set on the groundwater inflow management. The control of EDZ will also still require further testing to prove that the quality required can be verified by non-intrusive means.

On the basis of the investigations and interpretations conducted the objective of final confirmation of the Olkiluoto site suitability can be reached as expected. In most respects the conditions correspond to the models developed before the construction of the ONKALO. What perhaps are the main new findings are the significant number of single fractures classified as "large", i.e., with dimensions of at least several dozens of meters, and the characteristics of the matrix pore waters. The large fractures will affect the location rules of deposition holes, and are important for the efficient use of the rock resources. The properties of the matrix pore waters may still call for supplementary studies to ensure consistent interpretation of the site evolution.

Regulatory approach to the construction of ONKALO - J. Heinonen (STUK)

General

The Finnish regulation requires that the bedrock in disposal site shall be characterized at disposal depth before submitting the construction license application. This requirement is further developed in STUK guide YVL 8.4 which defines that characterization involves construction of a research or characterization facility at the site. ONKALO will first function as an underground rock characterization facility to ensure the suitability of the Olkiluoto site for repository purposes and then as an access route to the actual repository. The construction of ONKALO therefore already means “de facto” construction of the disposal facility because the access tunnel, the shafts and other underground parts will be utilized during disposal operation. ONKALO URCF has been constructed prior to construction license based on Governments decision given in the Decision in Principle, as the Olkiluoto DiP contains an authorization for starting limited facility construction. STUK has the responsibility of regulatory oversight of ONKALO construction and oversees it like it would be an access route to a nuclear facility. However, a construction license is needed before starting construction of the encapsulation facility and of the first disposal tunnels and deposition holes.

STUK has re-organized and increased its resources in response to the progress of the disposal project and expanding operations of Posiva. In particular, STUK has developed and started implementing a new regulatory approach for inspection and review of ONKALO and Posiva’s activities. STUK’s inspection program utilizes a graded approach based on safety importance of the repository’s structures, systems and components.

Regulatory requirements

The safety of the Olkiluoto disposal facility is based on ensuring the integrity of the containment of the disposed waste i.e. (engineered) containment for a long period of time and, protecting it from external impacts, and in the case this primary barrier becomes defective, effective limitation of the release of radioactive nuclides (retardation as well as protection from external impacts). For long term safety it is vital that such chemical and mechanical conditions are maintained in the bedrock and that the safety functions of the repository are not jeopardized over a long period of time in a variety of normal and abnormal circumstances.

Construction of ONKALO to the planned disposal depth (c.a. -430m) disturbs the geological environment and conditions in a variety of ways. The purpose of STUK’s regulatory control of ONKALO construction is primarily to ensure that the design, location, orientation and construction are carried out in such a manner that the geo-environment retains its favourable characteristics and conditions needed for the safety functions.

In particular, this implies the minimization of:

- Host rock responses to excavation, excavation disturbed areas and zones,
- Groundwater leakages to the ONKALO tunnels and shafts, and
- Introduction of foreign, potentially harmful substances to ONKALO during (cement and other grouting materials, reinforcement materials, explosives etc.).
- Pathways from surface to disposal rooms.

The Finnish regulatory framework has requirements that define how long-term safety shall be taken into account in facility design and construction practices:

- License applicant shall describe safety functions and performance targets for disposal system barriers. In case of bedrock these include isolation of waste and engineered barrier system from surface and retardation of radionuclides after canister has breached.
- License applicant shall develop a rock classification system that will be used to classify for example rock structures and ground water conditions that can have an impact to long-term safety. Posiva is developing Rock Suitability Criteria (RSC) that take into account requirements arising from long-term safety and which need to be implemented when making decisions of on rock suitability prior to excavation.
- The construction of the disposal facility construction shall aim at maintaining favorable rock characteristics important to long-term safety as well as possible.
- Impacts of construction shall be observed, measured and recorded with a monitoring program that includes for example characterization and surveillance of changes in stress field, seismic activity, brittle deformation, hydrogeology and hydrogeochemistry.

STUK's regulatory activities (approvals, reviews and assessments, inspections) are implemented in a graded approach. All the structures, systems and components of the facility are classified based on their significance to safety (safety classes 1, 2, 3, 4 and to those which are not important to nuclear safety). These include also constructed underground rooms. Since the management of the construction and related safety culture affect directly the safety and quality of the work and its long-term results, Posiva's management system is also subject to STUK's regulatory control.

Review and assessment

STUK has defined requirements for documents that are required to be submitted to STUK for review and approval. These documents include the preliminary safety analysis report, the safety classification report and the description of constructing organization, staff competences, the regulations, codes and standards to be used in the construction, the management system (especially safety and quality management), design data, drawings, construction documentation, in-service inspection plan etc.

In addition, Posiva was required to submit to STUK a plan on how the company intends to communicate to STUK the progress of the construction work. The purpose of this document is to facilitate well planned, timely and properly targeted and resourced regulatory activities synchronized with the actual construction activities and provide timely information for example on unexpected events underground. This documentation includes schedules, realization reports, as-built documentation, test results, information about research planned to be performed in ONKALO during construction, and information about ONKALO's unclassified systems.

In its review and assessment process for ONKALO construction, STUK is assisted by external consultants. All the results and regulatory decisions, including their justifications, are documented and published.

Inspection activities

ONKALO inspection activities cover all areas of STUK's responsibilities. Inspections are carried out in order to ensure that Posiva is in compliance with regulations, conditions and approvals of STUK in a high quality manner. Inspection activities can be divided into three areas, which are discussed in the following:

- Construction Inspection Program (CIP),
- Inspections concerning the readiness to begin excavation and other work phases, and
- Inspection concerning construction works on site.

Construction Inspection Program (CIP) - STUK has established a planned and systematic CIP-program. CIP is prepared, approved and implemented annually as a continuous process. The main levels of CIP are:

- Management system (ONP-A): Dealing with issues such as managing ONKALO construction, organization, safety culture, quality assurance, competence of staff, communication with STUK,
- Main Operations (ONP-B): construction project management and resources, safety issues, quality assurance for construction work, facility design,
- Functions and Activities (ONP-C): Posiva's inspections and QC, excavation and excavation disturbed zone, drillings, mapping of features and construction impacts to safety functions (to geochemistry, rock mechanics, hydrogeology, groundwater leakages to ONKALO, introduction of foreign potential hazardous materials to ONKALO, grouting, enforcement works and materials).

Inspections concerning the readiness to begin excavation and work phases - The ONKALO construction is divided into different phases. The purpose of the inspections related to these phases is to ensure that all the arrangements and conditions at the construction site are in order for the next construction phase to start (previous phase is properly completed). Examples of this type of inspections are inspecting the preparedness to begin shotcreting of a specified tunnel section, and inspecting the preparedness to start a new excavation phase.

Inspection concerning construction works on site - Inspections are targeted to excavation work processes, methods and practices, and their quality and compliance with approvals. Inspections are carried out approximately once in two weeks.

Experiences from regulatory approach

STUK's strategy has been to develop ONKALO oversight based on practices already implemented for other type of nuclear facilities. The development of regulatory activities has been an ongoing learning process, but in the end the oversight of ONKALO has been a very good opportunity to develop regulatory approach for disposal facility oversight. Following conclusions can be formulated already at this stage based on regulatory experiences and findings:

- The Finnish strategy has been to develop safety requirements along with development of understanding of safe disposal. This has been also the case in underground construction. The regulatory framework and expectations have to be clear to the implementer. The experience has been that both sides need to reserve quite much time in early phase of construction project for getting understanding of design and construction process and how regulatory activities fit in that.

- It is not possible to get all necessary information from surface drillings and characterisation. Also the characterisation and construction is going to be step-wise. This means that design work and regulatory review and assessment have to be flexible for changes.

- Construction workers are most likely familiar with ”conventional” rock engineering and underground construction. It is important to highlight what is done differently and why.

- In many cases the research organisation has to change to a construction organisation and also the nuclear facility license holder and workers without waste management background need to learn the background and reasoning for their work.

- In practice it is important that requirements coming from long-term safety be clear, justified and when possible also observable after construction. Most likely all underground facility parts don't have the same safety relevance and a graded approach should be used in setting requirements.

- In practice, the project will be construction driven (time schedule, costs) and integration of research, design and construction is important. This difference between conventional rock construction and disposal project needs to be highlighted in the planning and design phase.

Dealing with the current permissibility application for constructing a spent fuel DGR in Sweden

SKB's license applications for a spent fuel repository – O. Olsson (SKB)

Introduction

The nuclear power utilities in Sweden were in 1976 obliged to demonstrate a safe method for final disposal of spent fuel in order to start operation of new reactors. This initiated a comprehensive research, development and demonstration programme and the development of the KBS-method for final disposal. A new Nuclear Activities Act in 1984 gave the reactor owners full technical and financial responsibility for the waste. They gave in turn SKB the responsibility for all nuclear waste management. Reprocessing was no longer required and direct disposal of the spent fuel has, since then, been the main alternative. Alternative methods for final disposal have been evaluated and compared to the KBS-3-method but it has remained the preferred alternative. A comprehensive research, development and demonstration programme to strengthen the scientific basis and to refine the KBS-3-method has been operated by SKB since then. The RD&D programme has every third year been updated by SKB and reviewed by Swedish stakeholders.

The site selection process for the final repository for spent nuclear fuel was initiated in 1992. The work included general siting studies at the national and the municipal level (feasibility studies in 8 municipalities). In 2002, SKB initiated site investigations for siting of a final repository on two sites: the Simpevarp and Laxemar areas (Oskarshamn municipality) and the Forsmark area (Östhammar municipality). At the same time, the work on preparing license applications to construct and operate an encapsulation plant and a final repository for spent fuel was started. In June 2009, SKB announced Forsmark as the selected site for the final repository.

Applicable legislation

Nuclear facilities require permits in accordance with the Swedish Environmental Code and the Nuclear Activities Act. Both laws require that SKB describe the planned facilities and operations as well as the associated environmental risks and safety issues. SKB has submitted two applications to SSM (the Swedish Radiation Safety Authority) according to the Nuclear Activities Act and one to the Environmental Court according to the Environmental Code.

The Nuclear Activities Act states that this report must address radiation protection and nuclear safety during operation and after closure. The Environmental Code specifically requires a description of the potential impact of the planned operations on human beings and the environment. The Nuclear Activities Act requires an equivalent impact assessment.

The license application

The petitions for the application, according to the Environmental Code, are for the municipality in Oskarshamn to store nuclear fuel and nuclear waste up to 8,000 tonnes in Clab (the central interim storage for spent nuclear fuel) and to, adjacent to Clab, build and operate a plant for encapsulation of spent nuclear fuel. For the municipality of Östhammar (Forsmark) the petitions are to build and operate a facility for final disposal of spent nuclear fuel and radioactive waste, all in accordance to the application. The application according the Environmental Code thus includes the whole KBS-3-system - the final repository, the existing interim storage facility and the encapsulation plant.

The petitions for the application according to the Nuclear Activities Act are in Forsmark to build, possess and operate a facility for final disposal of spent nuclear fuel. In the facility, SKB intends to possess, manage, transport, finally dispose of and in other aspects manage the specified material, all in accordance with the application. Apart from the future repository, an application according to the Nuclear Activities Act for an encapsulation plant adjacent to Clab has already been submitted.

Since the petitions of the applications are different, the supporting documents contain parts that are identical and others parts that differ. The application under the Environmental Code contains about 2,800 pages in total, of which 600 are unique to that application. The remaining

2,200 pages are also included in the applications under the Nuclear Activities Act which for the final repository contains around 6,500 pages.

The application according to the Environmental Code includes a top document in which the case is summarized and the claims (petitions) are accounted for. The top document is supported by eleven underlying documents, as listed below:

- Environmental Impact Assessment (EIA)
- Operations and the general rules of consideration
- Site selection – siting of the final repository for spent nuclear fuel
- Choice of method – evaluation of strategies and systems to manage spent nuclear fuel
- Safety report for final disposal of spent nuclear fuel (SR)
- Safety report for operation of the final repository facility for spent nuclear fuel (SR-Operation)
- Long-term safety for the final repository for spent nuclear fuel at Forsmark (SR-Site)
- Technical description
- Proposal for inspection programme
- Right of disposition and list of concerned parties
- Preliminary Safety Report for Clink (interim storage and encapsulation plant)

All the documents refer in turn to an abundance of technical and scientific reports.

The application according to the Nuclear Activities Act contains a top document which is supported by ten underlying documents. The first seven documents listed above are also included in this license application. In addition, the application is supported by the following documents:

- Preliminary plan for decommissioning
- Operation, organization, management and control – site investigation for final repository
- Operation, management and control – construction of the final repository facility

The safety report constitutes an important part of the license application. It addresses both safety during operation (SR-Operation) and long-term safety after closure of the repository (SR-Site). The links between these two documents are described in the Safety Report Summary. An important aspect of the system is how production of the repository and its barriers results in the initial state and the potential impacts of operation on long-term safety. This is addressed in the so called production line reports which are main references to the safety report.

Hence, the construction of the repository and the expected initial state is described in a set of production line reports that describe the components of the system: the spent nuclear fuel, the canister, the buffer, the backfill, the closure, and the underground openings. Each production report gives an account of:

- the design premises,
- the reference design,
- an analysis of the conformity of the reference design to the design premises,
- the production procedures and controls made to assure that the product meets the specifications, and

  - o the initial state, i.e. the results of the production including expected variability in outcome.

The descriptions in the production line reports and the assessment of the initial state are based on results from production of canisters, buffer blocks, deposition holes and tunnels as well as full scale experiments performed mainly in the Äspö HRL. Hence, SKB has considerable confidence that a safe repository can be achieved with the application of the current design and the production and control methods presented.

The licensing review

The applications have been submitted to the Environmental Court and to SSM (the Swedish Radiation Safety Authority). The review processes under the Nuclear Activities Act and to the Environmental Code is currently in progress.

The Environmental Court will prepare the case and review it according to the Environmental Code. After some preparatory procedures they will hold a main hearing. Then they will give a statement to the Swedish Government which will request statements from the municipalities of Östhammar and Oskarshamn. The municipalities will accept or reject and have a right of veto. The Government will then make a decision on whether the final disposal system is permissible or not. If the application is accepted, the Environmental Court will hold a new hearing. Thereafter, the Court will grant permits and stipulate conditions pursuant to the Environmental Code.

SSM will prepare the case in accordance to the Nuclear Activities Act and put forward a statement to the Government. If the Government grants the permit, the authority will subsequently stipulate conditions pursuant to the Nuclear Activities Act as well as to the Radiation Protection Act. Preliminary safety reports taking these conditions into account will have to be submitted by SKB and approved by SSM before construction of the facilities can commence.

Preparations for implementation

SKB's current plan for future activities contains a certain element of uncertainty since the company has no influence over the time needed by the authorities to review the submitted license applications. Therefore, the timing of SKB's milestones may be altered. During the review process, the company will be prepared to take up all questions that may be raised during the process.

SKB expects a positive Government decision on permissibility in 2015. In such a case SKB plans to begin construction of the Nuclear Fuel Repository and the encapsulation plant in 2017, and some eight years later to commence trial operation of the Nuclear Fuel Repository and Clink (which will be the name of the facility when Clab and the encapsulation plant have been integrated). During the licensing review, SKB will continue with research to strengthen the scientific basis for the long term safety case and to continue technology development in order to take the necessary steps towards industrial implementation of the encapsulation and disposal process.

Concluding remarks

SKB has now been working in the site investigation regions for more than 10 years. We feel that the residents generally have trust in our work. SKB has occasionally commissioned opinion polls on people's attitudes towards a deep repository. One of the clearest tendencies is that people with the most knowledge about SKB and the final disposal method are the ones who are the most positive. This is particularly clear in the municipalities where we have performed feasibility studies and site investigations, and where the issue has been discussed for a long time. Around four out of five of the people in Oskarshamn and Östhammar are in favor of building the respective facilities in their municipality. This is a confidence in our project that must be maintained.

The selection of the site and the license application is the result of over 30 years of technical research and development and close to 20 years of siting work. We are now ready to change the emphasis of our work towards more of industrial implementation of a final repository for spent nuclear fuel in Forsmark. Within a few years SKB will also include a sizeable construction department.

At the same time we will, however, continue our programme for communication and stakeholder involvement which we consider to have been a corner stone behind a successful development and siting work so far.

Construction and Operation of a Deep Geological Spent Fuel Repository in Sweden; Some Regulatory Aspects and Challenges – B. Hedberg (SSM)

Abstract

The implementation of a deep geological spent fuel disposal concept in Sweden poses challenges on both implementer and regulator in many aspects. One such challenge is the application of the regulatory framework in a different situation compared to conventional process type nuclear facilities. A specific challenge in this regard is how to understand and address constraints from post-closure safety related to the construction and operation of the repository. The maybe most challenging aspect, however, is the unusually long time frame, i.e. many generations, for realization of the project. This paper addresses some of these challenges from a regulatory perspective.

Introduction

When nuclear power was introduced to become part of the Swedish energy mix in the late 1960's, the licensing process was somewhat different compared to today's situation. No formal regulations existed and requirements on licensees were imposed as license conditions. The present prerequisites for licensing nuclear facilities was formalised in the late 1990's through the introduction of the general regulations concerning safety in nuclear facilities [1]. It should in this context be emphasised that the general regulations were developed at a time when all Swedish nuclear power reactors were already constructed and taken into operation and that nuclear power was planned to be phased out by 2010. Thus, the main focus in the regulations is on safe operation of existing facilities rather than on construction of new facilities, and with great emphasis on nuclear power reactors.

Although the new regulations were to some extent (and in principle) used for the licensing of the extension of the central interim storage for spent fuel (Clab), they have so far not been used as basis to license a new nuclear facility. The on-going review of the by SKB[2] recently submitted

[2] Swedish Nuclear Fuel and Waste Management Co (in Swedish: Svensk Kärnbränslehantering AB)

license applications for establishing a spent fuel disposal concept[3] according to the so called KBS-3-method[4] will be the first time that the regulations will be used as formal basis for licensing a new nuclear facility.

A stepwise licensing process

One important element in the legislative and regulatory framework is the lifecycle perspective for a facility, based on a step-wise licensing process. Each decision to grant a license/authorization to move from one phase to the next is founded on the regulatory review of an application from the implementer, based on an appropriate collection of arguments and evidence to justify the decision. The lifecycle approach is emphasised by the fact that the government is involved only twice in the process; in the very first step (licensing for siting, construction, and operation) and in the very end when a licensee has fulfilled his duties and applies for exemption from further responsibilities ("de-licensing"). Authorisation for the intermediate steps is delegated to the regulatory authority. With this set-up, the government must - at least in theory - already at the time of licensing of a nuclear facility take all the subsequent steps until de-licensing into consideration, as a basis for granting a license.

The safety analysis report (SAR) is central in the overall process. The SAR should provide an overall view of how the safety of the facility is arranged in order to protect human health and the environment against nuclear accidents. The report shall reflect the facility as built, analysed and verified, as well as show how the requirements on its design, function, organization and activities are met. A preliminary safety report shall be compiled before a facility may be constructed. The safety report shall be updated before trial operation of the facility may be started. The safety report shall be supplemented before the facility is taken into routine operation. The safety report shall subsequently be kept up-to-date.

Conventional nuclear facilities and general principles

For conventional nuclear process type facilities, e.g. nuclear power plants, treatment and storage facilities etc., the different phases during the lifetime of the facility follow in sequence. That is, the construction phase is followed by the trial operation phase which is followed by the routine operation phase which is followed by the decommissioning phase. Also, construction activities are finalised before (trial) operation commences and no major changes is anticipated to the structure of the facility during its operational lifetime. Another characteristic for a conventional process type nuclear facility is that all radioactive materials will have been removed from the site before de-licensing of the facility.

As accounted for in the introduction, the general regulations focus on facilities in operation and do not address specifically construction of new facilities. The regulations have recently been amended to better address also the decommissioning phase.

Specifics for licensing a deep geological repository

For a spent fuel repository of a KBS-3 type, the situation is somewhat different compared to conventional process type nuclear facilities. The most significant difference being that, after final closure of the disposal facility, the whole inventory of radioactive substances is left at the site, which of course is the main purpose with the establishment of a spent fuel repository. Thus, containment and isolation of the waste from the biosphere for long periods of time is the main purpose with the facility.

[3] SKB has submitted three applications: One application for an Encapsulation Plant and one application for a Spent Fuel Repository under the Act on Nuclear Activities, and one application for the disposal system (i.e. both the Encapsulation Plant and the Spent Fuel Repository) under the Environmental code.

[4] The meaning of KBS (in Swedish: KärnBränsleSäkerhet) is Spent Fuel Safety and number 3 indicates that the current version of the concept is the third variant.

Another important difference is that the "operational phase" encompasses activities being carried out in parallel, i.e. characterization, excavation, construction, disposal, as well as partial backfilling and closure of disposal tunnels occurs simultaneously in different parts of the disposal facility. Thus, the repository is essentially being constructed and closed at the same time over a period of roughly 50 years. Hence, construction activities, or the "construction phase" continues throughout the operating life time of the repository and stops only when the facility is properly closed and sealed. Therefore, a specific challenge is to make sure that excavation/ construction/disposal/backfilling activities are carried out such as not to jeopardise the anticipated initial state for the passive post-closure development ("operation") of a sealed and closed repository.

As accounted for in the introduction, the general regulations do not focus very much on construction activities for establishing new facilities. Also, the concept as well as requirements on content and structure of the safety analysis report (SAR) is based on the operation of conventional process type of nuclear facilities, i.e. nuclear power reactors or a waste treatment or storage facilities. Hence, the general regulations for a deep geological KBS-3-type repository must be applied with due consideration to the specific character of the facility, i.e. a repository under continuous excavation/construction/
disposal/backfilling and partly closure. For the same reason, the traditional concept for a SAR may not be appropriate for a disposal facility in a state of continuously changing environment.

Constraints related to construction and operation from post-closure safety

For conventional non-nuclear facilities, ordinary norms and standards are applicable. Conventional requirements valid for any facility exists for e.g. rock excavation, mining, concrete structures, worker safety, fire safety, ventilation, electrical installations etc.

For any nuclear facility additional requirements apply with regards to operational nuclear safety and radiation protection. Those additional requirements can be described as imposing restriction on conventional non-nuclear facilities, i.e. the same type of activity that is performed in a conventional non-nuclear facility may be subject to harsher control and less flexibility when performed in a nuclear facility.

For a spent fuel repository designed to provide post-closure containment and isolation, additional restrictions apply due to the risk for potential interference with post-closure safety. Those additional requirements impose even harsher restrictions on the construction and operations of a repository compared to conventional nuclear facilities.

Within the regulatory framework, two pieces of regulations have been developed to address mainly requirements on consideration of post-closure safety, which is not addressed per se in the general regulations [2], [3]. These regulations are applicable only for disposal facilities and supplement the general regulations that apply to all types of nuclear facilities.

Unusually long timeframes

The unusually long time frame for realization of the project poses specific challenges on the regulator as well as the implementer. Current plans envisage closure of the repository in 50 or 60 years from now. The historical/technical development during the last 50-60 years illustrates the necessity to allow for flexibility during the period between licensing and de-licensing of a deep geological spent fuel repository. Especially as regards the need for flexibility and continued development of the disposal concept as defined in the license application and approved when granting the license. The license, including specific licenses conditions, must be specific enough to determine whether the proposed disposal concept is safe and robust enough to be approved for implementation. At the same time, the license – including specific conditions – must be flexible enough to allow for development/refinements of the concept, e.g. due to scientific or other development.

Concluding reflexions

Normally, the establishment of a nuclear facility is completed within a period from a few up to ten years, depending on the character of the facility. Also, the main phases in the life cycle for the facility, (e.g. construction, trial operation, routine operation and decommissioning) normally occur in sequence. For a Swedish KBS-3 type spent fuel repository, the situation is quite different.

Construction activities will continue in parallel with emplacement of spent fuel packages for 50-60 years until the repository is sealed and closed. Such a situation, with a constantly changing environment, was not envisaged when the general regulations was established in the late 1990's. The licensing and implementation of a spent fuel repository therefore require specific attention to the application of regulations with regards to the specific characteristics of the repository, especially with regards to constraints from post-closure safety related to construction and operation activities.

Also, the unusually long time frame for realization of the project poses specific challenges on the regulator as well as the implementer. The license, including specific licenses conditions, must be specific enough to determine whether the proposed disposal concept is safe and robust enough to be approved for implementation but also flexible enough to allow for development/refinements of the concept.

References

[1] The Swedish Radiation Safety Authority's General Regulations concerning Safety in Nuclear Facilities, SSMFS 2008:1

[2] The Swedish Radiation Safety Authority's Regulations concerning Safety of Disposal of Nuclear Material and Nuclear Waste, SSMFS 2008:21

[3] The Swedish Radiation Safety Authority's Regulations on the Protection of Human Health and the Environment in connection with the Final Management of Spent Nuclear Fuel and Nuclear Waste; SSMFS 2008:37

Final repository for spent nuclear fuel-the role of the municipality – M. Berggren and V. Lindfors (Municipality of Östhammar)

Final disposal of spent nuclear fuel – a responsibility across generations

A nuclear power plant creates waste that is highly radioactive and dangerous for 100,000 years. For this reason the waste must be stored in a way that guarantees safety for a very long period of time. The health and safety of future generations cannot be jeopardized.

The municipality of Östhammar has, throughout time, been an active part in the process to bring forward a solution for spent nuclear waste that is as safe as it possibly can for the inhabitants in our municipality. The two municipalities of Östhammar and Oskarshamn do believe that they have been an asset for the process and contributed to make the project more understandable for the general public.

The process of reviewing the SKB application for construction and running a repository for spent nuclear fuel by the authirities has just begun and will take several years to complete. At this workshop we will give an input of what can be expected if all the permissions are given and the local assembly of the municipality of Östhammar has said yes to the project as proposed from

SKB and with statements from the authorities that are positive. All conditions for the facilitiy due to health and environment safety and nuclear long term safety are also in place.

The context for the municipality

In Sweden there is a long tradition of local self-government which is enshrined within the Swedish constitution, and the municipalities are responsible for matters relating to our inhabitants and their immediate environment. The municipality of Östhammar is one of 290 municipalities within Sweden, and are in charge of primary and secondary education, childcare, elderly care and care for disabled among many other areas. The municipality is also responsible for water supply, sewerage, streets, rescue services, refuse collection and waste disposal as well as health and environment protection and spatial planning.

Even though municipalities have a strong position in Swedish society they must comply with central government decisions that affect the activities of the municipality. The activities also have to be consistent with the provisions, for example the Environmental Code and the Planning and Building Act, as well as other legislation and guidelines issued by the Parliament, central government and government agencies.

Local self-government is important in democratic terms. The citizens´ closeness to descision-making makes it easier for them to gain access to local politicians and hold them accountable for their decisions.

The municipality of Östhammar has a total area of 2 790 km2 whereas almost 50 % is water and consists of 21 400 inhabitants in wintertime which, with the long shoreline and the attractive archipelago, increase almost five times in the summertime. The central village is Östhammar with app. 4 500 inhabitants. The closest village to the powerplant of Forsmark is Öregrund with 1 600 inhabitants, some 20 km from the area of Forsmark.

The municipality and a repository for spent nuclear fuel

The municipality has been engaged in the project of final repository for spent nuclear fuel, more or less since 1995 when it first applied for money from the nuclear waste fund. By that time a consultative committee was established with representatives from all the political parties within the municipality and neighbouring municipalities.

Future potentials as well as threats must be considered when making decisions on the most favourable site and the method used for the disposal of nuclear waste, and the application from SKB, as well as the review by the authorities, must stand up to a number of public demands.

The work has included several stages of decisions for the municipality, due to the site selection process for SKB. The dialogue between the municipality and SKB as well as between the municipality and the authorities has been of great importance for getting the stepwise decision making process that has become practice in this question.

The municipality has intensively followed the process concerning establishment of a final repository through consultation meetings, by being observateur on meetings between SKB and Swedish Radiation Safety Auhority (SSM), seminars, statements etc. The openness and transparency throughout the process has been essential between all acteurs.

We have identified the need of simplified language within reports to make it accessable to the general public and also with meetings between the municipalities and SKB as well as with the public. The information has been processed within the municipality and put forward to the public through seminars, hearings, articles, adverts and web-pages.

The municipality has taken all opportunities to ask questions, to demand investigations and surveys in questions that really matters to people living in our municipality and to let all kind of voices be heard.

As descibed earlier in the paper the responsibilities for the municipality are multiple. The financiation has been a necessity for the municipality to make it possible to establish knowledge and awareness amongst the politicians and to work as an asset within the process of final repository in comparaison and with no competition about tax payers money for elderly care, health care, infrastructure etc. There has been 5 elections over time and there will be several more until all final repositories are in place; HLNW, HLLW, MLW and LLW (No decisions whatsoever is made on the repository for high level long lived waste)

Spatial planning, building permit and environmental protection

According to Swedish legislation, municipalities have a very high degree of self governence when it comes to spatial planning and building permit. All municipalities are obliged to assign a local authority that makes independent decisions about planning and building in the local society.

All spatial planning is made as layout plans that describe how the geographical area preferably should be used. Plans are confirmed by the Local Council, but the Urban Planning Committee elucidates the plans while dealing with building permit applications. The County Administrative Board can overrule municipal decisions if they are contrarious to the Planning and Building Act or to the Environmental Code.

In 2008, the Local Council confirmed a plan that makes it possible to give a building permit for a final repository for spent fuel in the Forsmark area. The spatial plan is valid for 15 years and admits buildings on the ground and a deep geological repository at least 400 m deep in the bedrock. When SKB applies for a building permit, an application will be considered by the Urban Planning Committee in the same manner as any other industrial establishment. The time limit for reviewing the application is limited by the legislaton to a maximum of 20 weeks. There has been a discussion at Nuclear Energy Agency workshops whether a repository for spent fuel could be constructed to contribute an added value to a society. The Swedish legislation does not give support to claim that, but it does not prevent us from making settlements with SKB. Any claims beyond what is demanded by the Planning and Building Act however have to be addressed by the Local Council. The Urban Planning Committee does not have authorization to do that.

The municipal role according to the Environmental Code is more delimited. The objectives of the Environmental Code are to protect the health of citizens and impact on the environment. Large industries are monitored by the County Administrative Board and that is also the case for a repository for spent fuel. Municipalities monitor smaller industries. In Östhammar municipality the Urban Planning Committee also is the local authority for environmental protection, but the role in the final repository case, is restricted to give a statement to The County Administrative Board on their request. The Committee can comment on long term safety aspects, but has instructed the department to focus on impact that may cause trouble during the construction phase.

The role of veto

In the 70´s the need for a decision from the government concerning issues about establishment of industries and activities that had a severe impact on the natural resources and environment was identified. There was a necessity for a descision maker that could put in all aspects of environment protection, labour market politics and regional politics for the interest of Sweden as a whole. During the 80´s several types of industries and activities were identified (for example paper mills, iron melting plants, industries for production of fertilizers, different kinds of energy production plants (including nuclear power plants) etc and other nuclear facilities like repositories) and the possibility for the municipalities to say no to the project (use their veto) was established in Swedish law. The government has to ask the municipality whether or not they can accept the project, before making the final decision about permission. The reason for the veto was due to the strong self-governance of the municipalities in spatial planning and issues of sitingas already described.

The municipalities have for several of the establishments, absolute veto. But for some, the government still can say yes even if the municipality has said no. The government shall, in that decision, make clear that the interest and need for society is so important that an establishment should take place despite the different problems and impact that have been presented to them. Nuclear facilities that also need permission from SSM are included in the latter. The government has to take into account whether or not there is an acceptance in the municipality, if the localisation could be done somewhere else with the same effort and precautions to get the same result despite higher costs if the municipality is negative, before they make a decision to overrule the municipality.

We are happy to share our knowledge

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Session Report – S. Smith (US NRC)

Finland – Challenges

The actual licensing procedure starts after the Government's decision-in-principle. The construction license is granted by the Government and must be applied before end of 2012. In order to receive a license, it must be ensured that the protection of workers, safety and environmental protection have been taken into account as appropriate. In addition, the construction of a final disposal repository and an encapsulation plant requires permits in accordance with the Environmental Protection Act and the Water Act, and a municipal building permit. A hearing procedure involving municipalities, authorities and citizens will be established during the application process for the construction license.

For the efficient use of both rock resources and manpower it was considered natural to design the ONKALO characterization facility in a way that it could later be used as an access way to the repository as well which implied that the design and construction of the facility should comply with nuclear regulations.

The focus of monitoring during construction should be placed on potential changes connected to long-term safety issues. These included geohydraulic, geomechanical or geochemical disturbances. The hydraulic changes could entail geochemical effects, but further geochemical effects could also be caused by the "foreign" materials used in the construction.

During construction the challenges for the implementer and the regulator are :

- QA program for construction
- how to control compliance with regulations and rules under each permit/license during construction
- how to react to new information during construction
- managing coordination/communication issues with contractors
- managing design changes and parallel investigations
- limiting groundwater inflow
- worker safety: accidents and improving safety measures
- management/control procedures for long term safety
- monitoring program during construction and operation (water levels, geochemical changes, rock movements, traffic, foreign materials)
- ensure construction retains geo- environment needed for safety functions
- some degree of flexibility in regulatory review and assessment
- education of workers: identify differences as compared to conventional rock engineering
- applicability of mining regulations

Sweden – Challenges

The site selection process for the final repository for spent nuclear fuel was initiated in 1992 and resulted, in June 2009, in the selection of Forsmark as the selected site for the final repository.

Nuclear facilities require permits in accordance with the Swedish Environmental Code and the Nuclear Activities Act. SKB has submitted two applications to SSM (the Swedish Radiation Safety Authority) according to the Nuclear Activities Act and one to the Environmental Court according to the Environmental Code. The application according the Environmental Code includes the whole KBS-3-system - the final repository in Forsmark, the existing interim storage facility and the encapsulation plant in Oskarshamn.

The challenges for the implementer and the regulator are the following:

- number of documents to elaborate and structure of these documents
- right of veto of municipalities
- management of a complex licensing process
- change from R&D to industrial operations implying the creation of a sizeable construction department in SKB
- strengthening of technical bases
- application of regulatory framework in a different situation compared to conventional process type nuclear facilities
- understanding and addressing constraints from post-closure safety related to the construction and operation of the repository
- management of the time frames of repository operation requiring flexibility and continued development of disposal concept
- flexible regulations: 1st use as basis for licensing a new nuclear facility; making adjustments for structural changes during construction and operation
- ensuring excavation/construction/backfill activities do not jeopardize conditions for passive post-closure
- application of general regulations for a KBS-3 type repository with consideration to the specific character of facility, i.e. continuous construction
- Traditional SAR - may not be appropriate for a facility in a state of continuous change
- maintaining public confidence, openness and transparency with public, host communities, and other stakeholders
- production reports that provide evidence of compliance with safety requirements and feasibility of construction

Preparing as an organization, to submit or to review a construction license application for a DGR of ILW and HLW in France

French National Case – Andra - Preparing to Submit Cigéo’s Creation License Application

F. Boissier, T. Labalette, P.C. Leverd and S. Voinis (Andra)

The reversible repository in a deep geological formation is the French reference solution for the long-term management of high-level and intermediate-level long-lived radioactive waste. Since the first French Act on nuclear waste management research (Act of the 30th of December 1991), Andra has carried out twenty years of conceptual and basic studies on the subject, leading in particular to the feasibility demonstration in 2005 and to the choice of the detailed reconnaissance zone (ZIRA) in 2010. Taking advantage from this work, Andra has now reached a new phase where the project is engaging in the design of the industrial installation named Cigéo. At this stage, the further development of the project implies that Andra undertakes a multiplicity of actions in order to successfully reach various external and internal key milestones. Of paramount importance is the careful articulation between a) the regulatory authorization and decision processes and b) the outcome of the industrial installation design phases.

The French Act on radioactive waste of the 28th of June 2006 and the other French nuclear regulations (e.g. the Decree of the 2nd of November 2007) build a regulatory framework that plans a succession of step by step decisions stages (**dates in bold** are fixed by the 2006 Act):

2013 – Public debate organized by the Public Debate National Commission;

> Some of the main issues that will be debated during this phase of dialogue with the public concern the reversibility, the memory keeping and the environmental and health survey modalities. In addition to the debate, a dialogue has started with the local stakeholders within the framework of the inter-district territorial scheme elaborated under the aegis of the Meuse Prefecture. Its goal is in particular to harmoniously define and plan the external infrastructures that have to be developed to support the construction and the operation of Cigéo (roads, railway tracks and terminal, power and water supplies, housing and territorial development…). This territorial scheme will be presented during the public debate. The Meuse and Haute-Marne districts request a sustainable partnership for hosting Cigéo. Prior to the public debate, Andra will propose a location for the surface facilities based on the current local dialogue and on technical studies. The location of the surface facilities will be validated after the public debate;

2015 – Creation license application and start of the regulatory review process;

> The content of the application file is defined by the 2007 Decree. It comprises notably various plans of the installation, the description of the solution envisaged for the closure of the facility, the preliminary safety case (operational safety, long-term safety, protection against malevolent actions, management of incidental situations, preliminary acceptance criteria…), the environmental impact studies (health, salubrity, transports, human activities, nature, patrimonial aspects…). These elements shall be produced on the basis of a sufficient detailed design, so that the safety authority can appreciate their industrial feasibility and their required performance in terms of safety. Furthermore, the review process of Cigeo's creation license application includes its evaluation by the national evaluation commission (CNE), the local councils and the parliamentary office for technical and scientific choices (OPECST). At the end of the review process, the government will present a bill in parliament in order to define the conditions of reversibility;

2016-2017 – New parliamentary Act on the reversibility conditions of the repository;

> The reversibility of the repository should be granted, as a precaution, for at least 100 years (2006 Act). Based on the analysis of the various potential motivations for reversibility, Andra will favor an approach relying on:
>
> - technical measures enhancing the retrievability of waste packages;
> - stepwise decision-making to control the disposal and closure processes at their key stages;
>
> The decision-making process, comprising information and involvement of the stakeholders (e.g. during periodical reversibility assessments), may be defined in this Act and therefore be strengthened. According to the 2006 Act, the final closure of the repository can only be authorized by a parliamentary Act;

2018 – Creation license granted by Decree;

According to French regulations, a creation decree must be preceded by a public enquiry. The creation Decree authorizes both the construction of the facility and the nuclear operations to be performed. An explicit and unequivocal safety demonstration has to be provided for these operations in the license application. In the case of Cigéo, the authorization for operations foreseen in the far future may be granted on the prerequisite that complementary dedicated files are transmitted in due time. This regulatory mechanism may be generalized to all operations for which complementary elements are found necessary by the regulator;

2025 - Commissioning of the repository;

The nuclear operations will start with the reception of the first waste package provided that the repository is commissioned by the safety authority. At this stage, the commissioning encompasses only the first part of the facility. Beyond 2025, construction and equipment work will be carried out concurrently with nuclear operations in the previously commissioned parts.

Besides the above mentioned procedures, Andra faces a number of other regulatory steps. Amongst these, the most notable are:

- Safeguard and security (physical protection of the facility and of information) regulatory authorization procedures;
- Declaration of "public benefit" of the project and building permit administrative process;
- Land acquisition and site preparation (preventive archeology, land clearing and woodcutting permit);
- Euratom declarations.

Internally, Andra has planned the outcomes of the successive facility design phases with the preparation of the various above mentioned application files to be transmitted to the regulators. The associated safety analyses are used to support the license application files and to iteratively feed the facility design:

2011 - Launch of the industrial project (requirements and technical specifications achieved, tender for the selection of system prime-contractor). The contract was signed early January 2012 with the Gaiya group, made up of the two engineering companies Technip and Ingérop;

2012 - Outcome of the sketch industrial design phase at the end of the year;

2014 - Outcome of the basic industrial design phase, with a more detailed level for the issues related to safety;

2015 - License application;

2016 - Outcome of the detailed industrial design phase.

In parallel with the regulatory procedures, continuous exchanges are undertaken with the waste producers, namely to identify and meet their industrial needs and to plan the reception of the waste over the period of operation. An international review of the project could also be envisaged.

During the periods of design, construction and operation of the repository, research and technical developments will constantly be carried out in Andra's underground research laboratory in Bure and in laboratories at surface in order to verify parameters, develop equipment, optimize disposal solutions and tackle potential emerging issues. The license of Andra's underground research laboratory in Bure has been extended until 2030.

Preparing to review the license application of the French geological disposal facility - Issues, challenges and perspectives – G. Dandrieux (ASN)

Context for GDR authorization

- Radioactive waste from the whole fuel cycle (58 NPP, dozens of research reactors and labs, reprocessing facilities)
- Project of national interest (political issues, cost issues, number of reviewers and stakeholders…)
- Long term project (development spans over decades)
- Specific authorization processes (e.g. in France - Parliament)
- Specific technical issues - A DGR is a complex object
- Public involvement

A French dedicated legislative framework

28th June 2006 Act on sustainable management of radioactive materials and waste

- The GDR is the reference solution for the management of long lived high and intermediate level radioactive waste (+ reprocessing policy)
- Defines the framework and proceedings for DGR licensing
- Gives the national agency for radioactive waste management Andra (state owned organization) the mission to design, construct and operate disposal facilities
- Defines milestones for preparation of the license application and plans for intermediate reviews
- Plans for R&D programs to be implemented (siting/safety demonstration/construction/..) in an URL hosted in the same host rock as the DGR
- Defines the funding system for the DGR
- Defines the roles of the actors (ASN, CNE, Andra, …)
- Includes Public consultations and Parliament involvement in the licensing process
- Requires the DGR to be reversible for at least 100 years

Challenges

Regulatory issues

- Development of dedicated regulations (site selection, construction/operation/closure requirements including LT aspects and reversibility)
- Adapting general regulation to specificities of a DGR (3D facility, specific licensing process, …)

LT project supervision : early involvement of the regulator

- To review intermediate safety cases
- To take position on R&D programs (demonstration of safety)
- To define appropriate milestones and specific technical reviews
- ! Avoid co-design

Technical issues

- Technical and scientific challenges for the operator and reviewers / few experience feedback on specific topics
    - o demonstration tunnels/vaults/sealings …
    - o regulatory R&D to support the evaluation
- Pluri-disciplinary project
- Dealing with uncertainties (e.g. : with respect to long term safety)
- New notions (e.g. optimization principle as applied to GDR: what is it? Associated requirements? How)

Procedural issues

- Defining expectations for the content of the SC (details, …)
- Integrating the future Law on reversibility (> license application submission)
- Defining content of license to allow for flexibility
    - o Dealing with open choices for the future (eg : identified optimization techniques or design)
    - o Consistency with technical optimization
    - o Defining hold points (construction, other operations)

  Under discussions

Preparing for the review of the DGR license application

- Intermediate reviews (2001, 2005, 2009, + other technical reviews)
    - o Recommendations to Andra for the LA (including on R&D)
- New specific regulations :
    - o 2006 Law on sustainable management of radwaste
    - o Safety guide on the disposal of radwaste in DGR (2008) : safety objectives and principles, site selection

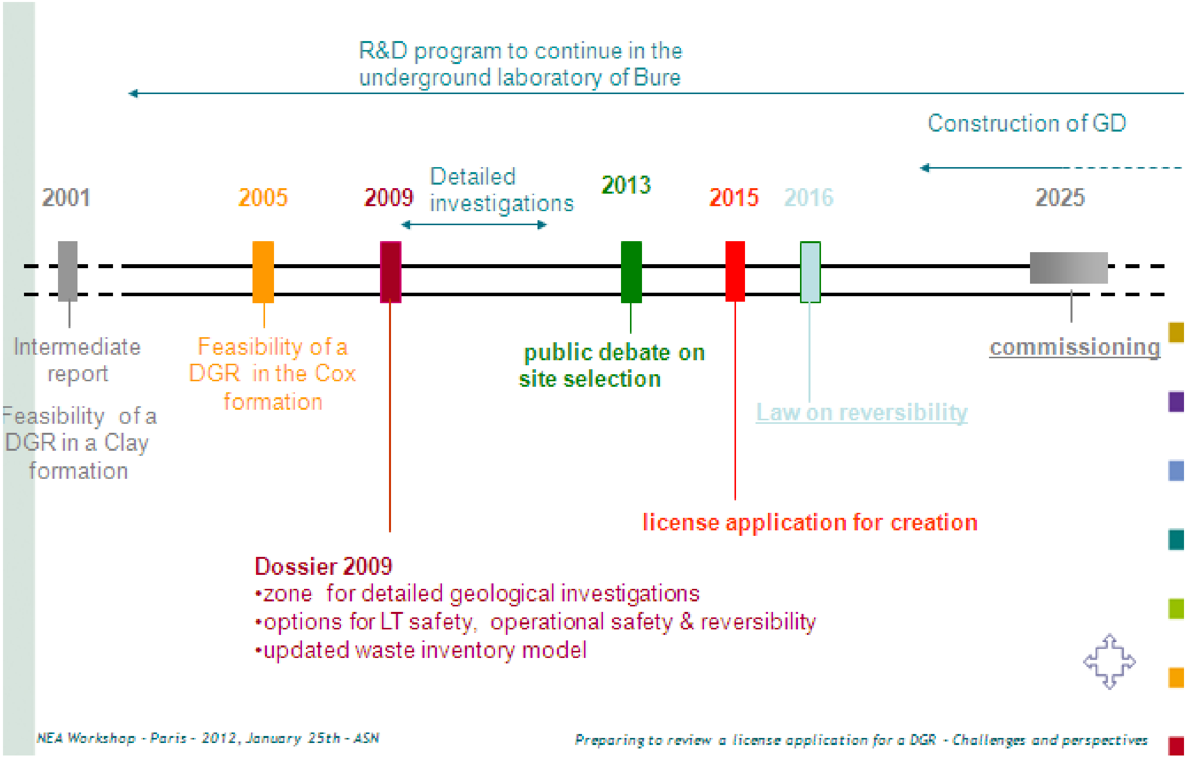
- Regulation on design, construction and operation of disposal facilities under development
- Updating regulation on waste conditioning and waste acceptance

- Developing/maintaining expertise throughout the DGR development
    - Dedicated technical experts at IRSN (ASN TSO)
    - Dedicated regulatory research laboratory (Tournemire)
    - Permanent Expert Group for Waste (kept informed on technical issues)
- Advanced dialog with the future licensee- Andra : meetings on technical or regulatory issues
- International benchmark (multilateral/bilateral, WENRA, EPS…)
- As license application for creation of the facility is approaching:
    - Consolidate human resources dedicated to the project
    - Develop the inspections program (e.g. oversight of construction)
    - Develop interactions with stakeholders (current: National Plan for rad waste management, local committee for information)
    - Develop communication on ASN missions and actions with respect to DGR

Conclusions and Perspectives

- Importance of adequate legal /regulatory framework (high level commitment, milestones, financing system)
- National Agency in charge of design and operation of disposal facilities
- Regulatory body involved in the project early in the process but avoid co-design with the implementer (intermediate reviews)
- Independence of Authorities
- New steps forward in France :
    - 2013 : Public Debate on the location of surface facilities in connection with the underground geological repository facility to be built in the Meuse/Haute Marne departments
    - 2015 : Andra to submit license application for DGR

Preparing for the review of the CIGEO license application



Experience in the Canadian programme in preparing for DGRs of all waste types

Preparing for Canada's DGR Projects – P. Gierszewski (NWMO)

The presentation gives an overview of two Canadian Deep Geologic Repository projects, and draws on this experience with respect to the Workshop topics of Issues for Construction, Preparing as an Organization, and Optimization.

The first project is the Ontario Power Generation proposed DGR for Low and Intermediate Level Waste. This facility would be sited at the Bruce nuclear site near Kincardine, Ontario. The project is currently in the Environmental Assessment and Site Preparation and Construction Licencing stage.

The second project is the Nuclear Waste Management Organization's proposed DGR for used fuel. This facility is currently in the siting phase. This is a staged process to find a willing and informed host community. Currently several communities have indicated interest in learning more about the project and having an initial feasibility screening conducted on their area.

Construction of a DGR is a large undertaking, with numerous technical topics to be addressed that may not be initially considered as part of conceptual design and initial postclosure safety assessment. Examples of construction issues that may affect the design are:

- Site access (supplies, access, workforce, and infrastructure);

- Shaft sinking approach, and ensuring it aligns with need for geoscientific information and postclosure performance;
- Local rock stresses impacting DGR design and layout; and
- Regulations applicable to DGR and their implications.

Examples of topics that need to be taken into account with respect to transitioning as an organization from a research or siting group to preparing to build a DGR are:

- Staffing, and evolution of required skills;
- Establishing appropriate Quality Assurance processes;
- Establishing design / records management;

Optimization proceeds in stages. During conceptual/preliminary design, there is iterative development of the safety case between geoscience, engineering and safety assessment. During detailed design, this continues but to a finer level of detail. During construction, the design continues to be revised based on the observed underground conditions. And finally, during operations, monitoring of the repository behaviour leads to optimization of the closure plans.

Canadian experience with the above topics is illustrated in the presentation.

Experience in the Swiss programme in preparing for DGRs of all waste types

The implementer's view – P. Zuidema, J. Schneider and T. Fries (Nagra)

Background information on the Swiss waste disposal programme and its current status

In Switzerland, all radioactive wastes have to be disposed of in deep geological repositories. Two repositories are foreseen, a HLW repository (for spent fuel, vitrified HLW from reprocessing and long-lived ILW) and a L/ILW repository (for NPP operational and decommissioning waste and waste from medicine, industry and research). Furthermore the possibility exists to have both repositories at the same site with combined surface infrastructure but with the disposal rooms spatially separated either in the same or in different rock layers.

Switzerland has an implementation strategy that consists of many steps. After the demonstration of the feasibility of safe disposal of all categories of waste in Switzerland was confirmed by the Federal Government in 2006, the focus was shifted towards site selection. The site selection process started with the publication, by the Federal Office of Energy, of the "sectoral plan for deep geological repositories" in April 2008. The process defined by the sectoral plan, which is divided into three stages, will lead to the selection of the sites for the two repositories as part of the general licence application procedure. The sectoral plan foresees strong involvement of the public in the siting regions, especially in conjunction with the siting of the surface facilities of the repositories. The Federal Office of Energy is responsible for managing the sectoral plan including the participation process to involve the public. For each of the repositories, the general licence is then followed by a construction licence, an operation licence and eventually by a licence to close the repository. The Federal Government decided on November 30, 2011 as endpoint of Stage 1 of the sectoral plan to accept all the six siting regions (three for HLW, six for L/ILW, with some overlap) that were proposed by Nagra in October 2008. The decision of the Federal Government is based on the results of rigorous reviews by the different authorities (including ENSI) and their experts as well as on the results of a broad consultation process. Stage 2 of the sectoral plan has now started which will lead to the selection of sites for the surface infrastructure of the repositories in the six siting regions and a subsequent narrowing down to at least two siting regions per repository type mainly based on considerations regarding safety and technical feasibility. In Stage 3 of the sectoral plan, the sites for the HLW and L/ILW repository will be selected and the general licence applications will be prepared.

Basic approach to developing the repositories

When developing a repository concept and selecting a site, it is important to consider all elements that are essential for implementing a repository. Besides post-closure safety, it is important to consider also the feasibility to reliably construct, operate and close the repository at least at a conceptual level. This also includes the evaluation of conventional and radiological safety during these phases.

To ensure that all relevant issues are considered in the development of the repositories, a requirements management process is used by Nagra. This process considers legal and regulatory requirements, the needs of the waste producers (e.g. requirements regarding the wastes to be disposed of), scientific and technical boundary conditions and stakeholder expectations.

When developing the repository concept, it is considered important to keep the complexity of the repository and its operation at a reasonable level (Motto: “keep things as simple as possible, introduce complexity as far as necessary”). This will contribute to reliable and efficient construction, operation and closure of the repositories.

The approach to developing a repository also takes into account the stepwise decision-making process. In this process, it is essential to maintain flexibility to take into account information becoming available only in later stages and to allow for learning also from experience in other programmes (Motto: “decide as late as possible, decide as early as necessary”).

A broad overview of key requirements and issues related to radiological safety

Disposal facilities

Swiss legislation requires that all radioactive wastes (HLW, LL-ILW, L/ILW) will be disposed of in (deep) geological repositories. The geological repositories must contain the following elements: the main facility, the pilot facility and test facilities. Test facilities (equivalent to a site-specific URL) are used to obtain additional information to build and operate the repository and as input for safety analysis required for the construction and operation licence application. The wastes will be emplaced in the main facility; the pilot facility (with the engineered barriers and the cross-section of the disposal rooms exactly the same as the main facility) contains a small but representative spectrum of waste packages and is used for extended monitoring during emplacement of the wastes and afterwards during the monitoring phase which can last for several decades or more. During the emplacement and monitoring phases, the retrieval of the wastes must be feasible without undue effort.

Post-closure safety as a dominant factor for site selection

Post-closure safety must be ensured by a system of passive barriers. Both the geological and the engineered barriers must contribute to safety. In the current phase of the repository development programme the main emphasis is on site selection and therefore on requirements related to geology. The broad categories of requirements cover (i) the barrier functions of the host rock, (ii) long-term stability, (iii) construction feasibility and (iv) reliability of site exploration, of rock characterization and of evaluation ("prediction") of future evolution to ensure a reliable safety case. However, site selection also requires considering the key characteristics of the layout of the repository and of the engineered barriers and their key functions. This also results in requirements such as (i) a geological environment that ensures that the engineered barriers perform as intended, considering also their temporal evolution and (ii) limiting repository-induced effects on the host rock barrier to an acceptable level.

Safety during the operational phase

To evaluate safety during the operational phase, according to Swiss legislation and regulatory guidance the following broad categories have to be evaluated: (i) normal operation, including operational deviations (likelihood of occurrence, $p > 10^{-1}$ /a), (ii) incidents ($10^{-1}/a \geq p > 10^{-2}/a$), (iii) accidents ($10^{-2}/a \geq p > 10^{-4}/a$) and (iv) unlikely accidents ($10^{-4}/a \geq p > 10^{-6}/a$). Furthermore, also (postulated) severe accidents (beyond design) are considered. For these categories different dose criteria apply.

Radiological safety during normal operation has to consider doses due to direct radiation as well as doses due to inhalation of airborne radioactivity from the waste packages and due to the release of natural radioactivity from the rocks (e.g. radon).

For the evaluation of incidents/accidents as part of operational safety, the initiating events are divided into (i) internal events, (ii) external events and (iii) events related to security taking into account aspects in connection with safeguards. These events may lead to an impact on some waste packages which may result in the release of radioactivity through mechanical impact (e.g. waste package drop due to equipment failure), thermal impact (e.g. fire), through exposure to water ((partial) flooding of facility) or a combination of these. Furthermore, the events may also affect safety-related elements of the repository (e.g. structures, installations, equipment). This possibility is also considered in the evaluation.

To ensure operational safety, such undesirable events have to be prevented or the likelihood of their occurrence to be kept sufficiently small and the consequences (e.g. release of radionuclides to the environment) have to be limited if such events nevertheless occur. This implies that measures have to be taken (i) through appropriate design (including design of handling devices / transport containers and shielding), (ii) through specific organizational / administrative measures (including the use of an appropriate operating scheme) and (iii) by ensuring adequate properties of the waste packages through corresponding waste acceptance criteria (nuclide inventory, properties of waste matrix, properties of waste package, etc.).

For the surface facilities, internal events and events related to security / safeguards and the way that they are managed are in principle comparable to those for similar, already existing nuclear installations (e.g. interim storage facilities, facilities for loading / unloading of transport containers, facilities for treatment / packaging of radioactive wastes) and thus, by analogy, their management is considered feasible through adequate design and operating schemes. Experience with similar existing nuclear facilities shows that the same is true for natural (flooding, soil/rock slides, forest fires, earthquakes, etc.) and anthropogenic external events (airplane crash, hazards due to nearby industry and transport (transmission lines, pipelines, road, railway lines, etc.)). For some external events such as severe flooding (especially when combined with erosion) the measures needed for adequate protection against these events may depend on the site selected for the surface infrastructure and thus are to be explicitly considered in the site selection process.

For the underground facilities, internal events, external events and events related to security / safeguards must also be considered. For the evaluation, it may be convenient to distinguish between (i) transportation of waste packages from the surface down to the level of the waste disposal rooms and (ii) the subsequent handling of the waste packages (transportation and emplacement in disposal rooms). Transportation of the waste packages from the surface down to the disposal rooms in the host rock can either occur through an access tunnel (e.g. by rack and pinion railway) or by shaft. Experience (e.g. from mining operations) and the project work in other waste management programmes shows that both options can provide a sufficient level of safety; thus, both options are considered in the design of the repositories.

For the underground facilities, special attention has to be given to the ventilation system and to sufficient redundancy and diversity in evacuation and rescue routes (multiple shafts / access tunnels).

Key issues related to the construction and operation of the repositories

Construction of the repositories

Construction of a repository includes implementation of the surface infrastructure, building the access routes to the host rock, excavation of the tunnel system within the host rock and excavation of the disposal rooms. Construction of the surface infrastructure (buildings, installation of equipment) is comparable to the construction of similar existing nuclear facilities (e.g. interim storage facilities, waste treatment facilities) and represents no special challenge. Construction of the underground facilities is in principle also comparable to other underground constructions such as tunnels or mines. However, the excavation of the disposal rooms and of sealing zones may require special attention to keep the damage to the surrounding rock as small as reasonably achievable.

The geotechnical conditions in the host rock are well known due to the extensive geological characterization work and are taken into account in the layout and design of the facilities (e.g. by avoiding geological structures that pose special construction challenges and by using a construction method and a liner layout adjusted to the geotechnical conditions expected). Preparatory work also includes geotechnical experiments in the site-specific URL especially for optimizing the layout of the disposal rooms (construction method, cross section, layout of liner).

In Switzerland, the underground construction needed to access the host rock (e.g. access tunnel, shafts) has to cross a range of different rock layers with differing properties which are characterized as part of the exploration programme. Further detailed geological characterization of these rocks can be done during excavation with testing in front of the tunnel/shaft face to adjust, if necessary, the excavation method (including grouting) and the liner according to the local geological conditions. In extreme cases, the alignment of the access tunnel may also be adjusted.

For the HLW repository, construction of additional disposal rooms in parallel to waste emplacement is foreseen. This needs spatial separation of the activities (waste emplacement and construction work) and is also considered in the layout of the ventilation system.

Operation of the repositories

During normal operation it is a key objective to keep the doses at a reasonably low level (ALARP). This includes consideration of direct radiation and inhalation of volatile radionuclides. Direct radiation due to surface dose rates is kept low through shielding by the buildings (walls, etc.), but also through shielding of the waste packages (as delivered to the repository), the shielding of the disposal containers and the use of shielding for the (external/internal) transport containers. Sufficiently low dose rates are also important to allow for interventions in case of malfunction of equipment; this means that sufficient shielding (including temporal shielding) has also to be available in places/steps which under normal operation are not accessed. For several waste types, sufficient shielding of the external and internal transport containers is considered essential, because shielding of the waste package and of the disposal container alone is not sufficient for these waste types.

The release of volatile radionuclides is kept low through adequate treatment and packaging of the wastes (ensured through adequate waste acceptance criteria) and the doses can be further reduced by an appropriate design of the ventilation system. In the design of the ventilation system for the underground parts of the repository, the release of natural radioactivity from the rocks (e.g. radon) has also to be considered.

Furthermore, it is the aim to keep the facilities free from contamination wherever feasible. Therefore, the waste packages delivered to the repository are required to be contamination free. However, some contamination is expected in the hot cells of the spent fuel encapsulation facility, where spent fuel is transferred from the transport casks into the disposal canisters. Most likely, the transfer cells used to load the disposal containers with L/ILW will be contamination free, but in the design contamination is considered possible (e.g. due to the unlikely event of a defective waste package being delivered).

Also, in the case of incidents and accidents, the aim is to avoid any contamination and release of radioactivity. This can be achieved by a design and an operation scheme that ensures that impacts on the waste packages can either be prevented or are small if they occur, and by providing sufficient resistance to impacts through the quality of the waste packages, the strength of the disposal containers and the resistance offered by the transport containers. Only in the very unlikely case of a severe accident, some release of radioactivity is accepted; however, it is expected that even in those cases the release of radionuclides into the environment can be avoided or limited to very small levels.

For emplacing the disposal containers (loaded with waste packages) in the disposal rooms, they have first to be unloaded from the internal transport container. Therefore, in the disposal rooms an increased level of radiation is possible because the shielding of the internal transport container is missing and corresponding radiation protection measures have to be taken.

In the current phase of the project, it is the aim to identify those safety related aspects of repository operation that may have an impact on the basic design concept and on the basic operational scheme and thus might influence site selection. More detailed analyses will be performed in later stages of repository development.

Conclusions

In Switzerland, a stepwise approach is chosen to implement the repositories needed to safely manage the wastes arising in Switzerland. Although the Swiss programme is still in an early phase of implementation with the current focus on site selection, all issues relevant to construct, to operate and to close the repositories are considered at least at a conceptual level. The stepwise approach, which foresees that both findings from previous steps and from foreign programmes are taken into account at each step, ensures that optimised projects are developed.

Regulatory aspects of construction and operation in Switzerland – M. Hugi (ENSI)

The regulatory mission with respect to radioactive waste disposal in Switzerland consists of the following tasks: to assess proposed solutions and supervise the preparation for geological disposal of radioactive waste, to review the licence applications in accord with the stepwise implementation process; to supervise the transport of radioactive material to and from nuclear installations; to supervise surface facilities and underground installations of deep geological repositories; and to supervise the safety of staff and the public and their protection from radiation.

Related nuclear legislation consists of the Nuclear Energy Act, the Radiological Protection Act including the corresponding Ordinances, and the Ordinance on the Decommissioning Fund and the Waste Disposal Fund for Nuclear Installations. In retrospective, the recommendations of the Expert Group on Disposal Concepts for Radioactive Waste (EKRA – introducing the concept of monitored long-term geological disposal) had rather strong implications for the revision of nuclear legislation in 2003: In Switzerland, deep geological repositories are required for the permanent and safe disposal of all categories of radioactive waste including spent fuel. A deep geological repository (DGR) consists of a main section, a pilot section and test zones. During the operation and observation phase of the repository the recovery of the deposited waste packages shall be possible without undue effort.

Nuclear legislation contains detailed regulatory statutes that are in accord with the stepwise implementation process for DGRs regarding, for instance, design and construction, operation and closure of the disposal facilities. Both Nuclear Energy Act and Nuclear Energy Ordinance request from the regulator to develop explicit guidelines on specific regulatory issues, e.g. on the requirements for the conditioning of radioactive waste, and on specific design principles for deep geological repositories and requirements for the safety case.

The Nuclear Energy Act stipulates that the obligation to manage and dispose of radioactive waste is met if the radioactive waste has been transferred to a deep geological repository, and the funds required for the monitoring period and the eventual closure have been secured. Furthermore, the Nuclear Energy Act requires the waste producers *(represented by the repository implementer*) to draw up a Waste Management Programme that institutes a management instrument for the stepwise implementation process, specifying R&D needs and financial provisions for deep geological disposal. The programme is developed and periodically updated by the implementer on the basis of newly acquired knowledge, and is reviewed and assessed by the regulator.

Financial provisions for the disposal of nuclear waste are also regulated in the Nuclear Energy Act and in the Ordinance on the Decommissioning Fund and the Waste Disposal Fund for Nuclear Installations. Therefore, two separate funds have been established (i.e. decommissioning fund and waste disposal fund) into which the operators of nuclear facilities pay annual contributions.

Design, construction and operating principles for DGRs and requirements for the safety case have been developed recently by the Swiss regulatory body. The corresponding guideline specifies protection objectives, protection criteria and specific requirements for DGRs, defines the procedure to be followed for demonstrating the safety of a geological repository, and identifies requirements for the operation of facilities, as far as these are specific to DGRs, and for their closure.

The Nuclear Energy Act stipulates a series of licences that must be obtained prior to completion of a DGR – starting with a general licence, followed by the licences for construction and operation, and finally the closure order.

The main prerequisites for granting the construction licence for a DGR are protection of human health and the environment and compliance with the obligations stated in the general licence. The construction licence defines the capacity of the disposal facility, the main elements of the technical implementation and the basic requirements regarding emergency preparedness. The licensing authority is the Federal Department of Environment, Transport, Energy and Communication (DETEC).

The preconditions for an operation licence are the compliance with the obligations of the general and construction licence, protection of human health and the environment, compliance with the nuclear safety and security requirements, fulfillment of the requirements regarding staff, organisation, quality assurance and emergency preparedness. An operating licence for a DGR is granted if (among other conditions) it is possible to recover the radioactive waste packages without undue effort until closure of the repository. The licence shall specify certain requirements, in particular activity limits for the waste to be disposed. The emplacement of each type of waste requires a permit to be obtained beforehand from the relevant supervisory authorities. The operation licence defines in particular the limits for the discharge of radioactive substances into the environment and the radiological monitoring of the surroundings. It is granted by DETEC.

Granting of licences (e.g. construction licence and operation licence) is subjected to the fulfillment of a series of regulatory statutes that are connected to a particular licensing step in the stepwise implementation process for DGRs. These statutes represent the basis for the review process performed by the regulator.

With respect to underground construction work, a considerable practical experience is available in Switzerland from the construction of railroad and highway tunnels, hydro-power installations etc. Specific regulation for underground workings exists in terms of e.g. industrial and engineering standards, standards on operational safety and health protection. However, DGR requires special considerations regarding for instance excavation methods (preservation of containment capability of the geological environment - EDZ minimization), tunnel lining (compatibility of lining with geological environment and barrier materials - limiting gas production) and provisions for radiation protection during operation (radiologically controlled areas, installations for remote handling of emplacement operations). The fact that the excavation of disposal galleries and the waste emplacement operation may be executed in parallel also requires some special attention.

Practical operating experience is available from other nuclear facilities: nuclear power plants, interim storage facilities and waste treatment facilities. However, special consideration must be devoted for instance to aspects of conventional safety for underground activities, technical solutions for waste package emplacement and backfilling and sealing of disposal caverns and galleries.

Preparing as an organization to review a construction license application for a DGR for HLW and SF in the USA – B. Hill (USNRC)

Background

Yucca Mountain, Nevada was identified by the U.S. Congress in 1987 as the sole candidate site for constructing a deep geologic repository for the nation's spent nuclear fuel and high-level waste. By 2002, the U.S. Department of Energy (DOE) had completed sufficient characterization and analysis of the site to support a required Site Recommendation, which provided DOE perspectives on the safety case. Although formally opposed by the State of Nevada, this Site Recommendation was approved by the U.S. Congress and the President, which authorized DOE to prepare and submit a license application for the repository. In June of 2008, DOE submitted this application (DOE, 2008) to the U.S. Nuclear Regulatory Commission (NRC) for its review and formal adjudication of contested issues during a 3-4 year period. Although subsequent actions by the Administration and Congress have changed the direction for geologic disposal in the U.S., the NRC staff was able to conduct a thorough technical review of the DOE license application and issue technical evaluation reports before the review and hearings were suspended in September 2011. This paper provides the author's perspective on how the NRC prepared for, and conducted, this first-of-a-kind licensing review.

Planning Framework

As mandated in the Nuclear Waste Policy Act of 1982 (Public Law 97-425), NRC had 3-to-4 years to complete its review of the DOE license application, conduct hearings on contested issues of fact and law, and reach a decision on granting or denying a license to construct the Yucca Mountain deep geologic repository. A general framework was apparent in planning for this task:

- The engineering and geologic characteristics of the Yucca Mountain site were not duplicated in other national programs, and innovative science and technology was being used by DOE. Thus, NRC had to establish a high level of staff and contractor expertise, which was free from conflict of interest, in order to conduct a fair and thorough review.

- DOE and other stakeholders had conducted a wide variety of scientific and technical investigations during an approximately 20-year-long site characterization program, and all of this information would need to be available for the review and hearings. Thus, a dedicated information management system would be required.

- A mandated 3-4 year schedule for completion of the review and hearings represented unprecedented constraints on NRC's licensing framework. Interveners had conducted many technical investigations and had indicated that many contentions would be filed for the hearings.

Thus, successful completion of all needed activities would require advanced project management skills and detailed planning.

- NRC would use a risk-informed, performance-based regulation to judge the safety of the proposed facility for the next one million years. Thus, implementation of this regulation would require development of unique review plans and guidance to provide a transparent and traceable basis for the ensuing licensing decisions.

Key Preparations for Staff

NRC made use of staff experience in licensing to help prepare for the Yucca Mountain license application review. NRC staff conducted reviews and monitored proceedings of license applications for other nuclear installations. Although regulations for these installations were significantly different from those for a deep geologic repository, participation in these reviews provided several important benefits to staff. These reviews familiarized staff with the levels of information needed to support compliance with different regulatory requirements, and on effective interactions with applicants and interveners. Staff also was able to bring risk-informed perspectives to these reviews, which often were helpful in resolving technical issues. Staff learned how to effectively document the results of their reviews in safety evaluation reports and how to ensure that the basis for their regulatory decisions was clearly communicated.

Many of the staff had the opportunity to participate in developing site-specific regulations for Yucca Mountain (i.e., Title 10 of the US Code of Federal Regulations, Part 63). One important benefit was that staff had to interact collaboratively with the NRC's legal staff in developing regulatory language that was both technically and legally correct. For many staff members, this was the first time they had the opportunity to work extensively with legal counsel and to better understand legal concerns and perspectives that would be important during the review and hearings. Developing regulations also gave staff important perspectives on the types of information that would be needed to demonstrate regulatory compliance, and how to ensure that those information needs were clearly communicated to the applicant and stakeholders.

The Nuclear Waste Policy Act of 1982 (Public Law 97-425) envisioned pre-licensing interactions with DOE. Staff conducted many public meetings with DOE, primarily at or near the Yucca Mountain site, to discuss the ongoing DOE program. Although these meetings focused on the DOE investigations, they also provided a forum to discuss alternative models and data that were developed by the NRC staff and other interested parties. Technical issues discussed during the meetings did not commit any organization to a position during licensing, which facilitated an open exchange of information. As a result of these meetings, staff had a much more complete understanding of the complex information presented in the license application and of alternative information that was available.

Recognizing that sustained technical support was going to be needed throughout the prelicensing and licensing process, NRC established the Center for Nuclear Waste Regulatory Analyses (CNWRA). Beginning in 1987, CNWRA worked with NRC to develop the independent technical information that would be needed to review the DOE license application. The CNWRA staff primarily conducted laboratory and field investigations in geoscience and engineering disciplines, developed a broad range of numerical process models, and analyzed the significance of different features, events and processes using performance assessment codes. Close collaboration between NRC and CNWRA staffs (herein simply referred to as NRC staff) ensured that appropriate knowledge and skills were developed and shared.

Key Preparations for Processes

NRC staff anticipated that the DOE license application would be complex and supported by a large volume of information that might need to be reviewed. Many staff members would need to participate in concurrent reviews of pre-closure, post-closure, and administrative sections of the application, along with an additional review of the Environmental Impact Statement. For the hearings to be completed within 3-4 years, staff would have approximately 18 months to complete their technical reviews and document the results in Safety Evaluation Reports. A dedicated project management team was established to organize the staff into appropriate review teams, and develop a work structure that allowed the teams to meet critical milestones and move on to ensuing tasks. The editing, review, concurrence, and publication of the Safety Evaluation Reports also had to be planned carefully to ensure completion within the allotted time. The team devoted several years to developing a computerized project plan with a detailed work breakdown structure, which could adapt to unplanned changes in staff availability or deadlines.

By 1987, NRC recognized that an extraordinary amount of information would likely be available for the Yucca Mountain hearings and that an electronic document management system would be needed (NRC, 1987). Under NRC's regulations for conducting the hearing (i.e., 10 CFR Part 2), all of this information had to be available to all participants in the hearings. Although the design of this document management system evolved significantly over 20 years, the implemented system (called the Licensing Support Network, or LSN) used a centralized search engine that queried indexed databases containing each participant's document collection. The LSN cost about $16M USD to develop over approximately 5 years, which did not include the considerable amount of resources needed to organize, digitize, and index the documents or develop ancillary support systems (Graser, 2010). Following submittal of the license application, the LSN could access, search, and retrieve more than 84,000,000 pages of images, text, HTML and bibliographic components of documentary material (Graser, 2009).

NRC staff also had to develop a standard review plan that addressed the unique risk-informed, performance-based requirements in Part 63. This review plan had to be developed well before DOE submitted the license application, so that the applicant and other stakeholders would have a clear understanding of the criteria NRC would use to judge regulatory compliance. After receiving considerable stakeholder input on a draft, NRC published the Yucca Mountain Review Plan (YMRP) in 2003. Most importantly, the YMRP (NRC, 2003) had to provide review criteria for all topics that might be relevant to demonstrating pre-closure and post-closure repository safety. This is because NRC staff could not predetermine which topics the applicant would rely on as significant to safety. Nevertheless, NRC staff expected the review to take a risk-informed approach and focus on topics that were significant to safety (e.g., NRC, 2003, Section 2.2.1). Developing the YMRP took more than 3 years and involved significant effort by tens of staff members.

Events After the Receipt of a License Application

The DOE license application of June 2008 was over 8,000 pages in length and was supported by approximately 3,000,000 pages of additional information. More than 80,000,000 pages of supporting documents, data, and other information were available through the LSN. Interveners submitted 319 contentions by 22 December 2008, which required NRC staff review and input to the legal team for timely response. Nevertheless, the NRC appropriation for conducting the licensing review declined substantially in subsequent fiscal years, which led to significant reductions in staffing, underfunding of infrastructure, and delays in completion of key milestones. DOE also experienced reduced funding in this timeframe, and in March 2010 petitioned the NRC's Atomic Safety and Licensing Board to withdraw its license application. Although the Licensing Board denied the DOE's motion to withdraw the license in June 2010, it suspended the hearings in September 2011. The legal issues surrounding these events are being determined in the U.S. Court of Appeals (Case #11-1271).

In spite of these challenges, NRC staff issued the first of five expected volumes of its Safety Evaluation Report in August 2010 (NRC, 2010). Subsequently, the NRC staff was directed to document the results of their remaining reviews in technical evaluation reports before the end of September 2011. These reports provide a detailed evaluation of the technical basis used by DOE in its license application, using review methods and acceptance criteria in the YMRP.

Retrospective on Staff Preparations

First and foremost, decades of preparation formed a cadre of dedicated, professional staff who had world-class expertise in their subjects. Coupling that expertise with extensive pre-licensing interactions with the applicant and stakeholders gave the staff an unprecedented knowledge of the technical issues surrounding the DOE's safety case for Yucca Mountain. That knowledge base, and the dedicated efforts of a professional project management team, was critical for staff's resolving all significant technical issues and completing its technical review of the complex DOE license application within 3 years.

One particular challenge that resulted from a long pre-licensing period was that staff needed additional awareness and training on the distinctions between academic or scientific reviews and regulatory reviews. In NRC regulatory reviews for Part 63, for example, the use of risk insights is an acceptable approach to determine that technical uncertainties would not significantly affect the acceptability of a safety analysis. In contrast, a purely scientific review would need to address, and resolve, all relevant sources of uncertainty before a result could be accepted. Both types of reviews must be technically rigorous, and the logic for review conclusions must be transparent. Nevertheless, the review process should allow for resolution of technical uncertainties that do not significantly affect the safety case.

Staff understood that the basis for the safety case must be demonstrated in the information presented by the applicant in license application and in formal responses to staff's questions. Throughout the pre-licensing period, NRC staff conducted a broad range of investigations on important technical issues. The results of these investigations provided an independent perspective on the risk significance of key issues and associated uncertainties, and were valuable in guiding staff's review and probing the applicant's safety case. Nevertheless, attention was needed to ensure that these independent investigations were used to confirm the acceptability of information in the license application and were not substituted as the technical basis for approving or disapproving the safety case.

Close and successful collaboration occurred between NRC's technical and legal staffs during the review and hearings. Staff's technical input often was needed to support NRC responses to various legal issues, and the Safety Evaluation Reports would establish NRC positions on the license application in the hearings. However, the technical focus for legal arguments often had to have a different emphasis and presentation than was used for the technical review. More extensive pre-licensing interaction between the technical and legal staffs would likely have increased the efficiency in communication between the staffs, and likely resulted in a better understanding of how to harmonize the approach for addressing legal and technical issues throughout the review.

Retrospective on Processes

Not surprisingly, differing interpretations occurred amongst the staff on the significance of technical issues that appeared important to safety. Although many of these differences were resolved at the team level, several mechanisms were in place that worked effectively to resolve such technical disagreements. First, NRC had developed a strong safety culture that fostered an environment where alternative views could be expressed and discussed without fear of retribution. This environment allowed team members to raise concerns about technical issues and discuss those concerns openly with their colleagues and immediate supervisors. Additionally, several Senior Technical Advisors (STAs) were embedded in the program. The STAs served as expert resources for staff and supervisors, and often mediated technical disagreements by probing the different interpretations and building a consensus on issue resolution that was acceptable to all team members. Remaining disagreements were elevated to a Safety Integration Review (SIR) team, which consisted of all supervisors and STAs. Staff presented alternative views to the SIR team, which evaluated the issue and recommended a path forward on resolving the issue. The SIR team often used risk insights in conjunction with technical information to develop a consensus on issue resolution. Most issues were resolved with the SIR team approach, however, discussions with division senior executives was necessary to resolve a few contentious issues. A formal process for resolving any remaining contentious issues was available at NRC, but was not needed for this licensing review.

Project management was a resource-intensive process that required training and dedication comparable to the technical review. Approximately one third of the staff was engaged in project management, as project managers, supervisors, or technical support. In addition to near-daily challenges in adapting to evolving budgets, hearing schedules and deliverable dates, project managers had to issue approximately 600 formal requests to the applicant for additional information and ensure the teams received timely responses to these information needs.

Although the YMRP addressed all topics that might be in the safety case, staff focused the review on topics that were significant to safety. This led to different interpretations over the level of detail that should be presented in the safety evaluation reports, with a view that all topics appearing in the YMRP needed to be addressed, not just the topics that were significant to safety. These differences might have been avoided if there was less specificity in the YMRP on what aspects of specific scenarios or features, events, and processes might need to be reviewed for each possible topic. A relatively generalized approach might have aligned the YMRP more closely with the flexibility given to the applicant in demonstrating compliance with regulatory requirements (i.e., Part 63).

Final Remarks

By the end of September 2011, the NRC staff had issued three Technical Evaluation Reports using a risk-informed, performance-based approach to review the DOE license application for a deep geologic repository at Yucca Mountain, Nevada, U.S.A. These reports augment the Introductory Volume I of the Safety Evaluation Report for the proposed Yucca Mountain repository, which was issued in 2010, and the many reports and documents generated over the NRC's multi-decade high-level-waste program. The review of this first-of-a-kind license application was successful, in large part, due to the dedication of the project staff in overcoming many external and internal challenges and in diligently preparing for an efficient and rigorous technical review.

The staff demonstrated that risk-informed, performance-based regulatory concepts can be implemented transparently in a regulatory review, and that a complex performance assessment can be thoroughly reviewed and used to assess the safety case for a one-million-year period of performance. Although professional disagreements occurred during the review, having objective technical advisors outside of the review teams was critical to implementing a process that achieved consensus on issue resolution. Staff's independent technical investigations during pre-licensing were extremely useful in developing risk insights and confirming the acceptability of the applicant's methods and results, but care was needed to ensure that this information was not substituted for the applicant's safety case. More information about NRC staff's review of the DOE license application, including links to the technical evaluation reports, is available at www.nrc.gov/waste/hlw-disposal/yucca-licapp.html.

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Session Report – F. Boydon (UK-ONR)

This report summarises presentations nationally and identify specific areas of interest followed by general comments observations out of all the presentations in the session.

France

Recognised good progress being made towards an application in 2015 and planned start of operation in 2025 and that this would be preceded by a public debate in 2013.

Aspects of specific interest

- Approach to reversibility
- Closure not part of license application but by specific decree
- List of regulator requirements including organisational structure
- Stepwise phased approach

Regulator has its own independent R&D programme to enable it to take a position on the R&D carried out by the implementer especially with respect to long term issues and the use of surveillance specimens.

Regulator needs clarity that implementer has adequate funding.

Early engagement between regulator and implementer to clarify expectations but need for care to ensure regulator does not become part of the design process with the result that it assesses its own designs and suggestions.

Regulator is updating its regulations on procedures for waste conditioning design and waste acceptance. It would be interesting to know what aspects of existing regulations are considered inadequate.

Canada

Two prospective repositories are being looked at, one for primarily LLW (90%) at Bruce which will be licensed to Ontario hydro and the other for spent fuel which will be licensed by the Nuclear waste management organisation (NWMO). NWMO is likely to design both.

It is interesting to note the differences in the 2 sites, e.g.

- Available skills
- Potential explosives at an existing nuclear site
- Assertion that the facility is not a mine as no mineral is being extracted

It is good advice to work with local authorities and regulators at an early stage to clarify what regulations will apply and which will not.

Again the value of a stepwise approach to design and operation was emphasised.

Switzerland

There is a legal requirement for all nuclear waste to be disposed underground. Two facilities are being envisaged but these could be combined.

Currently the siting process is underway and 20 potential sites in 6 regions have been identified.

A construction licence is planned for the underground research laboratory for 2020.

Current focus is on post closure safety and work to develop the design is progressing in a step wise manner.

The workshop supported the approach, “Decide as late as possible but as early as necessary.”

The design was being considered in 3 integrated areas,

- Surface facilities – where it was unlikely anything new would arise except for dealing with the required integrity of the canister seals.
- The access from the surface to the repository where again nothing particularly new was anticipated, and
- The disposal facility which needs to focus on minimisation of damage to the surrounding rock infrastructure and to characterise the rock, modifying the design as necessary.

It was noted that the Swiss legal basis requires regulators to produce guidelines and a waste management programme for the waste producers. These guidelines will cover issues such as the possible need for testing, implying the removal of backfill and future monitoring of the facility.

It was also noted that there is a requirement for a justification of staffing and organisational structure for an operational license.

General Comments

All countries endorse a stepwise phased approach as being necessary to iterate designs in the light of developments such as geological findings.

Early engagement with regulators is encouraged but regulators need to be cautious to avoid becoming involved in the design process themselves.

Regulators need to be clear about their expectations including any R&D requirements especially how to deal with ageing effects. Is it necessary for regulators to have their own independent research carried out and if regulators do perform research it is important to base regulatory judgements on the research results provided to them rather than their own research.

Information management both in terms of volume, and what is necessary to retain are likely to be important issues as will the format of the information to ensure that it is available for the desired time period.

Most regulators consider that the organisational structure of the license applicant is important but this structure is likely to evolve with time from that of a design organisation to one of a constructor/contractor to an operator (and constructor combined). How this evolution is managed will also be important.

The challenges of a deep geological nuclear waste repository are likely to be novel and it is important that regulators consider in advance what these might be and implement suitable recruitment and training processes for its staff.

Day 2 – Industrial Feasibility of Construction

Verification of Drift Seal Systems at the Morsleben Repository, Germany - Proof of Technical Feasibility and Functionality – J. Wollrath, R. Mauke and M. Siemann (BfS)

The Morsleben repository (ERAM) for low- and intermediate-level mainly short-lived radioactive waste is located in a former salt mine. The emplacement of radioactive waste has been finished in 1998. Licensing of the closure of the repository has been initiated by BfS.

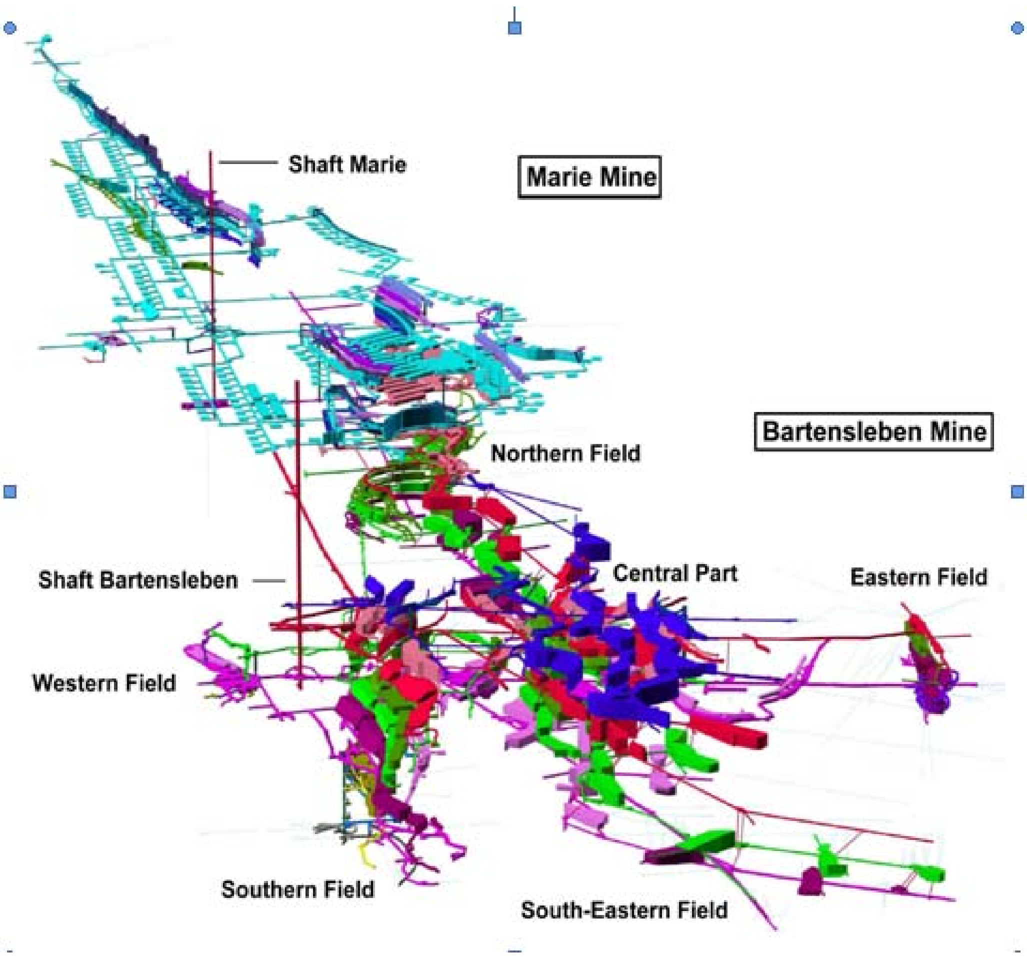

Figure 1: Sketch of the mine workings of ERAM

The closure concept is based on extensive backfilling with salt concrete complemented by seals. The seals will form a partition between the repository areas in which the radioactive waste is emplaced and the remaining mine workings into which a solution inflow cannot be ruled out. The seals should prevent the penetration of solution into the waste emplacement areas and the emission of radionuclides out of these areas. All but one seal will be located in rock salt, the other one in anhydrite. Because of the different rock properties special requirements are therefore placed on these constructions. The adherence of these requirements will be investigated and tested on real scale test constructions.

The drift seals located in rock salt are made up of one or more segments of salt concrete in lengths between 25 m and 30 m. A succession of several segments will be separated from each other by plastic joints to prevent the occurrence of restraint stresses. Injection of the contact joint between the sealing body and the surrounding rock salt will be carried out on at least one segment. In this respect the sealing structure consists of three components, namely the seal body made of salt concrete, the contact zone between the seal body and the surrounding rock salt and the rock salt excavation damaged zone (EDZ) (Figure 2). All these components will be observed during the in situ investigation.

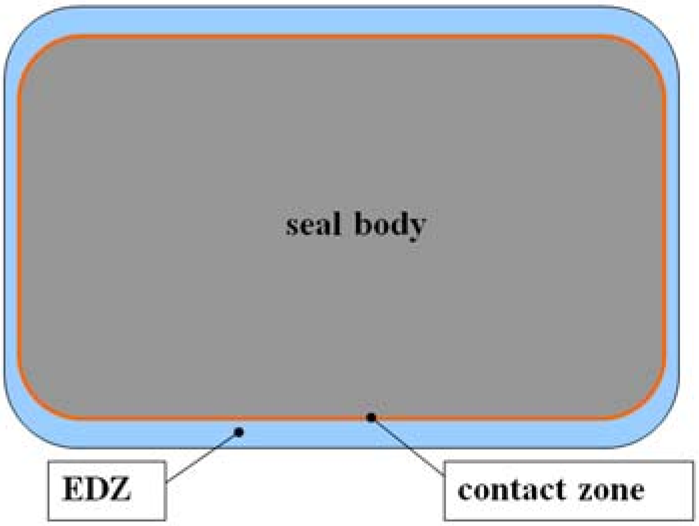

Figure 2: Schematic cross-section through sealing structure

To demonstrate the feasibility of constructing such a seal structure an in-situ experiment is performed. A test drift and an accompanying parallel drift have been newly excavated for the experiment (Figures 3, 4). Boreholes for the measurement cables have been drilled from the gently rising parallel drift. Also emanating from the parallel drift hydraulic pressurisation tests are performed by using the fluid chamber adjoining the seal construction. The cross-section of the newly excavated drift was gently rounded and the roof ridges have been chamfered with a 3 gon inclination approx. 6 months after its excavation to minimise the EDZ.

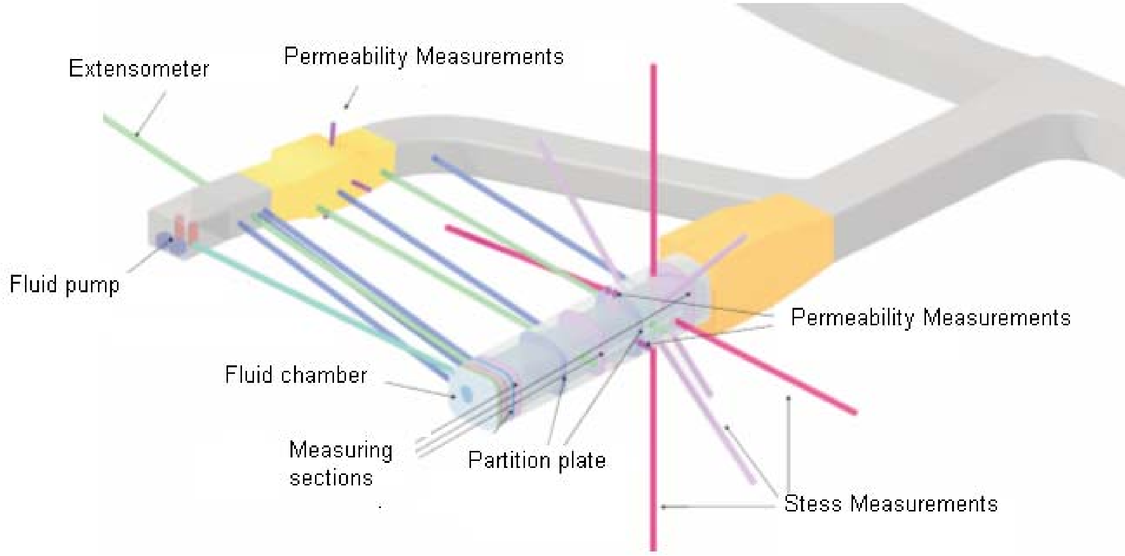

Figure 3: In-situ test (Schematic view from above with accompanying drift)

Concreting of the construction with salt concrete took place “wet on wet” in December 2010 within approx. 20 hours. Injection of the contact zone between the seal body and the surrounding rock salt was carried out in February 2011.

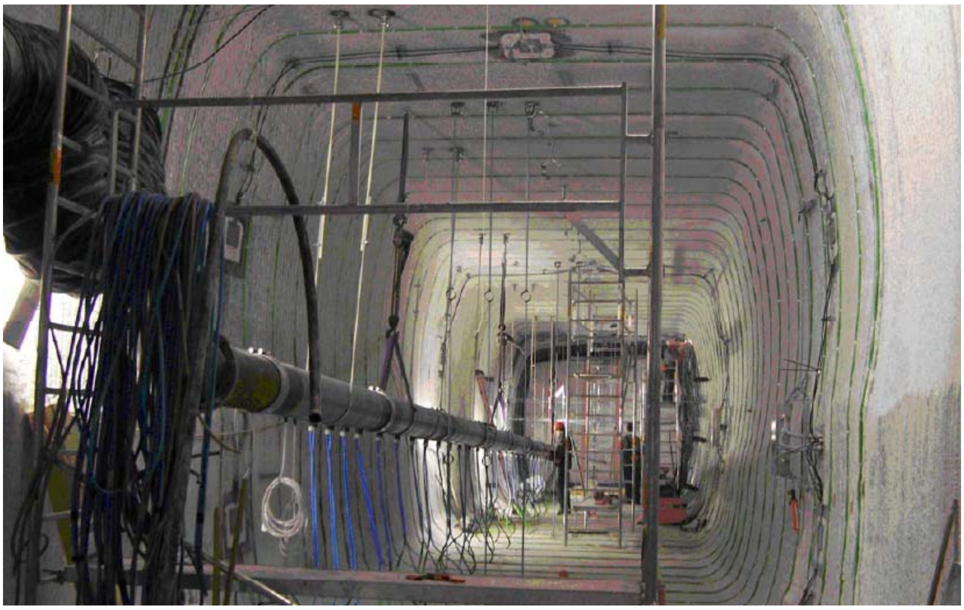

Figure 4: Photo of the test site with installed sensors, closed circular grouting pips and cladding tube

Besides implementing the construction draft for a seal segment, the manufacture of the trial construction also comprised geotechnical instrumentation for stress, strain, displacement, temperature and pore pressure measurements that are carried out in the contact zone, the seal body and the surrounding rock salt. Additionally, a comprehensive site investigation programme has been carried out, in particular with regard to the stress state and the convergence behaviour of the surrounding rock salt.

In addition to the in-situ measurements, test specimens from different areas of the construction have been drilled. Laboratory tests of strength and permeability, as well as in-situ permeability measurements are planned for these drillings. In 2012 the pressure chamber will be filled with brine solution to ascertain the permeability of the whole sealing structure.

So far all presently available results indicate that this in-situ experiment in rock salt will be successful.

For the seal which has to be built in the non-creeping anhydrite an in-situ experiment is planed, too. For this special seal a swelling material has been selected to realise that the contact zone between the seal body and the anhydrite will be pressurised long-lasting.

Both in-situ experiments will aid to the final proof of technical feasibility and functionality of the drift seal systems at the Morsleben repository.

Planning for implementation in a volunteer process – Ch. Tweed (RWMD)

The framework for implementing geological disposal of the UK's higher activity radioactive waste is laid out in the Managing Radioactive Waste Safely (MRWS) White Paper published by the UK Government in June 2008. The process to site a facility will be staged and based on voluntarism and partnership with local communities. This process is in its early stages and it will be some time before a site is selected. This paper outlines the work being undertaken by the Nuclear Decommissioning Authority's Radioactive Waste Management Directorate (NDA-RWMD), the implementing body for geological disposal in the UK, to plan, along with others, how we will deal with the waste and get it safely underground. It describes how we are:

- developing the work programme;
- demonstrating safety;
- providing packaging advice; and
- developing the organisation.

It also describes the processes used to build confidence in our plans.

Preparatory work to implement geological disposal is well underway and in March 2010, NDA-RWMD published 'Geological Disposal – Steps towards implementation'. This report describes the preparatory work already undertaken, the planning of the future work programme and the management arrangements to deliver it, including :

- the radioactive wastes and materials that may require geological disposal;
- geological settings that are potentially suitable to host a geological disposal facility;

- a range of geological disposal concepts that may be appropriate for the disposal of the different types of radioactive wastes and materials in the various types of rock considered suitable;
- the use of a reference case disposal concept as a basis for planning assumptions and as a benchmark for provision of information;
- the stages of work comprising the geological disposal implementation programme;
- how we identify and aim to meet the relevant regulatory requirements;
- the main organisations that we will work with to deliver geological disposal and the nature of our relationships with those organisations;
- how we communicate and engage with the public and stakeholders, and how we aim to develop this part of our programme; and
- the costs of geological disposal.

The plans cover all stages of implementation of a geological disposal facility, including its final closure. As the development of the implementation programme is at an early stage there are inevitably many uncertainties; these are outlined in the above report and explanations given of how they are accommodated in our planning. In order to build confidence in quality of the plans, they have been reviewed from both a technical and a project perspective.

Ensuring and demonstrating safety is of prime importance in geological disposal. We have therefore published a Disposal System Safety Case (DSSC) to demonstrate why the geological disposal facility will be safe to operate, will remain safe after it is closed and will meet all applicable regulatory safety requirements for radioactive waste disposal. At the moment, before we know the location of the geological disposal facility and can therefore produce a detailed design for it, our safety case is based on our understanding of the scientific and engineering principles underpinning geological disposal. We call this a 'generic' safety case as it does not relate to any specific site or disposal facility design. However, this work builds on more than 30 years of site-specific and generic experience studying geological disposal and undertaking safety assessments in the UK, as well as learning from more than 40 years of such experience in other countries. Therefore, although we are at the generic stage, we have a high degree of confidence in our ability to design, build and operate a geological disposal facility for which a strong safety case can be made, providing a suitable site comes forward through the volunteer site selection process.

For this generic safety case we have used examples of disposal concepts that have been developed around the world for various types of wastes and geological setting. This is to illustrate the types of engineered and natural barriers that could be used for a geological disposal facility in the UK. The generic DSSC consists of a hierarchy of documents. The main safety arguments during transport of the wastes, operation of the facility and in the post-closure phase are described in the Tier 1 reports. These draw on Tier 2 safety assessments which include calculations, some of which are for an illustrative disposal concept, one each for intermediate-level waste and high-level waste/spent fuel. In turn these are supported by more than twenty supporting reports, including a series of status reports which describe the extensive research and development evidence and understanding to support the safety arguments that are made in the three main safety case reports of the generic DSSC. In order to build confidence in the DSSC, all the documents in the DSSC suite were peer-reviewed and summaries of the review comments and the responses have been made.

Commercial utilisation of nuclear power in the United Kingdom started in 1956 and decommissioning activities at many of the UK's older nuclear sites are now well underway. An important part of the preparatory work being undertaken by NDA-RWMD is the provision of advice to waste packaging organisations on packaging of wastes to meet disposal requirements. In particular NDA-RWMD set standards and specifications for packaging of wastes, (container, wasteform and the waste package) and provide guidance on their application. We also assess and endorse packaging proposals where appropriate. An important part of this work is the provision of disposability assessments for wastes from potential nuclear new build. The Government believes it is technically possible and desirable to dispose of both new and legacy wastes in the same geological disposal facilities. We have carried out technical assessments of the disposability of the potential new wastes that would be produced that support this view.

Progress towards implementation of geological disposal in the UK will require NDA-RWMD to adapt into an organisation that can hold a nuclear site licence to operate a nuclear facility. Since the end of September 2009, we have been operating as a ‘prospective Site Licence Company’ and have started to develop the policies and procedures that will be required as a nuclear licensee. During the early part of 2011, an organisational review was carried out with the objective of developing a structure to deliver the programme mission and objectives in the most efficient manner. The review focussed on the requirements of the organisation for the next 5 years. As much of the required work will be undertaken through the supply chain, the aim was to develop NDA-RWMD as a lean, intelligent client focussed organisation. The proposed structure was discussed with the regulators who confirmed that that they had no objections to its implementation and then implemented from June 2011. It will be subject to periodic reviews to ensure that it is achieving its objectives. The next developments in the organisational structure will be those required for site investigations into the suitability of potential sites for hosting a facility.

The technical, programme, financial and organisational plans outlined above are designed to provide confidence that we will be able to implement geological disposal of the UK’s higher-activity wastes, provided a suitable site can be identified through the MRWS process.

Preparing for the Construction Licensing of a Deep Geologic Repository, The Canadian Regulatory Experience – K. Klassen (CNSC)

The Nuclear Safety and Control Act (NSCA) provides the Canadian Nuclear Safety Commission (CNSC) with the authority to licence nuclear facilities and nuclear-related activities in Canada. Licensees are responsible for safety, environmental protection and funding through all licensing phases, which includes site preparation, construction, operation, decommissioning and abandonment. A Deep Geologic Repository (DGR) for the disposal of used nuclear fuel or other radioactive waste is considered a nuclear facility and once a site is identified, its development throughout its lifecycle must be licensed by the CNSC.

Licences are issued in each phase for a specified period, and can be renewed and amended. Amendments and renewals necessitate re-evaluation and/or updating of the safety assessment, environmental impacts, and monitoring programs, when there are changes in information affecting the facility. Licensing contain conditions, providing the possibility for additional restrictions. This licensing approach ensures adequate regulatory control and provides for the continuing updating and refinement of the safety case and expectations for the performance of a facility.

Under the Canadian regulatory regime it is the licence applicant that proposes how they will meet the requirements of the NSCA and its Regulations. As the requirements of the Regulations are predominantly performance based, the applicant can be flexible and base their proposals on their unique licensing case. Their demonstration of safety must address the licensing phases of the nuclear facility and be commensurate with the risks they pose. While not being prescriptive, the CNSC provides guidance on how compliance with the regulations might be adequately demonstrated by licence applicants.

Ontario Power Generation (OPG) has submitted information required for a CNSC licence to prepare the site and construct a DGR for the disposal of low and intermediate level waste from the operation of their nuclear power reactors. That submission includes an Environmental Impact Statement (EIS), as required for a Panel Review under the Canadian Environmental Assessment Act (CEAA), and the information required for a licence application under the NSCA Regulations. The DGR EIS and the licence application is currently the subject of a public review by a Panel. The panel will address both environmental and licensing requirements in a joint, and parallel process established for this project by the federal Minister of the Environment and the President of the Canadian Nuclear Safety Commission. The CEAA part of the process must be concluded before a decision can be taken by the CNSC on a licence application.

The CNSC has prepared for the review of a licence application for a DGR in a number of ways. To ensure adequate information is available on regulatory expectations, policy, guidance documents, and discussion papers were developed. These included a policy on managing radioactive waste, guidance on assessing the long term safety of waste management systems, guidance on environmental protection policies and programs, and a discussion paper on expectations for repository siting and site characterization.

As with good regulation, the proponent and the regulator have had discussions in the pre-licensing phase, that period prior to the EIS and licensing submission. These discussions clarified CNSC expectations for the characterization of the site and for the development of the EIS and application. They also help to ensure that OPG understood these expectations. OPG provided initial drafts of some key documentation which CNSC staff has commented upon. These comments help to ensure that the applicant's final submission is comprehensive and of good quality. The review has also assisted the regulator in developing an understanding of project plans and possible issues associated with the proposed site.

The licensing and regulation of existing waste management facilities, uranium mines and tailings areas has provided a broad base of experience that is being applied to CNSC staff's review of OPG's documentation. Experience has shown that in addition to facility design, the quality management plan, design and construction management, and human performance management is of importance to conventional health and safety during construction, to radiation and conventional safety during facility operation and to performance expectations during operation and in the long term. These safety and control areas will, therefore, not be over looked during the regulatory review of the final submission and will be part of CNSC compliance inspect activities during construction. CNSC staff has also taken the opportunity to examine and seek confirmation of the implementation of the quality management plan used during the characterization of the site in the pre-licensing period. Confirmation of the implementation of an acceptable quality plan will support regulatory confidence in the data used and the assessments conducted to support the DGR submissions.

The CNSC is ensuring a technical knowledge base for the review of the DGR safety case. The CNSC has engaged in a multi-year research program focusing on the long term containment attributes of sedimentary rocks, namely homogeneity and extent, diffusion dominant transport, and past and future stability. This program follows from the earlier work of staff in research and assessment of a repository concept in crystalline rock for high level wastes, and in participation in international programs such as DECOVALEX (Development of Coupled Models and their Validation against Experiments), GEOSAF (Geological Disposal Safety Case), and IGSC (Integration Group for the Safety Case). The research includes the effects of the past and future evolutions of the thermal, hydraulic, mechanical and chemical regimes of the rock and the repository; gas generation and migration in argillaceous rocks; the study of natural tracer profiles to verify diffusion processes; and long term performance of bentonite seals. The research has also been used to identify, demonstrate and prioritize technical issues which will need to be addressed to support OPG's repository development.

The CNSC has, in the review of draft documents and in the research work completed to date for OPG's DGR, made preliminary observations of gaps and uncertainties that may have an effect on the final facility design, construction and conventional safety, waste placement operations, and expectations for long term performance. These were provided to OPG.

These areas are:

- The magnitude and direction of the principle stresses at the level of the underground development are not known at the Bruce site, but are important to conventional safety during construction and operation, and to the assessment of the rock damage zones that would influence the migration of gas and long lived radionuclides. They will determine the final orientation of the underground development and influence the locations and engineering details of the underground support.
- Confirmation of the geosphere during construction is important to both conventional safety and long term performance. Differences in groundwater flow, rock strength, the existence of unidentified fractures or joints from current expectations may require changes to the facility design and ground support. Confirmation of conditions will also reduce uncertainties in data and the geosphere model used in the safety assessment.
- Gas generation in the wastes and its effect on performance from the potential for gas to be concentrated in a part or portion of the repository under current plans, may impact waste placement and plans to seal off areas of the repository during future operations.
- The effect of multiple glacial cycles on long term performance, rather than one cycle in assessment modeling.
- Excavation methods and control of the excavation damage zone during construction of the main and ventilation shafts are important to long term performance as they might become preferential contaminant pathways to the biosphere.
- The design of the shaft seals in order to resist future disruptive natural processes, including multiple glacial loading and earthquakes, without deterioration of its long term performance.

Session Report – S. Voinis (Andra)

The session addressed key issues related to the industrial feasibility of construction. It covered the implementer and regulator points of view. The conclusions derive from three presentations completed by the outcomes of six WG.

Content of presentations

1 - Verification of Drift Seal Systems at the Morsleben Repository, Germany - Proof of Technical Feasibility and Functionality

The licensing of the closure of the repository in Morsleben has been initiated by BfS. The closure concept is based on extensive backfilling with salt concrete complemented by seals. In order to demonstrate the feasibility of constructing such a seal structure an in-situ experiment is performed in a drift of the repository.

– Sealing of open spaces and shafts
  - o Requirements : e.g mechanical , permeability , chemical robustness
  - o Verification : stability , permeability, LT behaviour
  - o Proof of performance :
    - – technical feasibility : manufacturing
    - – functionality : permeability …
  - o In situ test: design and technical measurements (T° , K)

– Challenging issues :
  - o short term test period compared to the LT requirements
  - o if necessary, go back to the design and SA : need flexibility
  - o be able to gather data and results for future construction

2 - Planning for implementation in a volunteer process in the UK

The framework for implementing geological disposal of the UK's higher activity radioactive waste White Paper published by the UK Government in June 2008. The process to site a facility will be staged and based on voluntarism and partnership with local communities. This process is in its early stage. The paper outlines the work being undertaken by the NDA.

The objectives are as follows : Show technical feasibility at an early stage in the following context :

- o Generic formation
- o Generic design
- o Generic safety case

– Accumulation of many years of knowledge facilitated to tackle this challenge
  - o Preliminary standard specifications (waste acceptance) for waste packages
  - o Documents to support the transfer of information to the next generation

– Need for an involvement of the regulator at the beginning

***3 - Preparing for the construction and licensing of a DGR* in Canada : issues for the regulator**

Ontario Power Generation (OPG) has submitted information required for a CNSC licence to prepare the site and construct a DGR for the disposal of low and intermediate level waste from the operation of their nuclear power reactors. That submission includes an Environmental Impact Statement (EIS), as required for a Panel Review under the Canadian Environmental Assessment Act (CEAA), and the information required for a licence application under the NSCA Regulations.

Discussions between the proponent and the regulator in the pre-licensing phase, clarified CNSC expectations for the characterization of the site and for the development of the EIS and application. They also helped to ensure that OPG understood these expectations. They concerned:

- o magnitude and direction of the principle stresses
- o gas generation
- o multiple glacial cycle …

They were facilitated by:

- o Participation in international exchanges – a way to expand knowledge
- o Own technical knowledge – own practices (past reviews) and expertise

The CNSC preparation activities include engagement in communication

- o Exchanges with mining people to explain the safety constraints
- o Exchanges between proponent and regulators prior to the EIS and licensing submission
- o Exchanges with stakeholders

Outcomes WG session -1

- Start with construction but during operational phase : Simultaneous construction & operation activities
- Need for technical requirements/criteria :
  – So that it can be judged whether «products» meet the requirements
  – LT safety issues to be considered during construction (e.g construction may affect site characteristics => Minimization of EDZ during excavation)
- Closure activities have to be taken into account in the license application for construction
- Relevance of the quality assurance management
- Need to keep flexibility in design in order to be able to take into account:

  – lessons learnt from the construction
  – balancing nuclear, conventional and mining regulations
  – evolution of the regulations

- Relevance of monitoring : *monitoring issues, Characterization of rock properties/verification of sitting results: adaptive system depending on results*
- Relevance of communication e.g.: *communication to miners about specific requirements of a nuclear facility – improvement of safety culture*

Day 2 – Industrial Feasibility of Operation

Towards the licensing of the Geological Disposal: Illustration of the 2009-2010 intermediate milestone – F. Boissier, P.C. Leverd, S. Voinis and M. Tichauer (Andra/IRSN)

France has a legal and institutional framework for the management of radioactive materials and waste. On June 28, 2006, the Planning Act No. 2006-739 of materials and radioactive waste management was enacted. This French Act mandates Andra (the National Radioactive Waste Management Agency) to conduct studies and research required for the siting and design of a deep disposal facility for high or medium-and long-lived (ILW-LL-HA) radioactive waste in a geological formation, in view of submitting a request for authorization to create such a repository to be examined in 2015. According to French regulations, a creation decree will authorize both the construction of the facility and the nuclear operations to be performed. The commissioning of the repository needs then to be authorized by the Nuclear Safety Authority (ASN) and at the due date of 2025, construction and equipment work shall be carried out concurrently with nuclear operations in the previously commissioned portions. In order to get all the authorizations, Andra will face a number of other external steps including the process of reviewing and evaluating the safety case by the regulatory authority and his technical safety organization (TSO), the Institute of Radioprotection and Nuclear Safety (IRSN). This step by step decision process involves the regulatory authority ASN, IRSN, at some stage the French standing committee in charge of facilities related to nuclear waste management ”GPD”, and Andra.

The Decree No. 2008-357 of 16 April 2008 made under that Act, sets out interim milestones before 2015, among which the delivery by Andra to the Ministers for Energy, Research and Environment by the end of 2009 of a record to take stock. That record included a share of studies on the design, the safety and the reversibility options, as well as the waste inventory to be disposed. In that frame, Andra sent to the ASN the so-called "Dossier 2009”. That intermediate stage aimed at helping in building confidence in the safety case of the repository and at identifying the challenging issues of concern or on which further work may be required. It focused on operational safety and verified that the subsequent evolution of the architecture design still satisfies post-closure safety functions. In that respect, the "Dossier 2009" presented an analysis of risks associated with the operation of the disposal and defined preliminary safety options to control them. A verification that the post-closure performances of the disposal were still guaranteed with the new architecture was made in order to ensure that evolution in design and engineering did not alter the conclusions issued in 2006 on the feasibility of the geological disposal.

IRSN reviewed this Dossier in 2010, and in that framework technical meetings were organized between Andra and IRSN on dedicated topics. At the end of the review period, IRSN submitted its conclusions at the Standing committee held on 29 November 2010. Following this process, the Standing committee made some recommendations and on that basis, ASN sent officially its requirements to Andra in view of the license application. During this review, Andra made official commitments to perform actions dedicated to the improvement of the safety case.

In view of the license application, challenging issues were identified on topics concerning both operational and post-closure phases, such as: containment systems, fire, explosion, co-activity, improvement in the understanding of the rock damage around the major underground structures and sealing of the repository, especially the industrial capability of the operator to seal adequately parts of the geological disposal.

As an illustration, some requirements on fire risk were identified in order to take into account the combined constraints of "conventional" underground facilities (tunnel, mine) and nuclear facilities. Andra committed to establish a specific reference document on handling fire risks for the underground nuclear facility, because none existing at that stage can be applied directly to this type of facility. Other requirements for the safety of the facility during the operational phase have been identified and concern the management of the explosion risk and the coactivity. Regarding the post-closure phase one issue faces the sealing of the different parts of the repository, in particular the industrial capability of the operator to seal adequately parts of the geological disposal.

The safety case that will support the license application in 2015 will present both operational and post-closure safety analysis in accordance with regulations. The review of the dossier 2009 pointed out some key challenging issues to be undertaken by Andra in view of the license application. They are mainly :

i. the management of risks associated with the underground facility operation, especially considering the activities to be undertaken in parallel, e.g. emplacement, construction, monitoring, safeguards, maintenance and closure,
ii. the definition of static and dynamic containment systems,
iii. the long-term safety implications of the operational activities; and evolution of the subsequent architecture,
iv. the implications of potential damage to the host rock and
v. the sufficient evidence to get enough confidence in the industrial capability to build technical solutions for seals.

WIPP – Pre-Licensing and Operations: Developer and Regulator Perspectives – T. Peake (US EPA) and R. Patterson (US DOE)

Background

The Waste Isolation Pilot Plant (WIPP) is a disposal system for defense-related transuranic (TRU) radioactive waste. Developed by the Department of Energy (DOE), WIPP is located near Carlsbad in Southeastern New Mexico (see Figure 1). At WIPP, radioactive waste is disposed of 2,150 feet underground in an ancient layer of salt which will eventually "creep" and encapsulate the waste. WIPP has a total capacity of 6.2 million cubic feet of waste.

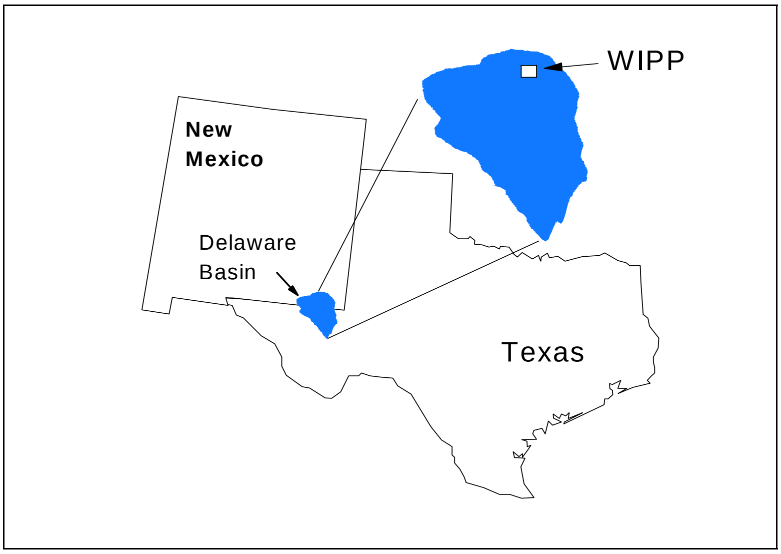

Figure 1. WIPP Location in the Southwest US

Congress authorized the development and construction of WIPP in 1980 "for the express purpose of providing a research and development facility to demonstrate the safe disposal of radioactive wastes resulting from the defense activities and programs of the United States."[5] The WIPP Land Withdrawal Act (LWA), passed initially by Congress in 1992 and amended in 1996, is the statute that provides EPA the authority to oversee and regulate the WIPP with respect to radioactive waste disposal. (Prior to the passage of the WIPP LWA in 1992, DOE was self-regulating with respect to WIPP; that is, DOE was responsible for determining whether its own facility complied with applicable regulations for radioactive waste disposal.) The State of New Mexico regulates DOE through its hazardous waste permit, which governs aspects of operations. Other oversight groups, such as the Defense Nuclear Facilities Board

The waste which may be emplaced in the WIPP is limited to transuranic (TRU) [intermediate-level] radioactive waste generated by defense activities associated with nuclear weapons; no high-level waste or spent nuclear fuel from commercial power plants may be disposed of at the WIPP. TRU waste is defined as materials containing alpha-emitting radioisotopes, with half-lives greater than twenty years and atomic numbers above 92, in concentrations greater than 100 nano-curies per gram of waste.[6]

Most TRU waste proposed for disposal at the WIPP consists of items that have become contaminated as a result of activities associated with the production of nuclear weapons (or with the clean-up of weapons production facilities), e.g., rags, equipment, tools, protective gear, and organic or inorganic sludges. Some TRU waste is mixed with hazardous chemicals. Some of the waste proposed for disposal at the WIPP is currently located at Federal facilities across the

[5] Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act of 1980, Pub. L. 96-164, section 213.

[6] WIPP Land Withdrawal Act, Pub. L. 102-579, section 2(18), as amended by the 1996 WIPP LWA Amendments, Pub. L. 104-201.

United States, including locations in California, Idaho, Illinois, New Mexico, Nevada, Ohio, South Carolina, Tennessee, and Washington.

Site Development

The DOE began the development of the WIPP facility by selecting a site. Several alternative sites were evaluated, and the present site was selected as the best alternative based on a considerable amount of existing geotechnical information that was confirmed by extensive research and testing. Subsequent research and review have increased the understanding of the geologic, hydrologic, geochemical, and mechanical properties of the host rock and surrounding strata of the site. A Final Environmental Impact Statement (FEIS), which evaluated alternatives for the safe, long-term isolation of TRU waste, was completed by DOE in 1980. In its Record of Decision for the FEIS, the DOE concluded that the phased development of the WIPP facility was appropriate.

The site preliminary design and validation phase followed the selection of the repository location. During this validation, the DOE constructed two shafts, excavated an underground testing area, and investigated various geologic, hydrologic, and other geotechnical features, further increasing understanding of the sites characteristics. In addition, the DOE evaluated methods for assessing the long-term performance of the WIPP facility. A series of geologic and hydrologic studies were conducted in accordance with an agreement between the DOE and the state of New Mexico.

The construction of the WIPP facility followed the site preliminary design and validation phase. Surface structures for receiving waste were built and underground excavations were mined, including one panel for waste emplacement and numerous areas for in-situ experiments. The data collected from these experiments and investigations were used to evaluate the potential short-term and long-term impacts of the WIPP facility.

Site Operations

The WIPP facility began waste disposal operations in 1999. During the disposal operations, which the DOE assumes for the purposes of this application to last 25 years, the DOE will receive, handle, and emplace TRU and TRU mixed waste in the repository. Decommissioning of the WIPP facility will follow the operational period. At that time, the repository will be prepared for permanent closure, i.e., surface facilities will be decontaminated and decommissioned, underground excavations will be closed, and shaft seals will be emplaced. Decommissioning is expected to require about 10 years to complete.

Communications

EPA and DOE have had and continue to have formal and informal communication with each other and the public depending on the context :

Formal

- Public meetings associated with New Mexico hazardous waste permit, National Environmental Policy Act
- EPA regulation development

Informal

- Roundtable/small group format held periodically in New Mexico
- Recertification meetings open to all public to discuss DOE recertification application (EPA & DOE staff involved)

Regulatory Focus – Pre-licensing/Pre-Operations

- 1980s to early 1990s, site characterization, mining, modeling
- In preparing application, had to shift from characterization and research to compliance demonstration
- Focus → preparing information on site characteristics, safety case preparation and analysis, regulatory requirements
- Document preparation, transportation, waste handling and disposal operations planning and practice
- Peer Reviews, sensitivity assessments of numerical models, and multiple PA's to evaluate repository performance with varying conservative parameters
- Confirmatory underground tests and demonstrations, e.g., waste handling
- Key Players: research scientists, site characterization scientists, technical subject matter experts, academics, numerical model developers and practitioners, engineers, mine experts

Operational Phase – Regulatory Challenges

- Operate w/in the PA/safety case envelope.
- Perform confirmation testing and monitoring programs.
- Document that WIPP continues to comply with EPA certification (every 5 years) and NMED permit requirements (10 years).
- Produce documentation showing planned changes continue to fall within the regulatory envelope.
- Changes made to facilitate operational efficiencies and save taxpayer money
- Key players: environmental scientists, regulatory specialists, numerical modelers, research scientists (limited).

Lessons Learned

- Need to transition from site characterization, research to compliance demonstration and operational readiness and different personnel
- Site developers and regulators need to have mechanisms to allow for changes, both large and small, for reasons as varied as efficiency, cost, safety, and regulatory compliance
  - A process or procedure needs to be developed and agreed to by all entities on how and when changes will be made.
- Periodic recertification and permit renewals take time to prepare and limit changes that can be implemented
  - Need to account for these renewals in planning
  - Drives schedules for research, modeling, etc.

Conclusions

- WIPP has been successful in the licensing and disposing of TRU waste in a deep geologic repository for 12 plus years.
- However, changes have been requested since certification
  - Types of waste disposed, the amount of engineered barrier used, and some design changes

  - Information presented to the regulatory bodies show there is no detrimental effect to human health, the environment, or long-term repository performance.

- WIPP continuously reviews operations and expects to submit other changes in the future to further optimize operations, enhance safety systems, and increase cost and disposal efficiencies.

Designing consideration for a HLW / Spent Fuel DGR in Germany with retrievability requirements – B. Thomauske (RWTH Aachen University)

Introduction

After the Fukushima event the Federal Republic of Germany has decided to phase out of the nuclear energy production. As of August 2012 eight of the remaining 17 nuclear power plants have lost the permission for energy production. Till end of 2022 all NPP`s will reach the end of their granted lifetime. This decision allows now to calculate the total amount of waste which has to be disposed of in deep underground repositories.

Another actual decision of the German government is to restart the site selection procedure for high level waste/spent fuel starting with a white German map. This means that investigations will be performed German wide. To give this decision a legal basis, a new law is planned to pass the parliament midyear 2012. The potential further role of the German repository project Gorleben which has been investigated since 1979 has also to be determined.

The coalition agreement of 2009 of the present government included a continuation of the investigations of the Gorleben salt dome. In addition it had been decided to perform a preliminary safety case in the years 2010 till 2012 followed by a peer review in 2013. Within this safety case an optimization of the technical planning of the disposal concept has been started. As a boundary condition for the technical concept retrievability has to be included but restricted to spent fuel and high level waste.

Retrievability is a new prerequisite in the German Safety Requirements, implemented in September 30th, 2010 by the German Ministry of Environment, Reactor Safety and Nature Conservation (BMU). Retrievability means the technical possibility to remove the waste containers out of a deep underground facility **within the operational** phase which means until the shafts are sealed and backfilled.

In addition the waste canisters have to fulfill the prerequisite that within 500 years after completion of final disposal it must be possible to handle the waste canisters. In addition aerosols must not be released out of the waste canisters during this period. This is a requirement to the waste canisters. It has to be shown by the waste producers that this requirement can be met.

Disposal Concept

For the Gorleben repository 2 main disposal concepts have been developed:

- Disposal in horizontal galleries and
- Disposal in vertical boreholes.

It is planned to dispose of waste containers with spent fuel or high level waste (so called Pollux containers) in galleries. In vertical boreholes – 300 m long – high level waste from reprocessing or fuel bundles are foreseen to be disposed of in smaller canisters.

Retrievability

The basic conceptual decision is that retrievability should technically be the reversal of disposal. Only if that cannot be performed in a safe and reliable way alterations have to be analyzed.

Important is to include the increased temperature of the host rock due to the heat production of the waste. Therefore the heat has to be removed at first.

In case of the disposal in **galleries** this is done by excavating parallel galleries so that the host rock can be cooled down by ventilation. Afterwards the waste canisters can be excavated and transported to the shaft and then above surface.

In case of **borehole** technique the concept of storing the unshielded waste canisters without any liner for the stabilization of the borehole had not been regarded as being appropriate for waste retrieval. This is due to the fact that it seems to be extremely difficult not to damage the waste canisters during the drilling process. Therefore it is planned first to drill the borehole and to install an iron liner in order to stabilize the borehole. This would be performed for a defined borehole area.

Afterwards when the whole area is prepared for disposal, the canisters are transported by using a transport cask for shielding, then with special designed transport equipment the canister will be disposed of in the borehole, the borehole sealed and the transport shielding cask will be sent above ground to take over the next waste canister. This will be continued until the borehole is completely filled. The space around the waste canisters is filled with material (e.g. sand) to stabilize the canister within the borehole liner and to transport the heat from the waste canister to the host rock. The borehole will be sealed.

To retrieve the waste canisters the disposal procedure has to be performed in the inverse sequence.

In conclusion retrievability seems to be feasible and has no serious impact on the developed waste disposal concept.

Consequences

The new requirement to include retrievability for spent fuel and high level waste in the waste disposal concept led to a few consequences:

- Waste containers must fulfill the requirement not to release aerosols in the first 500 years after closure of the repository.
- There are no consequences for the horizontal disposal of the waste containers in galleries.
- For the vertical disposal of the unshielded waste containers in boreholes the boreholes have to be stabilized by cylindrical liners. These liners can be regarded as long cylindrical over packs.

- After transport of the waste containers above surface they have to be stored in interim storage facilities. These interim storage facilities, the waste handling facilities and the waste containers needed for long term storage have to be available in case waste has to be retrieved.

Summary

Since 2012 retrievability is part of the German waste disposal concept. In the preliminary safety studies of waste disposal in the Gorleben salt dome retrievability had been included.

The waste disposal concept on this new basis seems to be feasible. Retrievability has lead to a few but manageable consequences to the waste disposal concept.

Session Report – P. Gierszewski (NWMO)

Observations

- They were a limited number of presentations so the notes involve some extrapolation.
- Organizations in the process of developing concept/site are producing Generic or Interim Operational Safety reports and they find that it is a useful exercise (as with Post Safety Assessments reports).
- Retrievability as a specific report is assessed within Safety Report supporting documents.

Issues for Operation

- Identification/resolution of key accident scenarios
  - Design optimization
  - Update of guidance if needed / Regulator expectations
  - ?? Generic issues
- Operations impact on Postclosure SA
  - Operate within safety case basis
    - Process demo /emergency tests / QA / monitor
  - Definition of safe operation envelope
  - EDZ in emplacement rooms/shaft well known;
    but in other large rooms and/or “old” tunnels?
- Co-activity – Simultaneous construct and operate
  - Not just “blast” risk
  - Fundamental effect on design and method of operation
  - Secondary effects such as in WIPP
- Confirmatory testing/monitoring
  - Seal technology long-term test
  - Shaft seal optimization
  - Monitoring of performance and/or initial postclosure conditions (What to monitor / alarm levels?)

- Waste acceptance (criteria, off-normal)
- ?? Knowledge retention/records over long term (design basis)
- Managing change / relicencing
  - Level of effort and expertise

Day 3 – Licensing Aspects

Optimization and BAT in a stepwise licensing process – Example of KBS-3V and KBS-3H – O. Olsson (SKB)

Legal framework

The Swedish legal framework, in accordance with IAEA and OECD/NEA recommendations, is based on a stepwise decision-making process. The first step in this licensing process was initiated when SKB (Swedish Nuclear Fuel and Waste Management Co.) submitted license applications to construct, possess and operate an encapsulation plant and a final repository for spent nuclear fuel in March 2011. Should the Government grant SKB a license, SKB will need another permit from SSM (Swedish Radiation Safety Authority) before the actual construction work can start at the repository site. Additional permits from SSM, and updating of the SAR, will be required before SKB will be allowed to start test operations and eventually routine operations.

Provisions with respect to the principle of best available technology/technique are found in the Environmental Code and in SSM's regulations. Under SSM's general guidelines, the principle of best available technology in connection with final disposal entails that "the siting, design, construction and operation of the final repository and appurtenant system components should be chosen so as to prevent, limit and delay releases from both engineered and geological barriers as far as is reasonably achievable. In considering different measures, an overall assessment should be made of their impact on the protective capability of the final repository."

Aside from the requirement on best available technology, optimization is an important requirement on the final repository's design and operation. Under SSM's regulations, optimization is a limitation of radiation doses to humans to a level "as low as reasonably achievable with regard to economic and societal factors".

KBS-3 and Best Available Technology

A fundamental requirement on a final repository is that it must be based on a system of passive barriers. Together, these barriers must contain, prevent and retard the escape of radioactive substances. SKB has developed the KBS-3 method because it enables the spent fuel to be kept isolated from the biosphere in an effective manner for such long periods of time that SSM's requirements on safety and radiation protection are met. Releases of radionuclides can only occur if the copper canisters are breached. In the license application SKB shows that the KBS-3 method (with vertical emplacement of the canisters) is available technology. The safety assessment shows that the probability of canister breaches is non-existent during operation and very small after closure of the repository, in a million-year perspective.

The safety assessment confirms that the design of the copper canister with an iron insert is the best available technology. Erosion of the buffer after a long time cannot be ruled out under certain conditions, but the safety analysis report shows that the radiological risk resulting from this is very small.

Every facility in the final repository system is optimised with respect to safety and radiation protection. Since the facilities are dependent on each other for the whole system to work, the interaction between the facilities is also adapted so that the whole system will satisfy the requirements on safety and radiation protection.

Variants of the KBS-3 method

The KBS-3 method allows for some variation in its implementation. This applies to both the choice of material quality in the barriers and the dimensions and placement of canisters and openings in the rock. The license application regards vertical deposition (KBS-3V), which is available technology and satisfies the safety requirements. By vertical deposition, the canisters are emplaced one by one, upright in deposition holes in the floors of rock tunnels. A variant of the KBS-3 method is KBS-3H, where the canisters are placed lying down in a row in horizontal tunnels. The two variants could be possible to combine within the final repository as the same type of canisters and the ramp and shafts providing access to the repository level can be used for both variants.

The development work on horizontal deposition shows that the method is interesting and promising, but not yet sufficiently developed to be available. More research and development is required to determine whether it can be used. Such work is currently undertaken in cooperation between SKB and Posiva. Only when and if a safety assessment shows that KBS-3H offers equivalent or improved safety will a switch to horizontal deposition be considered. Work is continuing on development of the technology for horizontal deposition.

Concluding remarks

The time from submission of the license application to start of deposition of canisters is estimated to approximately 15 years. Then deposition of canisters is expected to continue for approximately 50 years before the repository is backfilled and closed. In total we are looking at a period of close to 100 years. During this time significant advances in technology within many areas can be anticipated. It is also possible that what is considered best available technology with respect to final disposal of spent nuclear fuel will change with time. However, it is important to proceed with development of repositories based on technology that is shown to meet requirements and today is considered “best”. Disposal of radioactive waste cannot be postponed indefinitely based on anticipated technology development that may be applicable in the future. Postponement also entails societal risks that may obstruct safe disposal of waste which then could result in undue burdens to future generations.

The vertical or horizontal emplacement variants of the KBS-3-method are an example of the many technology issues that will be raised during the implementation of repositories for final disposal. There are still issues with respect to KBS-3H that need to be resolved and any decisions to change from 3V to 3H will have to await their resolution. SKB will continue the preparations for a final repository based on the KBS-3V variant as outlined in the license application. Future decisions on technology changes have to be carefully evaluated and thoroughly discussed between implementer, regulator and other stakeholders to maintain trust in the implementation of final disposal.

Results of the 2010 IGSC Topical Session on Optimisation – L. Bailey (NDA)

The 2010 IGSC topical session on optimisation explored a wide range of issues concerning optimisation throughout the radioactive waste management process.

Philosophical and ethical questions were discussed, such as:

- To what extent is the process of optimisation more important than the end result?
- How do we balance long-term environmental safety with near-term operational safety?
- For how long should options be kept open?
- In balancing safety and excessive cost, when is BAT achieved and who decides on this?
- How should we balance the needs of current society with those of future generations?

It was clear that optimisation is about getting the right balance between a range of issues that cover: radiation protection, environmental protection, operational safety, operational requirements, social expectations and cost. The optimisation process will also need to respect various constraints, which are likely to include: regulatory requirements, site restrictions, community-imposed requirements or restrictions and resource constraints.

These issues were explored through a number of presentations that discussed practical cases of optimisation occurring at different stages of international radioactive waste management programmes. These covered:

- Operations and decommissioning – management of large disused components, from the findings of an international study, presented by WPDD;
- Concept option selection, prior to site selection – upstream and disposal system optioneering in the UK;
- Siting decisions – examples from both Germany and France, explaining how optimisation is being used to support site comparisons and communicate siting decisions;
- Repository design decisions – comparison of KBS-3 horizontal and vertical deposition options in Finland; and
- On-going optimisation during repository operation – operational experience from WIPP in the US.

The variety of the remarks and views expressed during the topical session reflected the diversity of optimisation goals that may be pursued in the framework of a geological disposal programme. While optimisation of protection, as defined by ICRP, is regarded as a process to keep the magnitude of individual doses, the number of people exposed, and the likelihood of potential exposure as low as reasonably achievable with economic and social factors being taken into account, optimisation can also be seen as a way of increasing the technical quality and robustness of the whole waste management process. An optimal solution means addressing safety requirements whilst balancing other factors such as the need to use resources efficiently, political and acceptance issues and any other boundary conditions imposed by society. It was noted that optimisation variables are not well defined and could be quite programme-specific.

However, the discussion showed a lot of agreement and consensus of views. In particular, the summary noted general agreement on the following points:

- Optimisation is a process that can be checked and reviewed and needs to be transparent. Optimisation is therefore a learning process, and as such can contribute to building confidence in the safety case by the demonstration of ongoing learning across the organisation.

- Optimisation occurs at each stage of the disposal facility development programme, and is therefore forward looking rather than focussed on re-examining past decisions. Optimisation should be about the right way forward at each stage, making the best decisions to move forward from the present situation based on current knowledge and understanding.

- Regulators need to be clear about their requirements and these requirements become constraints on the optimisation process, together with any societal constraints that may be applied in certain programmes. Optimisation therefore requires a permanent dialogue between regulator and implementer.

- Once the safety objectives (dose/risk targets and other constraints) have been met, further optimisation should be aimed at moving the project forward as efficiently as possible, and this could largely be reflected as cost optimisation.

ONR Licensing & Regulation of a Geological Disposal Facility in the UK – F. Boydon and

D. Glazbrook (UK-ONR)

The UK has substantial quantities of waste which has arisen from operation and decommissioning of legacy nuclear plant. While a disposal route for Low Level Waste (LLW) has been in operation in the UK for many years, there is as yet no such route for Higher Activity Waste.

The government invited local communities to express an interest in hosting a Geological Disposal Facility (GDF). However, the Scottish government is opposed to deep disposal and proposes long-term interim storage in Scotland.

This paper describes the work underway and current progress in developing a GDF for the UK. In particular it describes the current legal system in the UK that enables nuclear facilities to be licensed and the background underpinning licensing of existing disposal facilities. It identifies changes which will be necessary to legislation to enable a GDF to be licensed and work which it is performing in close co-operation with the Environment Agency which operate a permitting regime for environmental aspects.

The Office of Nuclear Regulation (ONR) regulates safety, security and transport associated with nuclear sites. This paper focuses on the regulation of safety and radioactive waste.

The UK licensing regime is non-prescriptive and proportionate, allowing for a flexible approach to licensing. The licence is not time-limited but is designed to be used from construction, through commissioning for the lifetime of the facility.

Under the Nuclear Installations Act 1965 (as amended) ONR may attach licence conditions:

- In the interests of safety; or
- with respect to the handling, treatment and disposal of nuclear matter.

ONR has developed a suite of 36 Licence conditions, which typically require the operator to made 'adequate arrangements" to ensure safety. These arrangements would involve the use of 'hold points' beyond which the operator must not proceed without ONR's agreement. In determining whether to agree to progression beyond a hold point, ONR would be legally obliged to consult the Environment Agency to ensure a consistent approach between the two regulators. The arrangements also allow the design of the GDF to progress in a phased manner and for any changes that are made to be under regulatory control.

Session Report – P. Zuidema (Nagra)

Some general observations

Licensing is one of the most important steps in implementing geological repositories for radioactive waste. There are large differences between the different countries in the number and the level of the licences to be granted in the stepwise approach of repository implementation, ranging from one licence (combined with several regulatory permissions) to a number of licences, with decisions taken for all of them at a high (sometimes even at the highest political) level. In some countries the licences are granted by the regulator / commissioners, in other countries it is a decision by the government that needs to be confirmed by parliament and/or by a public referendum. This also reflects the differences in the societal and political framework in the different countries.

The prerequisites for licensing, however, are on a general level similar. To grant a licence, the project must have been developed to a sufficient level (including optimisation). This implies that for the next step, a high level of confidence is available, whereas for the steps further away not everything needs to be fully developed yet, although the path forward must be adequately defined. This approach is combined with the possibility to make adaptations taking into account future developments, based on a clearly defined (organisational) approach. Thus, it may be appropriate in a licence application to choose a design that allows for modifications and to mention alternatives in the licence application that may be implemented at a later stage (see e.g. SKB's licence application where in addition to the reference concept KBS3-V, the KBS3-H concept has also been proposed as an alternative that may be used at a later stage). This also means that sufficient flexibility should be maintained when granting a licence to accommodate possible future needs and developments should they turn out to be necessary. Thus, it is important to envisage in the licensing process that there may be differences between the design conceived in the licence and the actually implemented design. In broad terms, the licence forms the framework for the further development of the project by the licence holder in consultation with the supervisory authorities (e.g. where the supervisory authorities express agreement through the granting of permits for specific steps). These broad principles hold for licences early in the project (e.g. site licence) up to re-licensing during operation of the facility.

In the licensing process, a broad range of topics and themes has to be considered. This also requires that different regulations (nuclear safety and security, radiation protection, mining, conventional safety, environmental protection, land use planning, etc.) are addressed in the licensing decisions. This requires close coordination between the different regulatory bodies, often with one organisation being in charge of overall coordination including preparation of the licensing decision. Besides the regulatory bodies, often also other stakeholders are involved in the licensing decisions, e.g. through a broad consultation process also with public involvement.

When applying general regulations to geological repositories, the issues specific to a repository must be considered. These include the importance of geology, the fact that a geological repository is typically deep underground (up to several 100s of meters below ground), the long timescales relevant for post-closure safety (100'000 years and more for long-lived high level waste), the duration of repository implementation (typically requiring approx. 100 years or more from concept development to closure), the small size of construction work compared to a mine, etc.

Implementation of a repository is a challenging task with high demands on the implementing organisation. Therefore, the licence may contain requirements on the organisation of the (future) licence holder. These requirements often include also the need to implement an adequate quality management system, including procedures with respect to health, safety and the environment.

Optimisation as part of the licensing process

Adequate optimisation is considered an important element in licensing. Often the different regulatory guidelines provide not only input on what and how to optimise, but also define constraints that must be considered in the optimisation process. The factors to be considered in optimisation include nuclear safety and security; radiation protection (operational phase with normal operation and incidents/accidents; post-closure safety with expected/unlikely evolution); worker health and safety; technological issues including "robustness"; environmental aspects during construction, operation and post-closure phase; cost; societal expectations; etc. The endpoint of optimisation should represent a balance between the different factors considered in the optimisation process while respecting the constraints. Optimisation is normally forward oriented (except for situations that require remedial action) and should focus on those issues where (residual) flexibility is available. Optimisation should be done on different levels, from the overall waste management system (including waste treatment, interim storage, final disposal, etc.) down to individual elements of the repository system. Optimisation also has to find a balance on how long to keep options open and when to take decisions and narrow down the number of options; Optimisation, however, should not be used as an excuse to take no decisions and to not move forward. In optimisation, not only the endpoint counts; the process itself is equally important. Therefore, the process of optimisation should be conducted in a transparent manner and should rely on a structured interaction between regulator and implementer.

For nuclear installations there exist well established principles for optimisation. This includes "best available technology … not entailing excessive cost" (BAT/BATNEEC) as a general principle or "as low as reasonably achievable / possible" (ALARA/ALARP) for optimising radiation exposure. Whereas ALARA/ALARP is straightforward for the operational phase, for post-closure safety, normally less formal principles are applied. BAT/BATNEEC involves not only radiation protection and radiological safety but also looks at other factors including technical quality and robustness. “Best available technology” does as such not require the development of new technology but focusses on available technology. Improvement and changes in technology during operation of the repository do not necessarily lead to a requirement to replace existing technology with new technology; there is always a need to evaluate the performance of existing technology in comparison with potential advantages of new technology, also taking cost into account.

In general, system optimisation for post-closure safety may be based on the relevant safety functions and includes site selection (in those countries where several feasible host rock alternatives exist and/or where differences in geological situations may have an impact on safety) and the design of the engineered barrier system. For the operational phase, there are working procedures, installations, equipment, etc. that need to be considered for optimisation. Optimisation will continue during the operational phase, e.g. in the framework of re-licensing.

Summary

K.-J. Röhlig (TUC)

During the five sessions of the workshop, much insight has been gained in a variety of issues and challenges that national programmes will encounter as they approach the construction phase of deep geologic repositories as well as their plans to address and resolve these issues. Due to the wide range of participating programmes and due to the different phases of repository development represented, the information presented at the workshop ranged from general and generic questions to specific technical, managerial, administrative, legal, regulatory and procedural issues. Although many issues still awaiting their resolutions, it can be observed that there were joint views amongst the participants with respect to the nature and specificities of these issues. These include:

– the need for flexibility (within a so-called safety envelope) when projects evolve over time,

– the need to address targets could be very difficult in nature and in some cases may compete with each other when developing and optimising repository systems,

– the central role of management with regard to developing adequate professional attitudes and an appropriate safety culture, taking into account the various professional disciplines involved,

– the need for integrating different legal and regulatory fields, often addressed by different authorities, and the question of a "leading regulator"

– the technical challenge of conceptualising parallel processes such as excavation in parts of a repository and emplacement in others and the need to fulfil related safety requirements (mining and occupational, radiation protection etc.),

– monitoring may have different roles in different phases of repository development, or

– the outstanding role of the safety case prepared in advance to operation (waste emplacement) compared to the cases prepared at other stages of repository development, and the need to act accordingly in the regulatory and licensing process.

This set of issues is by no means complete. For the Regulators' Forum and the IGSC it is now necessary to identify those issues and approaches to their resolutions which are of joint interest in order to address them in their programmes of work.

The IGSC will, in accordance with its mandate, focus on topics related to safety case development and to the links to establish between different components of repository development. Subjects which have to be discussed and perhaps addressed in the Programme of Work include:

- Operational safety: In the past, IGSC focussed on the relationship of operational and post-closure safety. A move towards questions specific for operational safety and in particular the potential for developing a list of events, incident causes etc. to be accounted for when assessing operational safety ("operational safety FEP list") will be considered.

- Further attention will be devoted to establishing the linkage between the construction of engineered components and safety assessment, i.e. to the issue of feasibility to construct components according to the design specifications made by, or used in, safety assessments.

- The IGSC will contribute to the EU MoDerN project in order to address issues related to monitoring and its linkage to safety demonstration.

- IGSC also will further address organisational issues.

Annex I: Programme

Preparing for Construction and Operation of Geological Repositories – Challenges to the Regulator and the Implementer

A joint international workshop of the RWMC Regulators' Forum and the Integration Group for the Safety Case

25-27 January 2012

Structure of the workshop and organisation:

Session 1 introduces the workshop, its aims, the challenges we face and what we want to achieve.

Sessions 2 consists of presentations of national case studies from both the regulators' and implementers' viewpoints. It focuses on issues and practices in construction and operation of geological disposal facilities and on challenges that the institutional actors may also face.

Sessions 3-5 deal with specific technical subjects.

Each of these sessions will start with a short introduction by the session chair followed by 3-4 brief (10-15 minutes) presentations in plenary. The role of the Session Chair is to lead the plenary discussion in his/her Session. The Session Rapporteur will document key points of the session, both for the stocktaking in plenary discussion and for the workshop proceedings.

In addition to the plenary presentations, participants will be organized into small groups, each with 10-11 people, to further discuss the pre-selected subjects.

Sessions 6 summarizes the key points discussed in the workshop.

This workshop intends to be highly interactive, with significant involvement by participants to take part in in-depth discussions. Participants will also partake in small- group round table discussions to gain further insights of the selected topics.

Workshop Chair: Georg Arens, RWMC Regulators' Forum Chair, BMU (Germany)

Workshop Co-Chair: Klaus Röhlig, IGSC Chair, Technical University of Clausthal (Germany)

25 January (day 1)

Session 1	**Opening of the Workshop**

9:30-9:55 Welcome note and background information

Uichiro Yoshimura, NEA – (10 min)

Introduction to the workshop : Topics, objectives and structure

Georg Arens, Workshop Chair – (15 min)

Session 2	**National Case Studies**

9:55-12:00 National case studies will be presented by institutional stakeholders in this session. Presentations will focus on the experience and issues related to the construction and operation of DGRs, particularly on long-term passive safety constraints.

Example issues :

- *On regulatory context :* respective role of regulators (if multiple regulators) ; the licensing process; post-closure requirements; operational safety regulations (i.e. mining regulation, nuclear safety regulation, radiation protection, …); retrievability; structure of the safety case; etc…
- *On policy making :* making decisions on solutions ensuring both safety and public acceptance ; ensuring a transparent process involving stakeholders ; not postponing decisions; etc...
- *On implementation :* demonstrating the industrial feasibility of the proposed solution; presenting a detailed design that balances potentially competing targets such as constraints related to construction, pre-closure safety and post-closure safety; illustrating the design choices within the framework of an optimisation process (BAT including costs, feasibility, retrievability options, time lapse for construction, etc); developing knowledge management aspects; updating QA; preparing for increased dialogue with, and scrutiny by, stakeholders; etc…

Morning Session Chair: Klaus Röhlig, Workshop Co-Chair

Morning Session Rapporteur: Shawn Smith, NRC

9:55-10:00 Session Chair opening remarks – (5 min)

The Finnish Experience with the Construction of Onkalo

Presentations by:

- **Implementer:** *Juhani Vira, Posiva* – (15 min)
- **Regulator:** *Jussi Heinonen, STUK* – (15 min)
- **Ministry:** *Jaana Avolahti, MEE* – (15 min)

Identification of issues and points for clarification for later discussion – 5 minutes.

10:50-11:10 Break

11:10-12:00 **Dealing with the current permissibility application for constructing a spent fuel DGR in Sweden**

Presentations by:

- **Implementer:** *Olle Olsson, SKB* – (15 min)
- **Regulator:** *Bengt Hedberg, SSM* – (15 min)
- **Municipality:** *Marie Berggren/Virpi Lindfors, Municipality of Östhammar* – (15 min)

Identification of issues and points for clarification, for later discussion - 5 minutes.

12:00-14:00 Lunch

14:00-17:00 **Session 2 (continued)**

Afternoon Session Chair: Georg Arens, Workshop Chair

Afternoon Session Rapporteur: Frans Boydon, UK-ONR

14:00-14:05 Session Chair opening remarks – (5 min)

14:05-14:40 **Preparing as an organization, to submit or to review a construction license application for a DGR of ILW and HLW in France**

Presentations by:

- **Implementer:** *Pascal Leverd, Sylvie Voinis / Fabrice Boissier / Andra* – (15 min)
- **Regulator:** *Géraldine Dandrieux, ASN* – (15 min)

Identification of issues and points for clarification, for later discussion - 5 minutes.

14:40 – 15:00 **Experience in the Canadian programme in preparing for DGRs of all waste types**

Presentation by:

- **Implementer:** *Paul Gierszewski, NWMO* – (15 min)

Identification of issues and points for clarification, for later discussion - 5 minutes.

15:00 – 15:35 **Experience in the Swiss programme in preparing for DGRs of all waste types**

Presentations by:

- **Implementer:** *Piet Zuidema, Nagra* – (15 min)
- **Regulator:** *Markus Hugi, ENSI* – (15 min)

Identification of issues and points for clarification, for later discussion - 5 minutes.

15:35 – 16:00 Break

16:00 – 16:20 **Preparing as an organization to review a construction license application for a DGR for HLW and SF in the USA**

Presentation by:

- **Regulator:** *Brittain Hill, USNRC* – (15 min)

Identification of issues and points for clarification, for later discussion - 5 minutes.

16:20-17:00 **Session summaries by Session Rapporteurs**-

Shawn Smith (10 min)

Frans Boydon (10 min)

Plenary discussion – (20 min)

- to be led by Session 2 Chairs

17:00 *Cocktail reception*

Jan. 26 (day 2)

Session 3 **Industrial feasibility of Construction**

9:00-12:25 **Session Chair:** Frédéric Bernier, FANC

Session Rapporteur: Sylvie Voinis, ANDRA

This session will focus on issues related to constructing of a repository.

Example issues: key safety issues to be addressed by implementer in order to ensure the design of the repository (i) is feasible to construct; (ii) meets all design requirements, including monitoring requirements and specific requirements related to the long-term safety of the repository; (iii) meets expectations of the regulator(s). The significance of URL experiments in the views of the implementers and regulators?

9:00-9:05 Session Chair opening remarks – (5 min)

9:05-9:55 Presentations on:

- Verification of Drift Seal Systems at the Morsleben Repository, Germany - Proof of Technical Feasibility and Functionality: *Jürgen Wollrath, BfS* – (15 min)
- Planning for implementation of a DGR for ILW and HLW in a volunteer process in the UK: *Cherry Tweed, RWMD* - (15 min)

Preparing for Reviewing the Construction License of a Deep Geologic Repository for low and intermediate level waste, The Canadian Regulatory Experience: *Kathleen Klassen, CNSC* - (15 min)

Identification of issues and points for clarification, for later discussion - 5 minutes.

9:55-10:20 Coffee break and move to round table discussions. Information of the round-table groups and participants will be provided at the workshop.

10:20-11:20 **Round table discussions :**

- Refer to list of questions, to be provided separately.

11:20-11:30 Rapporteurs to upload presentations (by e-mail)

11:30-12:30 **Round tables reports by round-table rapporteurs**

12:30-13:50 Lunch

Session 4 **Industrial feasibility of operation**

13:50 - 18:10 **Session Chair:** Risto Paltemaa, STUK

Session Rapporteur: Paul Gierszewski, NWMO

This session will discuss various operational issues of a repository.

Example issues: What are the main operational issues? What key accidents and disturbances should be addressed in design and management system? Impact of retrievability on the design and operations of a repository.

13:50-13:55 Session Chair Opening Remarks - (5 min)

13:55-15:00 Presentations:

- Towards the licensing of the GD: Illustration of the 2009-2010 intermediate milestone – *ANDRA / IRSN, France*,- *Sylvie Voinis/Michaël Tichauer* - (15 min)
- WIPP Pre-Licensing and Operations: Developer's and Regulator's Perspectives, *Tom Peake, EPA* (& Russ Patterson, DOE) – (30 min)
- Designing consideration for a HLW / Spent Fuel DGR in Germany with retrievability requirements: *Bruno Thomauske, RWTH Aachen* - (15 min)

Identification of issues and points for clarification, for later discussion - 5 minutes.

15:00-15:15 Coffee break and move to round table discussions

15:15-16:15 **Round table discussions :**

- Refer to list of questions, to be provided separately

16:15-16:25 Rapporteurs to upload presentations (by email)

16:20-17:15 **Round table reports by rapporteurs**

17:15-18:10 **Session summaries by Session Rapporteurs**

Session 3 and 4 rapporteur reports

- Sylvie Voinis (10 min)
- Paul Gierszewski (10 min)

Plenary discussion (25 min)
- to be led by Session Chairs

Jan. 27 (day 3)

Session 5 **Licensing Aspects**

9:00-13:00 **Session Chair:** Marie-Pierre Comets, ASN

Session Rapporteur: Piet Zuidema, Nagra

This session will evaluate the various licensing aspects during repository development.

Example issues : Level of flexibility of design that the licensing process allows. To what extent can the licensing process affect the implementation of the repository design and result in modifications? How does optimization affect later stage modifications of the design concept?

9:00-9:05 Session Chair opening remarks – (5 min)

9:05-9:55 Presentations on:

- Example of KBS3-V and KBS3-H (including connection to optimisation/BAT): *Olle Olsson, SKB* – (15 min)
- Optimization (results of the IGSC 2010 Topical Session): *Lucy Bailey, NDA* – (15 min)
- A regulator's view: *Frans Boydon, UK-ONR* – (15 min)

Identification of issues and points for clarification, for later discussion - 5 minutes.

9:55-10:20 Coffee break and move to round table discussions

10:20-11:20 **Round table discussions :**

- Refer to list of questions, to be provided separately

11:20-11:30 Rapporteurs to upload presentations (by email)

11:25-12:25 Round table reports by round-table rapporteurs

12:25-12:55 Session summary by Session 5 rapporteur

Piet Zuidema, NAGRA – (10 min)

Plenary discussion – (20 min)
- to be led by Session 5 Chair

Session 6 **Summary and closing of the Workshop**

13:00-13:10 Summary
Georg Arens and Klaus Röhlig – (10 min)

Closing remarks by NEA
Claudio Pescatore – (5 min)

Annex II: List of participants

Peter ANDERSSON	Swedish National Council for Nuclear Waste Ministry of the Environment Sweden
Georg ARENS	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) Germany
Jaana AVOLAHTI	Energy Department Ministry of Employment and the Economy Finland
Lucy BAILEY	Nuclear Decommissioning Authority United Kingdom
Pierre BÉREST	CNE France
Marie BERGGREN	Municipality of Östhammar Sweden
Frédéric BERNIER	Federal Agency for Nuclear Control (FANC) Belgium
Walter BLOMMAERT	Federaal Agentschap voor Nucleaire Controle Belgium
Fabrice BOISSIER	Agence nationale pour la gestion des déchets radioactifs (Andra) France
Frans BOYDON	UK Office of Nuclear Regulation United Kingdom
William BOYLE	Office of Nuclear Energy U.S. Department of Energy United States

Gérard BRUNO	International Atomic Energy Agency (IAEA)
Marie-Pierre COMETS	Autorité de sûreté nucléaire (ASN) France
Miguel Angel CUÑADO PERALTA	ENRESA Spain
Géraldine DANDRIEUX	Autorité de Sûreté nucléaire (ASN) France
Christophe DEPAUS	ONDRAF/NIRAS Belgium
Eberhard FALCK	Université de Versailles Saint-Quentin-en-Yvelines Germany
Uschi FANKHAUSER	Nagra Switzerland
Klaus FISCHER-APPELT	Gesellschaft für Anlagen und Reaktorsicherneit mbH (GRS) Germany
Thomas FRIES	Nagra National Cooperative for the Disposal of Radioactive Waste Switzerland
Paul GIERSZEWSKI	Nuclear Waste Management Organization (NWMO) Canada
David GLAZBROOK	Nuclear Installations Inspectorate United Kingdom
Bengt HEDBERG	Swedish Radiation Safety Authority Sweden
Jussi HEINONEN	Radiation and Nuclear Safety Authority (STUK) Finland
Pirjo HELLÄ	Saanio & Riekkola Oy Consulting Engineers Finland

Wolfgang HILDEN	European Commission EU
Brittain HILL	US Nuclear Regulatory Commission United States
Markus HUGI	Swiss Federal Nuclear Safety Inspectorate ENSI Switzerland
Mihaela ION	Nuclear Waste Management Organization (NWMO) Canada
Katsuhiko ISHIGURO	Nuclear Waste Management Organization of Japan
Jongtae JEONG	Korea Atomic Energy Research Institute (KAERI)
Sven KEESMANN	Nagra Switzerland
Julia KISS	PURAM Hungary
Kathleen KLASSEN	Canadian Nuclear Safety Commission Canada
Uwe KÖHLER	Nagra Switzerland
Gloria KWONG	NEA/PR OECD
Flavio LANARO	Swedish Radiation Safety Authority Sweden
Thierry LASSABATERE	Electricité de France France
Pascal LEVERD	Andra France

Virpi LINDFORS	Municipality of Östhammar Sweden
Tapio LITMANEN	University of Jyväskylä Finland
Daniel METLAY	U.S. Nuclear Waste Technical Review Board United States
Mauro OLIVETTI	Italian National Agency for New Technologies,Energy and the Environment Italy
Olle OLSSON	Swedish Nuclear Fuel and Waste Management Co. (SKB) Sweden
Erkki PALONEN	Posiva Oy Finland
Risto PALTEMAA	Radiation and Nuclear Safety Authority - STUK Finland
Tom PEAKE	US Environmental Protection Agency United States
Claudio PESCATORE	NEA/PR OECD
Alice POIRAT	EDF France
Philippe RAIMBAULT	Consultant France
Hans RIOTTE	NEA/PR OECD
Klaus-Jürgen RÖHLIG	Technische Universität Clausthal Germany
María del Carmen RUIZ LOPEZ	Conseil de Sécurité Nucléaire Spain
Vesa RUUSKA	Posiva Oy Finland

Shigeyuki SAITO	Japan Nulcear Energy Safety Organization (JNES) Japan
Elisabeth SALAT	IRSN France
Jürg SCHNEIDER	Nagra Switzerland
Monika SKRZECZKOWSKA	National Atomic Energy Agency Poland
Shawn SMITH	US Nuclear Regulatory Commission United States
Bruno THOMAUSKE	RWTH Aachen University Germany
Gavin THOMSON	Environment Agency United Kingdom
Michael TICHAUER	IRSN France
Cherry TWEED	Nuclear Decommissioning Authority (NDA) United Kingdom
Maarten VAN GEET	ONDRAF/NIRAS Belgium
Hughes VAN HUMBEECK	ONDRAF/NIRAS Belgium
Juhani VIRA	Posiva Oy Finland
Sylvie VOINIS	Andra France
Gabriela VON GOERNE	Federal Ministry for the Environment Nature Conservation and Nuclear Safety Germany

Keiichiro WAKASUGI	NEA/PR OECD
Juergen WOLLRATH	Bundesamt für Strahlenschutz (BfS) Germany
Uichiro YOSHIMURA	NEA/SRAN OECD
Piet ZUIDEMA	Nagra Switzerland