
European pilot study on the regulatory review of the safety case for geological disposal of radioactive waste

*F. Besnus¹, J. Vigfusson², R. Smith³, V. Nys⁴, G. Bruno⁵, P. Metcalf⁶, C. Ruiz-Lopez⁷,
E. Ruokola⁸, M. Jensen⁹, K. Röhlig¹⁰*

¹IRSN – Institut de radioprotection et de Sûreté Nucléaire – BP 17 – 92262 Fontenay-aux-Roses (France)

²HSK – Hauptabteilung Für die Sicherheit der Kernanlagen – CH-5232 Villigen-HSK

³Radioactive Substances Regulation Environment Agency c/o Defra Zone 3/H32, Ashdown House - 123, Victoria Street - London, SW1E 6DE

⁴AVN – Association Vinçotte Nucléaire – Rue Walcourt 148 – B-1070 Bruxelles

⁵EC – European Commission – Directorate General for Energy and Transport (EC/DG TEN) – Euroforum Complex – Zone d'activité Cloche d'or – 1 rue Henri M. Schnadt – L-2530 – Luxembourg

⁶IAEA – P.O Box 100 – Wagramer Strasse 5- A-1400 Vienna, Austria

⁷CSN – Consejo de Seguridad Nuclear – C/Justo Dorado, 11 – 28040 Madrid

⁸STUK – Radiation and Nuclear Safety Authority – Laippatie 4/P.O-Box 14 – 00821 Helsinki

⁹SSI-Swedish Radiation Protection Authority – 17116 Stockholm

¹⁰GRS – Gesellschaft für Anlagen and Reaktorsicherheit mbH – Schwertnergassel, 50667 Köln, Germany

Abstract:

A number of countries within Europe are developing or giving consideration to the development of geological disposal facilities for the disposal of high level radioactive waste. The safety authorities in these countries are interested in exploring the possibility of a harmonised approach to the demonstration of safety of such facilities and the regulatory review of documentation providing such demonstration. As such and with technical support organisations and international bodies they have initiated a pilot study on how these elements should be presented in a safety case, for, inter alia, regulatory review and approval. It is envisaged that such a study will cover assessment of the site and engineering, impact assessment and assessment of the management systems ensuring quality and will be compatible with internationally agreed safety standards, guidance and recommendations. It is foreseen that the safety case will evolve and mature as the project develops and this aspect has been considered within the pilot study, together with regulatory review and decision-making at discrete milestones associated with the disposal facility development. The study is focussed on regulatory expectations for the different milestones and addresses uncertainty management. The paper presents the work carried out to date and the views for future work.

A SUMMARY OF THE FINDINGS OF THE EUROPEAN PILOT STUDY

A number of countries are developing or giving consideration to the development of geological disposal facilities for the disposal of high level radioactive waste and harmonising approaches to achieve a high level of safety for such facility becomes a foreseeable and necessary objective. To this respect, important steps have already been successfully taken by international organizations such as IAEA and OECD/NEA in developing internationally agreed standards, guidance, recommendations and collective opinions. Within the European Union, a Working Party on Nuclear Safety (WPNS) is currently analyzing to what extent

common approaches of waste management are implemented by EU Member States while the Western European Nuclear Regulators' association (WENRA) has started harmonising views concerning best safety practices for the predisposal management of radioactive waste. In parallel, France and Belgium have cooperated in developing ideas on the safety approach to geological disposal and reached common positions that were presented to an enlarged group of European regulators and International organisations. It was considered that valuable momentum had been created by the French-Belgium initiative and that efforts to develop common views should be enlarged to other interested countries within the European region. It was consequently decided to launch a pilot study, aiming at sharing experience and opinions on the expectations of the regulator for different elements of a safety case for geological disposal of radioactive waste at the different steps in a project to develop such a disposal facility. The pilot study is carried out by a group of regulators and technical support organisations from Belgium (FANC, AVN), UK (EA), France (ASN, IRSN), Finland (STUK), Germany (GRS), Spain (CSN), Sweden (SSI), Switzerland (HSK), as well as representatives of international organisations (IAEA, EC).

Although regulatory frameworks differ considerably between countries, the Working Group recognised that regulatory practice differs to much less an extent.

It is now widely accepted that development of a disposal facility and its safety case should take place in a step-by-step manner with well-defined decision points. The degree to which a step-by-step process is implemented in regulations varies from country to country, and so do the requirements concerning the involvement of regulators and licensing authorities at various decision points. The Working Group considers, however, that it is important to keep regulatory and licensing authorities and their technical support organisations informed about the state of development at each step and to involve them in the major decisions (e.g. about the disposal facility concept or about R&D priorities), no matter whether or not there is a formal requirement for doing so.

From a regulatory perspective, the key stages are :

- conceptualisation,
- siting,
- design,
- excavation/construction,
- operation,
- closure.

For the purposes of the pilot study, the group chose to focus on :

- the conceptualisation stage, during which a safety strategy must be developed together with a review of potential sites and design options as well as preliminary assessments in order to enable decision making on committing resources to the next stage of the project,
- the siting stage, for which the safety strategy must be confirmed as well as design suitability for given site(s) that have undergone due characterisation in order to make decision of site selection for hosting a disposal facility,
- the design stage that comprises design validation and safety assessment in order to license construction of the disposal facility.

The group considered that at each development stage each of the following aspects should be considered :

- facility design and the safety strategy
- demonstration of site and engineering suitability

- impact assessment
- adequacy of management systems

In this respect, the safety case presenting the arguments and supporting information and assessment related to the above aspects will have to be comprised of clear information, from the very beginning of a disposal project, covering the design options and the key elements upon which safety relies, together with a description of the preferred strategy to acquire progressively enough knowledge of the factors governing the containment and isolation capacity of the disposal system. The safety case will also need to accommodate uncertainties, as discussed further below. Given that a preliminary design and safety strategy is a necessary input for project implementation, the assessment of the soundness of the proposed options is essential to enable the project to move forward to the next step. The safety case must therefore be comprised of information, assessment and arguments, covering the three components mentioned above and aiming at identifying advantages and disadvantages of the chosen design and strategy in terms of safety throughout the project development. The elements to be described are:

- **that related to assessment and demonstration of the site and engineering suitability** ; this comprises all information concerning site and design selection, characterisation and validation with regard to safety. The site and engineering assessment must include a description of the functions assigned to each component of the disposal system (for both the operational and post-closure phases) and an analysis, through a performance assessment, of the capacity of these components (including the host rock) to fulfil their given role. In this respect, the situations and phenomena that may affect system performance, both internal and external (heat, corrosion, radiolysis, mechanical stress, criticality, seismicity, climate change, etc.) must be identified and quantified so as to assess the system behaviour and robustness. The site and engineering assessment also address elements of construction feasibility and reliability. In all these respects, the design and site performance will need to be justified and the uncertainties remaining at the particular stage of the project will be identified,
- **that related to impact assessment** in terms of radiation dose, risk, some combination of both or other entities indicating potential impact ; this comprises appropriate modelling and data selection so as to assess exposures that might arise from facility operations and long term evolution with a sufficient level of confidence. It requires clear substantiation that assessment of selected scenarios provides a conservative estimate of the impact of the facility. It also requires sensitivity analysis so as to identify key dependencies on parameter values and assumptions together with evaluating the effect of uncertainties,
- **that relating to demonstrating the adequacy of management systems** associated with the project to assure an adequate level of quality in respect of all safety related aspects of the project ; this comprises in particular organisational arrangements for implementing the project, planning of major actions to be taken during the different steps, elaboration of operational and control procedures, record keeping and review.

All these elements are of course inter-related and form together the necessary bases for demonstrating the safety of a disposal facility and providing input to decision making.

The group considers that this structure should be maintained through every stage of the step-by-step process, with the content of the safety case being progressively developed as the project proceeds. For each key step of decision making, a decision should be taken only if structured information on all important elements of the disposal system is available and the supporting safety assessment is performed, even if at preliminary steps only partial information is available. For example, selecting a site cannot be based only on consideration of geological data but also requires an analysis of site and design compatibility, an

assessment of how the whole system works together to achieve safety and consideration of whether appropriate techniques are available to realise the system.

Uncertainties concerning the safety of disposal facilities are unavoidable due to the complexity of the phenomena of concern and the scales in time and space under consideration. Their management is central when developing a disposal system and assessing its safety. For this reason, the issue of uncertainties and their management has been chosen for a more detailed examination in the frame of the Pilot Study in order to identify the level of commonality on this subject among the participating countries, to better understand differences, and to propose some common grounds for guidance. A self-contained document has been developed and appended to the Pilot study final report, focusing on the handling of uncertainties in the context of the overall safety strategy, safety assessment and evaluation of compliance with safety requirements. The document elaborates on the following concepts :

- **Safety Strategy.** Conscious accounting for uncertainties and analysis of their possible consequences is a required part of any safety assessment for a radioactive waste disposal facility. Within a step-by-step approach to disposal facility development, this includes providing a register of significant uncertainties and a management process for assessing and, where appropriate, avoiding, mitigating or reducing them.

- **Assessment strategy.** Regarding the effect of uncertainties on the safety assessment, emphasis is placed on those elements of the assessment which are not yet fully included within guidance provided by international organisations such as IAEA or NEA, namely :

- the strategy of scenarios
- the role of deterministic and probabilistic approaches, and
- the role of best estimate, conservative and pessimistic models and parameter values.

- **Evaluation of compliance with safety requirements in the presence of uncertainty.**

Although the approach for compliance evaluation differs considerably depending on the country, the issue remains that many uncertainties in the post-closure safety case cannot reliably be quantified. Calculated doses or risks can only be regarded as broadly conservative indicators rather than anything more definite or concrete and, accordingly, the post-closure safety case needs to be based on multiple lines of reasoning.

In conclusion, the Pilot Study offers examples of the ability to find common ground among the regulators from different European countries, both in terms of the general framework and for particular topics, e.g. uncertainty management. This suggests the possibility of work to find further areas of common ground and, perhaps, areas for harmonisation.