Environment Agency

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Understanding controls on the performance of engineered barrier systems in repositories for high-level radioactive waste and spent fuel
Project summary SC060055

A new report by the Environment Agency explores factors that might influence the long-term safety of an underground repository to dispose of high-level radioactive waste (HLW) and spent fuel (SF).

Several countries have looked into disposal options for HLW and SF and have investigated a range of repository designs. These are based on multiple barrier concepts that include an engineered barrier system (EBS) designed to contain and isolate the waste. The EBS is emplaced at depth within a suitable host rock, which acts to provide protection to the engineered components and to ensure geological isolation.

This project has explored current understanding of what controls the performance of different repository designs for HLW and SF disposal, focusing on the role of the engineered barrier system (EBS).

The project aimed to explore the implications for waste form design, waste packaging and repository design, by looking at our current understanding of processes that could influence the long-term performance of a repository. The report sets out an approach to analysing key controls on repository performance, along with an analysis of different types of disposal systems.

The project carried out a literature review of disposal systems proposed by radioactive waste management programmes throughout the world, choosing some representative disposal concepts to illustrate the range of controls on performance. It also reviewed safety functions attributed to different components of the EBS, and identified groups of features, events and processes (FEPs) that describe these safety functions and threats to these safety functions.

Simple computational models were used to explore the significance of each of these FEPs as controls on the performance of barrier components.

Six representative concepts for geological waste disposal systems, based on generic geological environments, were defined:

- shorter-lived waste package/overpack – clay buffer - hard fractured rock/granite;
- longer-lived waste package/overpack – clay buffer - hard fractured rock/granite;
- shorter-lived waste package/overpack – clay buffer – mudrock;
- shorter-lived waste package/overpack – cement buffer – mudrock;
- shorter-lived waste package/overpack – no buffer – mudrock;
- shorter-lived waste package/overpack – no buffer - bedded evaporate.

The report identified eleven key controls on the performance of the geological waste repository:

- chemical stability of engineered barriers;
- physical stability of engineered barriers;
- chemical environment of the EBS;
- groundwater flow characteristics;
- deformation characteristics of the host rock;
- waste characteristics;
- transport characteristics in the host rock;
- structure of the host rock;
- thermal conditions in the geosphere;
- thermal conditions in the EBS;
- radioactive decay and in-growth.

However, the relative importance of these different controls and their overall impact on safety will depend on:

- characteristics of the chosen site;
- the detailed nature of the system to be built;
- the detailed repository design;
- implementation of the repository design.

Furthermore, the performance required of an EBS depends not only on technical issues connected with the EBS itself, but also on regulatory requirements and the characteristics of the surrounding geosphere (geological environment in which the system is based).

The extent to which any radionuclide is able to migrate from the EBS is controlled by the half-life of the radionuclide, its chemical properties (principally whether it is sorbing or non-sorbing) and the physical and chemical properties of the barriers. For spent fuel the buffer and backfill are secondary barriers to contaminant transport, except for radionuclides that are strongly sorbed onto the buffer and backfill materials. For long-lived radionuclides such as iodine-129, the buffer and backfill act to delay release rather than reduce the flux from the EBS. The key role of the buffer and backfill is to protect the canister in which the waste is contained for as long as is required.

This summary relates to information from project SC060055, reported in detail in the following output(s):

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