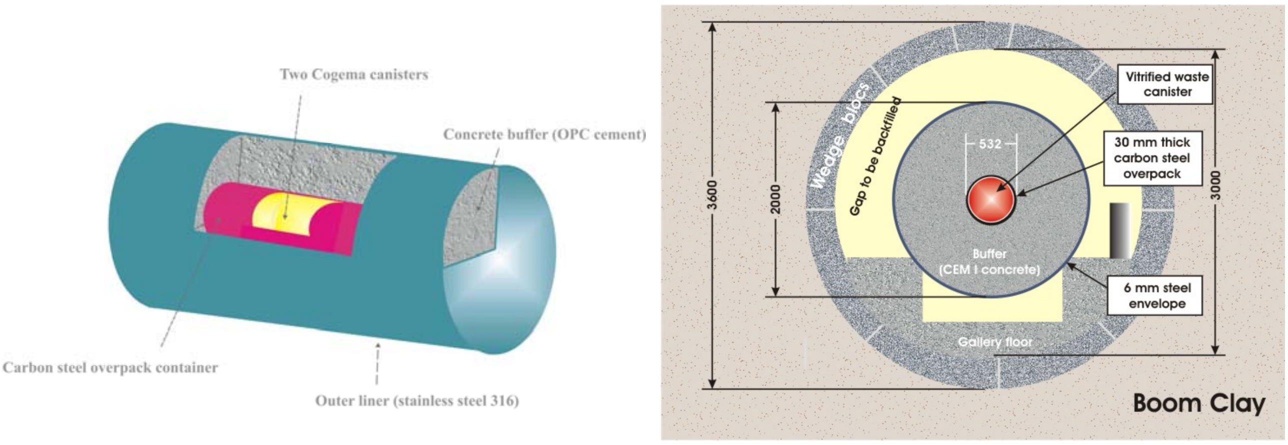
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

PRELIMINARY ON-SURFACE EXPERIMENTS FOR BACKFILLING A HLW REPOSITORY: THE ESDRED PROJECT

Background

ESDRED is a technological integrated project within the context of the 6th Framework Program of EURATOM. The project aims to demonstrate the technical feasibility at an industrial scale of specific technologies related to the construction, operation and closure of a deep geological repository for spent fuel and long-lived radioactive waste. The Belgian design for high level waste disposal is based on the so-called Supercontainer concept. Within this concept, the waste is encased in a carbon steel overpack, which is consequently fitted into a 70 cm thick concrete shell, in its turn enveloped by a stainless steel liner. A Supercontainer measures about 2 m in diameter. In the design of the repository, the Supercontainers will be emplaced, one after the other, in disposal galleries. The space between the Supercontainers and the gallery lining needs to be filled up with a solid material. The most essential function of this component, referred to as backfill, is to prevent a collapse of the gallery. A secondary function is to limit the presence of free oxygen, to limit corrosion. In the ESDRED project EIG EURIDICE, together with SCK•CEN and ONDRAF/NIRAS, investigates technologies to apply the backfill.



The Belgian reference solution for HLW disposal: the Supercontainer concept.

Objectives

Two options to apply the backfill were investigated within the ESDRED project: gunite the gap with a granular material and backfill the gap with a grout. The prime operational target will be to achieve a 100% filling of the gap. A wide variety of materials was tested. A number of considerations regarding long-term safety and operational feasibility impose constraints on the backfill component:

- it should preserve the corrosion-protective environment established by the Supercontainer;
- it should not act as a thermal isolator;
- it should not introduce organic materials that can give rise to the formation of migration-enhancing complexes between radionuclides and soluble organic compounds;
- it should be constructible at a sufficiently high rate;
- the strength of the backfill must be low enough to enable retrievability;
- dust generation and water run-back during the construction should be limited.

Principal results

Tests were performed on two different test stands: one for the granular option and one for the grout option. Both stands are 5 m long, covering the length of one Supercontainer for vitrified high level waste. In both stands, the Supercontainer is represented by a carbon steel tube. The stands are reduced-scale representations (~5 m³ of void space); the diameters are at 2/3rd of real-life dimensions.

DRY GUNITING A guniting vehicle was designed and build within the frame of the ESDRED project. After its installation in front of the mock-up, a high quality dry-gun machine was rented. A first backfill test with pure sand was performed. The projection machine managed to backfill the gap up to the very top and a rate of about 2 m³/h was reached. Similar tests were executed with other materials and material mixes. All tests were successful, except for the combination sand-cement, where a serious degree of segregation was observed, with cement remaining at the top of the void, and sand in large concentrations at the bottom.
As a result of the tests, a list of appropriate materials was established: pure sand (siliceous), pure bentonite (MX-80), a 75/25 mixture of MX-80 with sand, a mixture of MX-80 with cement and sand only slightly

enriched with cement. An important achievement was the robustness of the projection machine; it continued operation under harsh conditions without one single interruption.

Dry guniting tests: guniting vehicle (left and centre) and dry-gun machine (right).

GROUT BACKFILLING A specially designed grout was prepared in two mixers providing the grout via a buffer reservoir in a constant flow to the grout pump. After about 1 hour and 40 minutes, the injection of the mock-up was completed. The test stand for grouting was heated from the inside (simulating HLW decay heat); this aspect is important for the workability and the hardening phase of the grout. To approach the expected conditions at the time of injection in the real-life situation, the mock-up was insulated and the temperature of the central tube was kept at 40-50°C. After hardening of the grout, several core samples were taken to analyse the strength and thermal conductivity of the backfill, these analyses are currently ongoing. Once the casing was removed, an apparent 100% void filling could be observed. A slice was cut from the mock-up using a diamond cable and the perfect filling of the gap was illustrated.

Grout backfilling tests: mock-up with central heater (left) and insulation (centre). Perfect filling of the gap was illustrated when a slice of the mock-up was cut (right).

Future work

Of the two tested techniques, grouting is the preferred option since it results in a cementitious backfill which makes it similar to the surrounding components. In a next phase of the project, in 2007 and 2008, a full-scale 30 m long mock-up will be grouted. Furthermore, the logistical needs behind the backfilling works to ensure a continuous operation will be studied.

Main contact person

Wim Bastiaens, wim.bastiaens@sckcen.be