DISPOSAL OF NUCLEAR WASTE IN DEEP BOREHOLES

TECHNOLOGY OVERVIEW

Deep Isolation is an international company developing alternatives to mined repositories to achieve geologic disposal of long-lived nuclear wastes.

Our advanced nuclear technology consists of boreholes directionally drilled into suitable host rocks using standard drilling methods, site characterization techniques to ensure geologic isolation, and patented canister technology to transport and manage fuel assemblies. Deep boreholes have been extensively studied and developed in previous decades. Waste disposal in deep boreholes offers a potential for enhanced safety due to inherent features such as the highly thick and protective natural barrier of host rock, a reduced proximity to near-surface flows, a reduced risk of radionuclide transport at such depths, and less subsurface disturbance from drilling compared to mining excavations. As a result, borehole repositories can provide robust and deep isolation for many types of radioactive wastes, expanded options for siting repositories, and a scalable implementation that can adapt to specific waste management programs and inventories.

REPOSITORY DESIGN OPTIONS

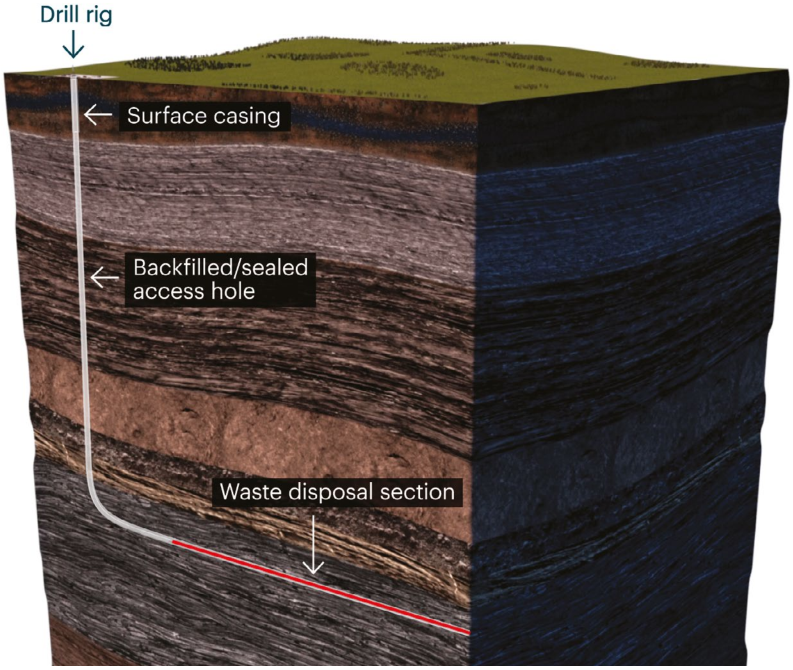
There are multiple borehole configurations that can be used to dispose of nuclear waste, including horizontal, vertical, and slanted. The optimal configuration and depth will depend on the available host-rock, waste type, and needs of the country and community hosting the repository.

Unique to Deep Isolation, the deep horizontal borehole design capitalizes on the drilling advancements made in the oil and gas industry that make borehole disposal siting options even more flexible.

In horizontal repositories, a vertical access hole is drilled and cased from the surface to a point a few hundred meters above the target repository horizon. A smaller-diameter hole is drilled and cased from that point in a gradual curve (less than 8 per 100 feet) until the hole has reached a horizontal orientation. The radius of the curvature is large enough to allow for movement of waste canisters about 5 meters long. From the bottom of the curved section, the disposal section is drilled and cased for a distance of a few hundred to a few thousand meters.The waste is emplaced in Duplex stainless-steel corrosion-resistant canisters, then lowered down the drill hole, typically to a depth of 1 kilometer or more, and placed end-to-end in the encased horizontal section of the borehole.

DEMONSTRATING GEOLOGIC ISOLATION

The performance of a nuclear waste repository is measured by the radiation exposure risk to humans



A schematic representation of a deep horizontal borehole repository.

and the environment. To improve confidence in site characterization and thus long-term safety, Deep Isolation offers a patented method to measure the isolation of stagnant pore fluids in the vicinity of a potential repository. Demonstrating long-term performance and safety involves heat and fluid transport modeling of the subsurface combined with risk-informed assumptions about the likely features, events and processes that could affect the safety of the repository. Initial safety calculation models conclude that the isolation and large rock volume present in deep horizontal or vertical borehole disposal are effective in minimizing the potential radiological exposure to humans and the surface environment.

ENGINEERED BARRIER SYSTEM COMPONENTS

CORROSION-RESISTANT CANISTERS

One component of the engineered barrier system is a long-term durable canister specifically designed to hold spent nuclear fuel assemblies or other high-level radioactive waste. Canisters made of highly corrosion-resistant stainless steel are very stable in the reducing chloride environments found at depth and provide an engineered barrier expected to last for many years, after which time the thermal effects created by the spent nuclear fuel will have dissipated and many radionuclides will have decayed.

CASINGS, BACKFILLS, AND SEALS

Cemented steel casing provides stability to the borehole, and a borehole liner ensures a smooth conduit for canister emplacement and retrieval.

After emplacement of the canisters, the disposal section access casing is removed, and the section is plugged by filling the upper portion of the drillhole with sealing materials that may include a combination of bentonite clays, cements, asphaltic compounds, and various rock forms. The backfilled and sealed portion of the borehole is more than a kilometer in length and provides a robust barrier to radionuclide mobility and transport in all types of borehole disposal.

Deep Isolation Waste Canister

PLACING AND RETRIEVING

Placement and retrieval methods for borehole equipment are highly developed and are commonly performed using wireline with a tractor, coiled tubing, or drill-pipe methods. Methods to prevent and release stuck canisters during emplacement have been assessed and developed and are not expected to challenge the operational safety of the repository. Regulations may require that high-level waste disposed of in a deep geologic facility be retrievable. In the drilling industry, retrieval of objects from deep boreholes is routine, including uncooperative retrieval.

TECHNOLOGY BENEFITS

There are safety, operational and economic benefits to disposing of spent nuclear fuel and high-level radioactive waste in deep boreholes:

- The repository is located far below drinking water aquifers, in formations that have been isolated from the surface for millions of years.
- The depth of the repository protects it from inadvertent intrusion and near-surface disturbances.
- A reduced physical footprint and increased siting flexibility means disposal could take place close to reactor sites and interim storage facilities, minimizing transportation.
- Borehole repositories of different sizes and shapes can be built in a modular fashion, tailored to the specifics of the waste inventory as well as geographical and geological conditions.
- Worker safety is improved because no one goes underground.
- Disposal costs are substantially lower than for mined repositories due to their smaller size, reduced subsurface infrastructure, and staged implementation.

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