Nuclear waste management and disposal

VTT Technical Research Centre of Finland is the biggest multi-technological applied research organisation in Northern Europe with approximately 2,900 employees. We have approximately 100 experts serving the field of nuclear waste management, along with 10,000 m² of modern laboratory facilities, ranging from nanoscale material studies through full-scale structural mock-ups.

VTT has over 25 years of experience serving Finnish and Swedish nuclear waste management organisations, including support with high level waste management for Posiva Oy and Svensk Kärnbränslehantering AB (SKB) as well as Low and intermediate level (LLW) waste (TVO and Fortum Oy) and regulatory authorities in Finland and Sweden. We are active members of the European Technology Platform on Implementing Geological Disposal (IGD-TP) as well as OECD NEA committees on RWMC (Radioactive Waste Management Committee), IGSC (Integration Group for the Safety Case) and TDB (Thermochemical Data Base). We have participated in numerous EU and international projects, including many FP7 Euratom projects.

The VTT offering

VTT has the expertise needed to assess the long-term safety of spent fuel and other nuclear waste disposal stages. The assessment of a disposal system’s overall safety is based on understanding the coupled behaviour of its subsystems, gained through in-situ characterisation, experimental studies, demonstrations and mathematical modelling. The following sections present some examples from our nuclear waste management research:

Modelling for post-closure safety assessment
Assessing the long-term safety of waste repositories means modelling the physical and chemical characteristics of radionuclides, the containers into which they are placed, and the surrounding environment.

Some of the parameters we look at include:
- The time-dependent inventories of radionuclides
- Volumes and flow rates of groundwater close to the repository
- Transport properties of radionuclides along water-carrying fractures in bedrock
- Structural behaviour of disposal canisters and of barrier materials like clay, concrete, and bedrock

VTT has performed several increasingly complex safety assessments of geological repositories for spent fuel. Such an assessment was recently done for the 2012 construction licence application of Posiva’s spent fuel repository in Finland.

Non-destructive evaluation and testing
VTT has performed non-destructive evaluations (NDE) for over 50 years. Together with the customer organisation responsible for the safe disposal of spent nuclear fuel, we have developed a solid methodology for inspecting the disposal canisters and engineered barrier system (EBS) components, like buffer and backfill. VTT is focused on developing more reliable, economical, and precise NDE methods, both new and conventional, for our customers’ specific needs.

VTT’s internationally competitive facilities include an accredited non-destructive testing (NDT) laboratory with advanced mechanised eddy current and phased array ultrasonic inspection systems, as well as scanning acoustic microscopes and state-of-the-art simulation programs. We have expertise in traditional wired and newer wireless
transmissions systems, for real-time monitoring of site and EBS components. Monitoring programs are developed with clients to show conformance to performance targets and ensure stakeholder confidence.

Development of encapsulation and disposal technologies
VTT has contributed to the development of disposal canister concepts and other engineered barriers for the disposal of spent nuclear fuel. We have devoted together with the customer considerable effort to the development of double-layer, copper/cast-iron canisters. These consist of a massive cylindrical nodular graphite cast iron insert covered by a 50 mm-thick copper overlay. We have worked closely with clients to optimize the manufacturing of EBS components, such as using isostatic and uniaxial compaction of bentonite, as well as manufacturing of bentonite pellets and concrete structures as tunnel plugs.

We have developed quality control systems for raw material procurements and EBS component manufacturing. We are refining techniques for installing compacted bentonite blocks into disposal holes and deposition tunnels, and are currently involved in large-scale laboratory testing of these techniques. We have developed moisture protection systems to prevent EBS early state deterioration during the construction phases.

Site characterisation and evaluation
VTT has been investigating and characterising Finnish nuclear waste disposal sites for over 20 years. We begin by collecting data on the disposal site, including fracture properties and networks within crystalline bedrock, as well as groundwater chemistry and movement in the repository area.

This data is used to construct a three-dimensional model of the site that displays the geophysical and geochemical properties required to provide natural barriers against the release of nuclear waste, and to design high-standard, underground repository. Understanding a repository site’s geological past helps in estimating its future. We have had a role with Finnish stakeholder involvement, including studies in urban/municipality impacts of repository site selection.

Operational safety of spent fuel management and transportation
VTT evaluates the operational safety of interim storage and encapsulation of spent nuclear fuel. We have made risk analyses of the transportation of spent fuel from a power plant to a disposal site. These covered various modes of travel, be it road, rail, or ship. We were recently involved in probabilistic risk assessment (PRA) related to the transportation and encapsulation operations.

Nuclear waste long-term safety research in a nutshell
- Characterization of radioactive waste
- Design of disposal concept (KBS-3)
- Operating waste and decommissioning
- Bedrock and groundwater characterization
- Long-term safety of materials, disposal facilities and safety case
- R&D supporting repository planning and construction
- Engineering barrier system component manufacturing and quality control
- Operational safety of disposal facilities, including PRA
- New and alternative waste management technologies
- Licensing support
- Low and Intermediate waste storage

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