Sandia National Laboratories

Geotechnical Studies and Engineered Barriers

Description

Sandia National Laboratories has served as the science advisor to the Waste Isolation Pilot Plant (WIPP) for a quarter century. During this period, Sandia devised and deployed an array of geotechnical experiments pertaining to site characterization and performance assessment. Because the WIPP facility is situated in a bedded salt formation, research in rock mechanics, geophysics, and engineered barriers has considered characteristics unique to the host rock. This section reviews past and ongoing geotechnical research conducted by Sandia in its role as science advisor for the WIPP.

Through the WIPP project, Sandia has developed unique expertise for evaluation of waste form degradation (e.g. metal corrosion, cement degradation) in high-ionic strength media, which is particularly valuable for the design of a nuclear waste repository in a salt formation or in an environment with saline groundwater. The Nuclear Waste Management Program takes advantage of Sandia's strength in materials research and science and collaborates with other organizations of the lab, as well as universities, to develop various functional materials to meet various needs of nuclear waste management. One of the earliest waste encapsulation technologies, a durable ceramic waste form proposed for disposal of high-level waste, was developed at SNL as the corrosion resilient titanium (TICOD12) High-Level Waste cannister .

In Situ Experiments

Sandia and WIPP project personnel executed a suite of large-scale experiments underground. *In situ* investigations established performance metrics and validated computational methods. A review of these experiments will help establish an appreciation of the scale of site geotechnical studies. Beginning in the mid-1980s, several underground experiments were deployed and for more than a decade, full-scale room experiments examined creep induced by mining, disturbed rock zone development, thermally driven response, waste package performance, and plugging/sealing techniques. Primary *in situ* experiments included:

- Thermal/Structural Interactions/Heated Axisymmetric Pillar
- Defense High-Level Waste Mock-up
- Defense High-Level Waste Thermal Overtest
- Plugging and Sealing Tests
- Waste Package Performance Tests

Many smaller scale underground investigations, such as those pertaining to hydrology and seal materials, were also undertaken.

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Engineered Barriers

The WIPP isolation barriers include man-made panel closure systems, a robust shaft seal system, and a chemical backfill of magnesium oxide (MgO). The geological (natural) barriers at the WIPP site provide more than adequate radionuclide containment and isolation to allow the repository to comply with all applicable EPA and New Mexico Environment Department (NMED) disposal regulations.

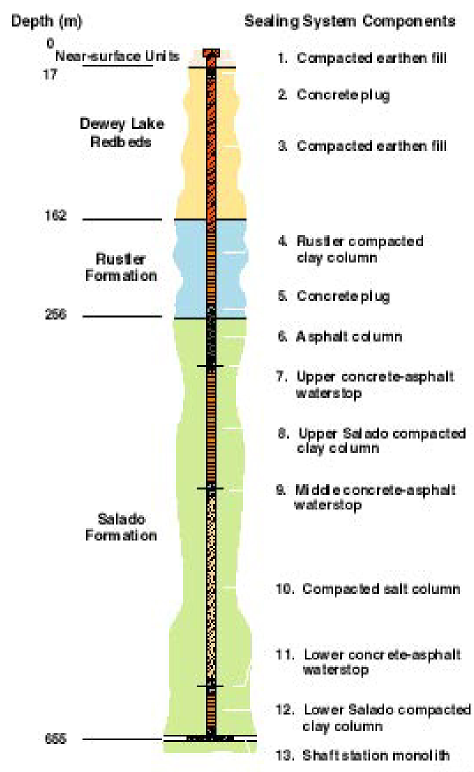
The panel closure system separates the active disposal panel from other operational areas during the disposal phase of 35 years. The MgO backfill provides added assurance of safe repository performance. Alkaline conditions created by the MgO backfill reduce the potential for actinide mobilization in brine by reducing actinide solubility and destabilizing potential forms of colloids. The MgO backfill will also remove any carbon dioxide (CO_2) from the disposal room environment that may be formed by microbial degradation reactions. Chemical reaction between water, MgO, and CO_2 forms a new solid phase in the repository and stabilizes the disposal pH to between 9 and 10, reducing actinide solubilities. Contemporaneously, MgO backfill reduces liquid saturation.

Transuranic Waste Boxes with Attached Magnesium Oxide Filled Bags

Shaft seals play a crucial role in the repository performance by blocking fluid flow from overlying units into the repository and blocking pressure-driven flows from the repository to overlying units. The current WIPP shaft seal design incorporates functionally redundant components of concrete, crushed salt, clay, and asphalt. Disposal-phase seal system activities will refine and simplify the shaft seal design, in several research areas:

- Crushed salt constitutive properties and models
- Clay-seal field applications and specifications
- Longevity of concrete materials under WIPP conditions
- Enhanced emplacement methodologies
- Disturbed rock zone characterization and constitutive modeling

Physical seal systems incorporate a breadth of rock mechanics applications. The rheological behavior of rock salt is one of the major reasons that it is a preferred medium for waste disposal. As stress conditions approach equilibrium, salt fractures heal. Eventually, salt is expected to encapsulate the waste and close potential flow paths. Because of the importance of rock mechanics phenomena to the performance of the sealing systems and to the behavior of the disposal rooms, geotechnical monitoring is continuous in the underground. Field tests results, databases, constitutive model development, and modeling capability are actively being shared with other repository programs.



Shaft Seal System Components

International Collaborations

Sandia has established and maintained geotechnical site studies via partnerships and collaborations with other radioactive waste management organizations. These currently include:

- Tunnel sealing experiment in Canada, which derives technical direction from the Canadians (AECL), Japan (Japan Nuclear Cycle Institute), and France (Agence nationale pour la gestion des dechets radioactifs).
- Technical collaborations and interactions with various test programs in Germany, with emphasis on the disturbed rock zone (DRZ), database assembly, and constitutive modeling collaborations.
- Flow and transport experiments to visualize and model diffusion in low-porosity rocks in Switzerland with the National Cooperative for the Disposal of Radioactive Waste (NAGRA) and in Sweden with the Swedish Nuclear Fuel and Waste Management Company (SKB).

The main benefits to the WIPP from these collaborations are increased confidence in conceptual and numerical models for two-phase flow and transport in fractured rock in a complex chemical environment.

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