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CO-DISPOSAL OF MIXED WASTE MATERIALS

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ABSTRACT

Co-disposal of process waste streams with hazardous and radioactive materials in landfills results in large, use-efficiencies waste minimization and considerable cost savings. Wasterock, produced from nuclear and chemical process waste streams, is segregated, treated, tested to ensure regulatory compliance, and then is placed in mixed waste landfills, burial trenches, or existing environmental restoration sites. Large geotechnical unit operations are used to pretreat, stabilize, transport, and emplace wasterock into landfill or equivalent subsurface structures. Prototype system components currently are being developed for demonstration of co-disposal.

INTRODUCTION

Westinghouse Hanford Company, under the direction of the U.S. Department of Energy, Richland Operations Office, is developing systems for co-disposal of waste materials. Co-disposal. as defined here, is the disposal of radioactive and/or hazardous process generated waste materials in combination with contaminated waste materials produced from waste management and environmental restoration retrieval actions. Co-disposal is a significant waste minimization and resource-use avoidance technology. Development testing and demonstration activities are being conducted on a *National Environmental Policy Act*-approved, geotechnical test-bed located at the Hanford Site, Richland, Washington. The co-disposal process is being implemented at an environmental restoration location wherein waste materials are exhumed, treated, and replaced in the geologic media at the location. The process can be implemented optionally where waste materials are exhumed from an environmental restoration location, treated, transported, and placed in a landfill or similar subsurface waste disposal location. Onsite treatment and disposal will be conducted at past-practice *Resource Conservation and Recovery Act of 1976-* (RCRA) or *Comprehensive Environmental Response, Compensation and Liability Act of 1980-* (CERCLA) contaminated industrial waste trench or landfill locations.

The benefits of co-disposal are many and, by using these co-disposal technologies for mixed waste landfills, significant efficiencies and cost savings can be realized. Co-disposal utilizes 100 percent of the volume of a landfill by incorporating packaged mixed waste into a matrix of treated waste feed materials originating from multiple waste-producing processes. This high-durability, high-leach-resistent, high-strength and low-conductivity material is called "wasterock."

Treated feed materials (i.e., wasterock) can significantly reduce radiation dose by providing shielding during waste package placement and subsequent landfill operations. Wasterock will provide secondary confinement of packaged waste and physical stability to the landfill. Inefficient and costly backfilling of the landfill with uncontaminated materials is eliminated. Co-disposal will reduce regulatory restrictions on barrier design of landfills. Waste package disposal can be increased by more than 300 percent if a mixed waste landfill and co-disposed interstitial package wasterock is used. This increased efficiency for a typical RCRA mixed waste landfill can translate to a cost savings of greater than $100,000,000 per landfill.

Demonstration of the co-disposal process and geotechnical equipment is planned in conjunction with a soil-wash treatability study of uranium and polychlorinated-biphenyl-contaminated soil materials. The demonstration will use soil-washing sludge, contaminated-liquid chemical process evaporator condensate, and coal-fired power plant fly and bottom ash as wastestream feed makeup materials. Both polymer and cement treated wasteforms will be produced.

PROCESS FEED CONTAMINATED MATERIALS

The essence of co-disposal is the incorporation and transformation of materials that would otherwise be considered waste into a useful feed material for underground stabilization and isolation of mixed waste landfills or other similar waste disposal structures (1). Extremely large volumes of these waste materials have been and will continue to be generated at the Hanford Site and other waste management sites (government and private sector) over the next few decades. These materials can originate in the form of bulk or packaged liquids, solids, or slurries. Typical Hanford Site-generated materials are discussed as examples.

Mixed fission products, activation products, transuranics, heavy metals, and organic solvents, etc. have contaminated large volumes of geologic media (soil materials) through surface and subsurface structures. These include landfills, trenches, ponds, cribs, reverse wells, and similar underground structures. These materials can be retrieved and transported to areas on the Hanford Site that are more environmentally acceptable and less accessible to the public. A significant portion of these materials will require treatment as defined by regulatory review and approval.

Similar contaminants are often included in the matrix of retired chemical separations plants, reactor buildings, and auxiliary buildings. As structures are decontaminated and decommissioned, a large volume of contaminated rubble will be generated. The contaminated fraction of this rubble may require treatment and/or transportation to a more suitable and approved disposal location.

Structures such as chemical separations plants, evaporators, and waste treatment plants produce large quantities of low-level radioactive and trace-quantity contaminated hazardous materials liquids. These liquids have been discharged to ponds, evaporation basins, infiltration cribs, and similar waste disposal structures. Several wasterock formulations can use these liquid waste materials. Regulatory approval of beneficial use of these liquids is highly probable.

Ash originating as a byproduct of coal-fired steam generation plants at the Hanford Site has been produced in large volumes during the past 5 decades. This material (fly ash, bottom ash, and aggregate) is a solid waste and requires expensive disposal. Most of the ash currently is stored in large above- and below-grade piles. Ash can serve as a filler/binder agent in most wasterock formulations. The ash has been chemically analyzed and found to be within regulatory limits for wasterock.

Retrieval of contaminated solid waste and associated geologic media during site characterization and sampling operations produces significant quantities of bulk contaminants and well cuttings. These are typically placed in steel drums. Operational cleanup and spill spoil materials are typically collected in the same containers. Drummed waste, especially mixed waste, requires transport and acceptance by an onsite permitted treatment, storage, and disposal facility. This is an expensive activity, involving increasing economic and environmental liabilities. This waste could serve as an aggregate for most wasterock formulations and could be used before storage requirements are prompted.

ADMIX FEED MATERIALS

Polymers can be added to contaminated soil and aggregate materials to form a thermoset-injectant slurry, which in turn forms a stable leach-resistant monolith. Polymers can be added to the equivalent contaminated materials and can be cast into large blocks. These can be used at the site of contaminant excavation, or they can be transported to a disposal landfill. The contaminated aggregate is mixed with a monomer that is reacted with a binder to form a durable solid after appropriate cure. These include polyacrylic acids, methacrylates, and styrenes (2).

Concrete formulations consisting of contaminated soil and aggregate utilizing cement and pozzolan as binders is a typical, cost-effective stabilization material for mixed wastes. Other concrete formulations (e.g., sulfur concrete) are derived from contaminated soils, aggregate, and a thermoplastic cement (modified sulfur cement, polyethylene). This material requires homogenization and heating of the particulate and binder. These formulations also can be used as previously discussed (onsite), or they can be transported to a distant disposal location for final disposal.

Where there is a concern with leachability of specific radionuclides or hazardous elements, either in wasterock or in waste containers within the wasterock matrix, sequestering agents can be added to treated slurry materials. Several tests have been conducted to evaluate the effectiveness of zeolites, naturally occurring phosphates, naturally occurring pyrrotite, ferrous sulfide, anion exchange resins, and mixed metal oxide/hydroxides (3). These or other agents can be added to wasterock before cure to inhibit transport of contaminants into the geologic media surrounding the waste disposal landfill, trench, etc. These materials induce precipitation, ion exchange, molecular sieve entrapment, chelation, or other mechanisms that retard contaminant transport to diffusion-controlled rates that are within regulatory limits.

WASTEFORM QUALIFICATION

Wasterock formulations will be qualified for each combination of waste and admix materials. Qualification is a formal process whereby wasterock is tested against several prescribed protocols. Current prequalification activities primarily follow American Nuclear Society procedure 16.1 and the U.S. Environmental Protection Agency Toxic Characteristics Leaching Procedure for hazardous material and radionuclide leach resistance. American Society for Testing and Material and American Petroleum Institute standard tests are used for strength, durability, and flux density.

Formulations are prequalified for use in solidification processing. Qualification verification is completed as part of quality control conducted concurrent to process operation and subsequent destructive testing. Qualification tests depend on the type of waste used in the wasterock formulation, i.e., solid, hazardous, or mixed radioactive and hazardous.

MOBILE FIELD UNIT OPERATIONS

The co-disposal operational system is based on several transportable and mobile unit operations. These unit operations or modules can operate as individual subsystem components or in combination with other components, dependant on application of retrieved or generated waste materials or an holistic system. Solidification treatment, thermal treatment, admix treatment and other geotechnical and geochemical processes may be used alternatively. The primary unit operations currently used for co-disposal are delineated in the following operational description.

Transport, Mixing, Shearing, and Pumping Module

This semi-truck trailer-mounted module carries both liquid and dry (granular or powder) nonhazardous and nonradioactive feed materials in tanks and bins of 3.5 $meters^3$ and 1.8×10^1 $meters^3$, respectively. Dry feed materials are fluidized in separate bins with purified nitrogen gas to promote materials handling and metering. Liquid and dry feed materials are metered through pumps and augers into a colloidal mixer by programmable electronics components permitting batch or continuous batch mixing.

Slurry produced in the colloidal mixer is recirculated continuously by a shearing pump that ensures that the materials are wetted and hydrated. Slurry is then transferred to a pumping tank and alternatively pumped to the next unit operation by either of two progressive cavity pumps or a large dual-action piston pump. This variability in pumping capacity permits required variability in low- or high-pressure and low- or high-volume throughputs requirements. Maximum capacity throughput for progressive cavity pumps is 4.4×10^{-3} and 2.6×10^{-3} $meters^3$ $second^{-1}$ and for the piston pump at pressures of 5.3×10^{-3} and 2.5×10^2 kilograms $meters^{-2}$, respectively.

The unit operation components are powered by a 1.7×10^5 watt diesel power plant that provides hydraulic, pneumatic, and electrical power to component as required. This unit operates as a stand-alone unit, or the unit can operate tethered or interfaced to other units through slurry transfer piping.

Batch Plant/Silos Module

A mobile, semi-truck multitrailer-mounted unit operation for contaminated and noncontaminated materials processing is used either at the point of waste retrieval or at the point of landfill/trench placement. This module is capable of either wet or dry batch operations. In addition, the module can be operated at ambient temperatures for typical slurry materials production or at elevated temperatures for production of, for example, modified sulfur-cement materials.

The module has a throughput of 5.0×10^{-1} $meters^3$ $second^{-1}$. Materials are introduced to the module through two silos. The primary silo is a two-compartment arrangement with a combined capacity of 58.3 $meters^3$. The secondary silo or single compartment aggregate bin has a 38.2-$meter^3$ capacity. Metering and mixing is operated via a load-cell-based 9.2-$meter^3$ recirculating screw batcher. Batch formulation control is operated by a programmable electronic subassembly. Dry particulate amazons (dust control) are collected and recycled into the module using a large, high-throughput roughing filter and high-efficiency particulate air filter components.

The module is electrically powered from a mobile auxiliary feed 8.0×10^4 watt electrical generator. The use and configuration of this module is highly variable, dependant primarily on the wasterock formulation being used.

Materials Classification and Separation Modules

Bulk dry feed materials often require pretreatment to obtain optimum or process-acceptable materials. Standard bulk loading, classification, and conveying modules are modified for use under hazardous and radiation health physics conditions. Primary materials separation for both uncontaminated and contaminated feed includes grisleys, vibratory screens, and large dry-feed hoppers. Secondary materials handling and separation involves shaker classifiers and screens coupled to conveyors (mechanical and pneumatic). Separated materials, either contaminated solids or clean feed stock, are stored in hoppers before being processed.

Materials classification and separation modules are primarily interfaced with batch plant components after waste from slurry formulation. However, the same modules can be used as pretreatment unit operations at the point of contaminated materials retrieval.

Chassis-Mounted Pump and Boom with End Effectors

This fully mobile module carries a large-capacity pump, boom, and end effectors (remote-operated tools used on the terminating portion of the boom) used for materials placement. The primary use of this module is for the backfilling of existing mixed waste landfills. Throughput of the module at maximum capacity is 3.2×10^{-2} meters^3 second^{-1} using a dual-action piston pump. Slurry from the pump is transferred through a four-part roll-and-fold boom. The boom is fully articulated and capable of vertical, lateral or subgrade reach of approximately 32 meters. The sluing radius of the boom is 6.3 radians. The boom reach is required for slurry placement within a landfill with a protracted placing distance. The boom also allows placement of slurry within a landfill where radiation dose is excess of contact handling limits. Slurry placement can be performed through a termination tube affixed to the boom or through a remote, hydraulically operated end effector that uses a coaxial pneumatic placement injector.

The module is chassis mounted and powered by a 2.6×10^5 watt diesel power plant with power-take-off drive. All components are operated with hydraulics. This module is a stand-alone unit; however, it can be remotely operated by electronic tethers, thereby reducing radiation dose.

Pressure Injection

Slurry is injected into existing high void-volume underground waste tanks, drainfields, large industrial containers, etc. using this module. The module is modified from its original configuration as a hydraulic jet grouting system. The injector consists of a counter rotating percussion/abrasion subassembly that is interchangeable with tricone drilling bits, a high-pressure cutting tool, a swivel, and nonreturn valves. This subassembly is operated from a 4.2-meter-long articulated mast and winch assembly.

This chassis-mounted self-propelled module is powered by a 6.6×10^3 watt diesel power plant. All assemblies are powered hydraulically. The module is trammed on independent oscillated crawler tracks for stability and placing site access. The pressure injection module is used independently when in drilling mode and in series with the transport, mixing, shearing, and pumping module during slurry materials placement (injection). Throughput is not limiting.

This unit may additionally be used in its more traditional application of construction of barriers around waste retrieval areas or waste disposal landfill structures. These barriers can be constructed of numerous formulations of wasterock.

Testing and Quality Control Laboratory

In addition to geotechnical equipment unit operations, a mobile laboratory module is used as an integral part of co-disposal. Real-time materials and process testing is conducted in this laboratory. Materials and operations quality-control verification is also conducted using standard procedural testing in this module.

Numerous tests and quality control procedures may be used during materials processing and placement. Present typical laboratory testing involves a spectrum of internationally accepted procedures. Flow-cone testing is done to determine the consistency of slurries and, indirectly, to determine changes in gel or set time. Viscosity (dynamic/kinematic) tests are conducted to determine much the same characteristics as flow-cone measurements. In addition, viscosity measurements are conducted on liquid-feed wastestreams to determine required changes in wasterock formulation composition. Density of the slurry and solid waste stream materials is measured primarily to determine consistency.

Slump is measured on slurry materials to evaluate the consistency and flowability of slurry during placement. Time of set is also used for analysis of placement requirements. Additionally, set time is an important slurry characteristic required for materials hauling and transport time. Phase separation is also determined to verify regulatory requirements of negligible free liquids used in landfill disposal. Adiabatic temperature change and placing temperature determinations are also important characteristics that require measurement to evaluate materials cure and ultimate strength.

Preparation of samples for long-term laboratory verification testing is also completed in the mobile laboratory module. These verification tests ensure wasterock strength, durability, liquid/air flux density, leach resistance, and regulatory compliance. As a precursor to verification testing, standard laboratory testing of numerous other feed materials are typically completed with the results used as feedback to process control.

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