SAND2014-0625P

Deep Borehole Disposal Status

Deep Borehole Consortium Meeting
Albuquerque, New Mexico

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FY13 Highlights

- DOE Funded FY13 R&D
- Increased interest in DBD of HLW forms
- Commingling and Waste Forms Options Studies
- DOE Proposal on DBD Demonstration
- 7 White Papers related to DBD of HLW forms

FY13 R&D Objectives

- **Advance the deep borehole disposal technical basis needed to site and implement a full-scale demonstration project**
  - Collaboration with potential international partners
- **Plan and begin the experimental research program for investigation of alternative sealing methods and the time-dependent properties of candidate seal materials under a range of environmental conditions**
- **Further establish the preliminary safety framework for this disposal concept and for a deep borehole disposal demonstration project**

Increased Interest in Deep Borehole Disposal

- **DOE**
  - Considering the application of DBD to HLW waste forms
    - Commingling Study
    - Draft Evaluation of Options for Permanent Geologic Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste in Support of a Comprehensive National Nuclear Fuel Cycle Strategy
- **IAEA Members**
  - Poland, Philippines, S. Korea, Kazakhstan

FY13 Contributions

- *Deep Borehole Disposal Research: Demonstration Site Selection Guidelines, Borehole Seals Design, and RD&D Needs,* Bill Arnold et al., November 2013, SAND2013-9490P
- *Thermal-Hydrologic Modeling of a Deep Borehole Disposal System*, Bill W. Arnold and Teklu Hadgu, International High-Level Radioactive Waste Management Conference April 30, 2013
- *Deep Borehole Disposal of Spent Fuel*, Pat Brady, Invited Talk, NEI Conference, St. Petersburg Fl. May 7, 2013.
- *Deep Borehole Disposal Concept for High-Level Radioactive* Waste, Bill W. Arnold, Presented to the Kansas Geological Survey – August 13, 2013
- *Deep Borehole Disposal of Nuclear Waste*, Bill Arnold and Pat Brady, Presented at the American Nuclear Society Annual Meeting held November 10-14, 2013 in Washington, DC
- Bates, Ethan Allen, Michael J. Driscoll, Richard K. Lester, and Bill W. Arnold, 2014, Can deep boreholes solve America's nuclear waste problem?, *Energy Policy*, (in review).

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Commingling

- "The Commission therefore urges the Administration to launch an immediate review of the implications of leaving responsibility for disposal of defense waste and other DOE-owned waste with DOE versus moving it to a new waste management organization" *Blue Ribbon Commission*

- "As supported in the Administration's Strategy and recommended by the BRC, DOE has initiated an analysis of the pros and cons of commingling civilian and defense waste." *Secretary Moniz, U.S. Senate Energy and Natural Committee, July 30th, 2013*

Slide taken from Pete Lyons' presentation on Nov 18 at the NWTRB Technical Workshop in DC

Questions following Pete Lyons' presentation on Nov 18 at the NWTRB Technical Workshop in DC

BAHR: This is Jean Bahr, a Board member. You mentioned that you're looking at borehole disposal for some types of high-level waste. Could you amplify what particular types of high-level waste might be amenable to the kinds of borehole designs that are being investigated?

LYONS: I could ask Monica to do that, but, honestly, this is very early in the study, and I'm not at all sure that it makes any sense to be identifying specific candidates now. We see some that might be amenable to it, but, under Monica's leadership, there's a broad range of studies going on looking at the extremely wide range of different forms of high-level waste that exists around the complex. Certainly not suggesting that it looks very logical for spent fuel, but there's a whole lot of other wastes that are out there. Monica, I don't know, do you want to add to that?

REGALBUTO: We're looking at small packages. So, one example is cesium-strontium some capsules, okay, but nothing big. Something that can fit in the current drilling technology. Certainly not advocating crushing spent fuel assemblies or nothing like that. We will be publishing a report from Sandia, probably maybe mid-December, end of the year for sure, where we have analyzed the whole inventory. We did a similar study where we analyzed the whole spent fuel inventory, the commercial, and then this year we did it for the defense. And then, you know, you clearly have a lot more waste categories, and we tried to group it in terms of different characteristics that make them similar. And there is a group of them that are small packages that can potentially go in a borehole.

Disposal Options Evaluation Results for the WG1: CSNF in Purpose Built Containers

Disposal Concept	Disposal Option Performance	Confidence in Expected Performance Bases	Operational Feasibility	Secondary Waste Generation	Technical Readiness	Safeguards and Security
Salt	✓	✓	○	●	✓	✓
Crystalline	✓	✓	○	●	✓	✓
Clay/Shale	✓	✓	○	●	✓	✓
Deep Borehole	✓	○	●	●	○	○

Legend: ✓ Strong | ○ Moderate | ● Weak/Uncertain | × Not Feasible

Disposal Option Performance	Confidence in Expected Performance Bases	Operational Feasibility	Secondary Waste Generation	Technical Readiness	Safeguards and Security
Likely to comply with long-term standards? (Yes/No)	Additional EBS components needed above baseline for each design concept Robustness of information bases; simplicity vs. complexity; knowledge gaps	Ease in ensuring worker health and safety at all stages Special physical considerations at any stages based on physical characteristics	Amount of low-level waste generated during handling and treatment Amount of mixed waste generated	Status of waste form technologies Status of transportation and handling systems Status of disposal technologies	National security implementation difficulty Radiological dispersion device prevention implementation difficulty

Disposal Options Evaluation Results for the Deep Borehole Concept: 10 Waste Groups

Waste Group	Disposal Option Performance	Confidence in Expected Performance Bases	Operational Feasibility	Secondary Waste Generation	Technical Readiness	Safeguards and Security
WG1 - CSNF Purpose-built containers	✓	○	●	●	○	○
WG2 – CSNF DPCs	NA	NA		NA	NA	NA
WG3 – HLW glass	✓ NA	○ NA	○	✓ NA	● NA	✓ NA
WG4 - Other engineered waste forms	✓	○	✓	○	○	✓
WG5 – Metallic and non-oxide fuels	✓ NA	○ NA	✓	NA	○ NA	✓ NA
WG6 – Na-bonded fuel	Unknown	NA	NA	NA	NA	NA
WG7 – DOE oxide fuels	✓ NA	○ NA		○ NA	○ NA	○ NA
WG8 - Salt, granular solids, powders	✓	○	○	✓	○	○
WG9 – Coated-particle spent fuel	✓ NA	○ NA	○	✓ NA	○ NA	✓ NA
WG10 – Naval Fuel	NA	NA		NA	NA	NA

NA = not analyzed

Split scores indicate that size constraints preclude borehole disposal for some, but not all, wastes in a group

Legend:

✓ Strong | ○ Moderate | ● Weak/Uncertain | Not Feasible

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DOE-Managed SNF and HLW Suitable for Deep Borehole Disposal

- **Wastes that currently exist in forms that could be disposed of in boreholes of the reference diameter (17 inches [0.43 m]) or less**
  - Many small-volume types of DOE-managed SNF
  - Cs-Sr capsules at Hanford
  - Calcine wastes at INL
  - Sodium-bearing wastes at INL
  - Treated sodium-bonded fuels
- **Wastes that could be disposed of in boreholes of approximately 1 m (39.4 inches)**
  - All vitrified HLW, existing and projected
  - Most DOE-managed SNF
- **Wastes that could be disposed of in the reference design DBH only after repackaging or process redesign**
  - Projected vitrified HLW
  - Most DOE-managed SNF that is currently packaged in multicanister overpacks (MCOs)
- **Wastes that could not be disposed of in any reasonably foreseeable deep borehole concept**
  - Naval SNF

Deep Borehole Disposal of DOE Cesium and Strontium Capsules

Cesium and strontium capsules from the Hanford Site can be safely disposed in a single deep borehole with a bottom-hole diameter of 0.216 m (8.5 inches) drilled and constructed to a depth of 5 km.

- At the Hanford Site there are 1335 CsCl capsules and 601 SrF_2 capsules in pool storage.
- These capsules contained a total of 67 million curies of radioactive material in 2002 (National Research Council, 2003).
- Capsules are constructed with inner and outer sleeves of 3136L stainless steel or Hastelloy, and are 2.6 inches in diameter by 19.8 or 20.8 inches in length
- Overpacks for 23 leaking cesium capsules are somewhat larger with a diameter of 3.25 inches.
- Cesium capsules primarily contain ^{137}Cs, ^{135}Cs, and barium, and had an average thermal output of 144 W in 2007.
- Strontium capsules contain ^{90}Sr and zirconium, and had an average thermal output of 193 W in 2007.

White Papers

1. DOE-Managed HLW and SNF Eligible for Disposal in a Repository Developed under the Atomic Energy Act
2. Deep Borehole Disposal of Existing DOE Calcine Waste
3. Possible Locations for a Borehole Demonstration Test
4. Consideration of Larger-Diameter Boreholes in Deep Borehole Disposal
5. Inventory of DOE-Managed Spent Nuclear Fuel and High Level Waste Suitable for Deep Borehole Disposal
6. Deep Borehole Disposal of DOE Cesium and Strontium Capsules
7. Licensing Deep Borehole Disposal of High-Level Radioactive Waste

FY14 R&D

- **Funding - $317K**
- **Tasks**
  1. **Evaluation of Regional and Sub-regional geotechnical and other information for a drilling demonstration project**
  2. **Development of Reference Designs for Disposal of Alternative Waste Forms**
  3. **Borehole Seals Research and Planning**

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Member presentations are next

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