Used Fuel Disposition Campaign

Handling & Emplacement Options Study for Deep Borehole

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Objective of Study

- Develop conceptual design options for handling & emplacement of waste packages in 5 km deep boreholes

**Handling:**
- Begins with onsite receipt of shipping cask containing a waste package
- Ends with waste package locked in a receiving collar over the borehole
- Includes equipment and activities

**Emplacement:**
- Begins with waste package locked in the receiving collar
- Ends when waste package is safely released in emplacement interval
- Includes equipment and activities
Near-Orbit Activities

This study will influence other FY15 activities, including:

- Disposal Waste Package Specifications
- Shielding and Transportation Analysis
- Emplacement Mode Hazard Identification and Analysis

This study will be used:

- To brief subject-matter experts for the multi-attribute utility analysis
- Subject-matter experts will recommend options to be presented in the FY15 Conceptual Design Report
Waste Forms

- Primarily for U.S. DOE-title wastes including:
  - Compact HLW such as Hanford’s Cs-137 and Sr-90 capsules
  - Bulk HLW such as granular calcine waste from reprocessing at Idaho
  - Used Nuclear Fuel

- Waste characteristics:
  - Radiologically hot – up to 1,000’s rem/hour contact dose
  - Thermally hot - up to 400 w per meter for Cs Sr capsules
Began Options Study with 2011 Reference Design

• 2011 Reference Design for a simple and off-the-shelf waste disposal system that provides:
  • reference for performance assessment
  • reference for costing
2011 reference design for waste handling and emplacement based on Woodward-Clyde Study (1983)

Woodward-Clyde (1983) draws on “Climax Spent Fuel Test” (1978-1983) – Operational test where 11 UNF canisters were transferred to vertical storage holes, in the Climax Mine at 1365 ft depth on Nevada Test Site, UNF canisters retrieved after 3 years
Waste package arrives by tractor trailer in Type B shipping cask

- Purpose-built Type B cask has doors at both ends
- Special rail car moves Type B shipping cask over borehole
- Waste package lowered through Type B shipping cask into shielded remote handling area on top of borehole
- Waste packages assembled into strings of 40 packages
- String of **40 waste packages lowered by drill pipe** to the disposal zone
Shipping cask on flatbed trailer – note lid on each end of the shipping cask

Woodward-Clyde 1983
Shipping Cask in Climax Study (1978-1983)

Shipping cask on flatbed trailer – note lid on each end of the shipping cask
Waste package being lowered through shipping cask into borehole, leading to Climax Mine.
Handling & Emplacement System in 2011 Reference Design

- Emplacement rig floor is 49 ft above grade
- Shipping cask on rail car over borehole
- Shielded remote handling area (basement)

Woodward-Clyde 1983
Emplacement System in 2011 Reference Design

- **At grade, shielded floor**

  Equipment in shielded remote handling area (basement) for assembling and holding strings of 40 disposal overpacks

- **Emplacement borehole**

  Woodward-Clyde 1983
Remaining Presentation on Conceptual Design Options
1. Drill-String Emplacement of Strings of 40 Waste Packages
   - Undated version of 2011 reference system
   - Remotely assembling 40 packages into string, lower string with drill pipe

2. Wireline Emplacement of Single Waste Packages
   - Lower single waste packages using wireline

   - Same Waste Package for both options
   - Developing conceptual designs of waste packages
Waste Package Design Requirements

- Internal temperature: 480°F (250°C) or higher
- External temperature at 5 km: 338°F (170°C)
- Internal length: 17 ft (5 m)
- Maximum diameter: 11 in (28 cm)
- Exterior flush and free of sharp steps
- 12 inch shield on upper end

- Hydrostatic pressure at 5 km: 10,000 psi (65 MPa)
- Axial stress: 153,000 lb (70 MT) (weight of 40 packages)

- Factor of Safety of 2.0
Waste Package Stress Analysis

Waste Package Design Analysis by Jiann Su
SNL 6916

153,000 lbf
Axial Force

9600 psi
External Pressure
Example Waste Package Conceptual Design for Granular HLW

- **FILL PORT (4.75” DIA)**
- **WELDED NC77 DRILL PIPE THREAD**
- **WASTE**
- **18’ 9”**
- **10 ¾”**

Used Fuel Disposition
Drill-String Emplacement Option
Equipment for Drill-String Emplacement

1. **Shielded, Remote Handling Basement**
   - Subgrade, shielded room wrapped around borehole
   - 25 to 30 ft deep below grade
   - Triple blow-out preventer, power slips, mud handling, cameras, lights, etc.
   - Receiving collar over borehole, ~ at grade

2. **Emplacement Rig**
   - Rig floor 30 ft above grade
   - 1,000,000 lb capacity (string of 40 packages + 5 km drill pipe + FoS)

3. **Transfer Carrier** – rail mounted carrier to move waste package over borehole

4. **Control room** – for command and remotely-controlled operations

5. **Ancillary Surface Equipment** – generators, mud handling, cementing, shelter, toilets, etc.
Equipment Layout Similar to 2011 Reference Design

- Emplacement rig floor is 49 ft above grade
- Shipping cask on rail car over borehole
- Shielded remote handling area (basement)

Woodward-Clyde 1983
Handling Steps for Drill-String Emplacement

- Waste package arrives in purpose-built Type B shipping cask on a flatbed trailer
- Radiological surveyed & “receipt” paperwork
- Remove impact limiters
- Use crane to bring shipping cask vertical
- Place shipping cask on transfer carrier
- Move cask to borehole, lower onto receiving collar
- Secure to receiving collar
Removing Impact Limiters

Removal of typical impact limiters (photo courtesy of Waste Control Specialists)
Emplacement Steps for Drill-String Emplacement

- Remotely open upper door on shipping cask
- Attach drill pipe to threaded connection on waste package
- Slightly lift waste package
- Remotely open the lower door on the shipping cask
- Lower first waste package into basement with drill string
- Grip package with power slips and elevator ram (redundancy)
- Remove drill pipe and shipping cask

*Optimistically assume one package per day*
Emplacement Steps for Drill-String Emplacement

- Bring second waste package
- Remotely open upper door on shipping cask, attach drill pipe to threaded connection, lift slightly, remotely open the lower door on the shipping cask
- Lower waste package into basement with drill string
- Screw second waste package to first waste package
- Release power slips and elevator ram
- Lower both waste packages by one-package length
- Grip upper package with power slips and elevator ram
- Remove drill pipe and shipping cask
Emplacement Steps for Drill-String Emplacement

- Repeat 38 times, until string of 40 packages is hanging in hole
- String is 220 m (715 ft) long, weighs ~153,000 lb
- Use drill pipe to lower the string of waste packages to disposal zone
- Use both slips and pipe ram to hold each string of drill pipe, when adding next string of pipe (redundancy)
- If using 90 ft stands of pipe - repeat 172 times
- Assuming 7 minutes per 90 ft stand of drill pipe, ~ 20 hours to emplace the string and ~20 hours to trip out
- Set cement bridge plug
Wireline Emplacement Option
1. **Blow-out Preventer Shielding Room**
   - Double BOP at ground level, with mud handling and cameras
   - Build shielded room wrapped around and over BOP
   - Shielding room ~ 10 ft tall
   - Receiving collar over borehole ~ 10 ft above grade

2. **Boom-Type Crane** – to hold wireline sheave over the borehole

3. **Wireline Hoist** – Standard wireline truck with 20,000 ft of 0.488” diameter, double-armored 7-conductor electric wireline

4. **Ancillary Surface Equipment** – generators, mud handling, cementing, shelter, toilets, etc.
Similar to steps for drill pipe emplacement – but there is no transfer carrier

Crane lifts shipping cask from flatbed, and places on receiving collar

Secure to receiving collar
Emplacement Steps for Wireline Emplacement

- Remotely open upper door on shipping cask
- Attach wireline cable head to waste package
- Slightly lift waste package
- Remotely open the lower door on the shipping cask
- Lower waste package to emplacement interval (~ 3 hours)
- Electrically release waste package
- Remove wireline and shipping cask
- After 40 packages are emplaced, set cement bridge plug
Summary

- Reviewed 2011 reference design for handling & emplacement
- Discussed design criteria for waste package
- Presented example of conceptual design of waste package
- Described two conceptual design options:
  1. Drill-String Emplacement of Strings of 40 Waste Packages
  2. Wireline Emplacement of Single Waste Packages
- Summarized equipment needed for each option
- Summarized handling & emplacement steps for each option