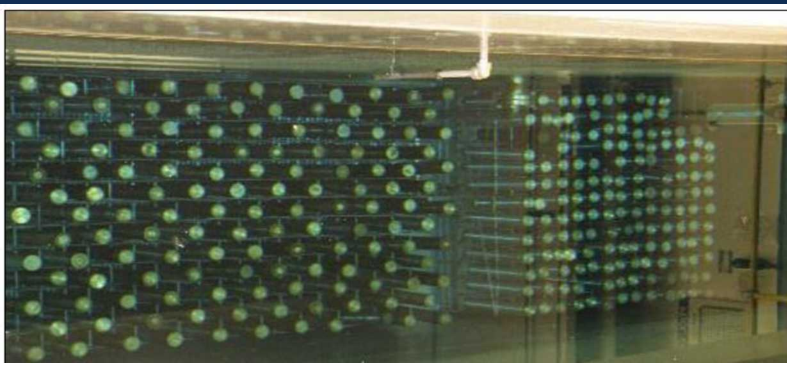
SAND2016-3275C

Exceptional service in the national interest

Sandia National Laboratories



Overview of Cesium and Strontium Capsules for Deep Borehole Disposal

Presented at The International Meeting on Deep Borehole Disposal of High-Level Radioactive Waste

University of Sheffield, UK, June 13-15, 2016

Laura Price, SNL

U.S. DEPARTMENT OF ENERGY

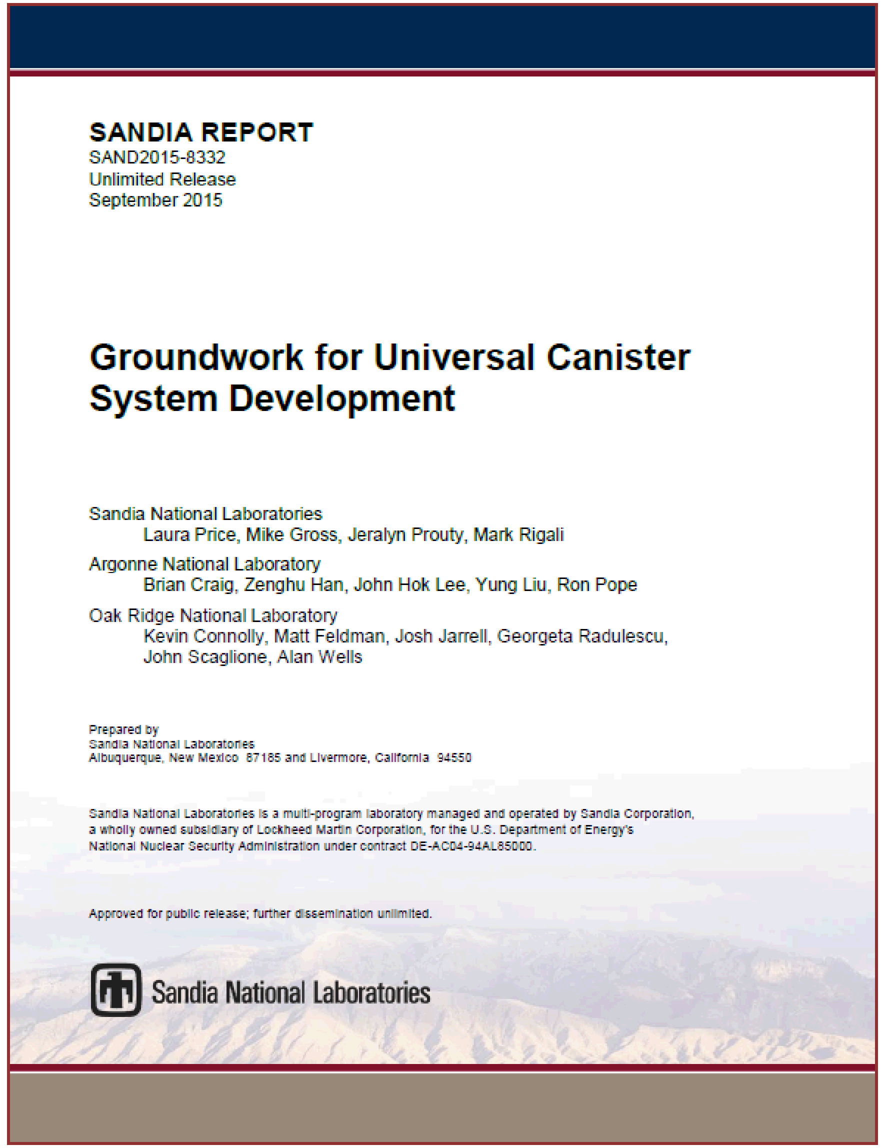
NNSA National Nuclear Security Administration

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND2016-XXXX C

Overview of Presentation

- History of cesium and strontium capsules
- Characteristics of Capsules
- Current and proposed storage
- Transportation of capsules
- Considerations for deep borehole disposal
- Regulatory considerations

Contributors



SANDIA REPORT
SAND2015-8332
Unlimited Release
September 2015

Groundwork for Universal Canister System Development

Sandia National Laboratories
Laura Price, Mike Gross, Jeralyn Prouty, Mark Rigali

Argonne National Laboratory
Brian Craig, Zenghu Han, John Hok Lee, Yung Liu, Ron Pope

Oak Ridge National Laboratory
Kevin Connolly, Matt Feldman, Josh Jarrell, Georgeta Radulescu, John Scaglione, Alan Wells

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Sandia National Laboratories

History of Cs and Sr Capsules

- Cesium (Cs) and strontium (Sr) were recovered from Hanford reprocessing wastes from 1967 to 1983.
- Cs and Sr were removed to reduce the heat generation rate of the wastes in the tanks
- Cs was recovered from the waste, converted to CsCl, and stored in 1,584 doubly encapsulated capsules.
- 794 CsCl capsules leased to three companies for radiation sterilization of commercial products
- Sr was recovered from the waste, converted to SrF_2, and stored in 640 doubly encapsulated capsules
- Currently 1,335 CsCl capsules and 601 SrF_2 capsules
- Represent about 1/3 of total radioactivity at Hanford

B Plant and WESF

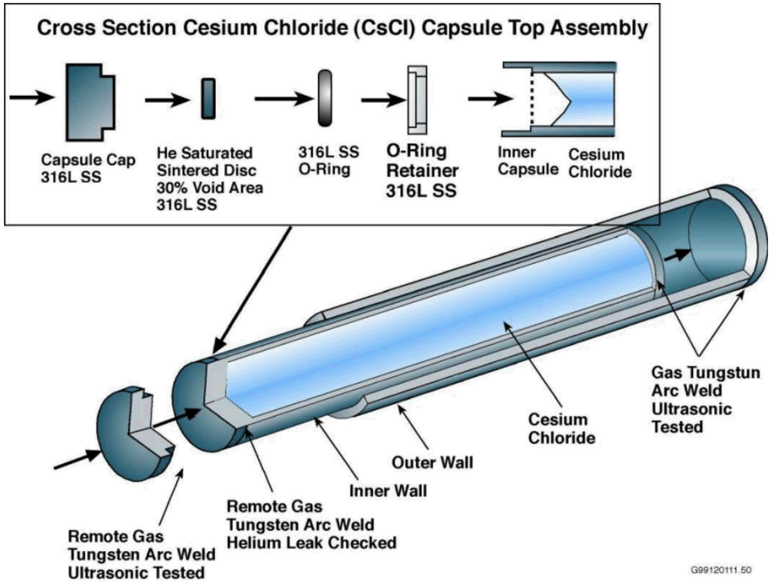
Sandia National Laboratories

Overview of Presentation

- History of cesium and strontium capsules
- Characteristics of Capsules
- Current and proposed storage
- Transportation of capsules
- Considerations for deep borehole disposal
- Regulatory considerations

Characteristics of Cs Capsules

- CsCl doubly encapsulated in capsules 20.775" long and about 2.6" in diameter
- Gross weight is 6 - 9.5 kg
- CsCl salt was melt poured; is very hard
- Both capsules fabricated from 316L SS
- Is a mixed waste – Ba, Cd, Cr, Pb, Si
- 6.5 x 10^7 Ci total of ^{137}Cs (as of 1/1/16) including daughter product, ^{137m}Ba
- About 450 Ci of ^{135}Cs, ~400 kg
- Average power – 119 W
- Average Activity of ^{137}Cs– 2.51 x 10^4 Ci
- Average surface dose rate – 6.34 x 10^5 rem/hour

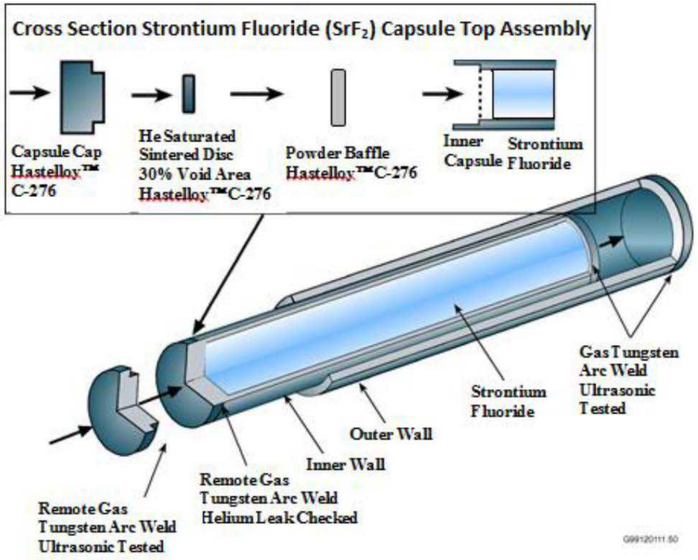


Characteristics of Type W Capsules

- CsCl doubly or triply encapsulated in capsules 21.825" long and 3.25" in diameter
- All capsules fabricated from 316L SS
- Al but one inner capsule fabricated from 316L SS
- 23 Type W capsules
  - 16 swollen capsules returned from commercial irradiators
  - 3 containing remnants from destructive testing
  - 2 containing CsCl powder and/or pellets from ORNL
  - 2 containing CsCl from the Nordion encapsulation program

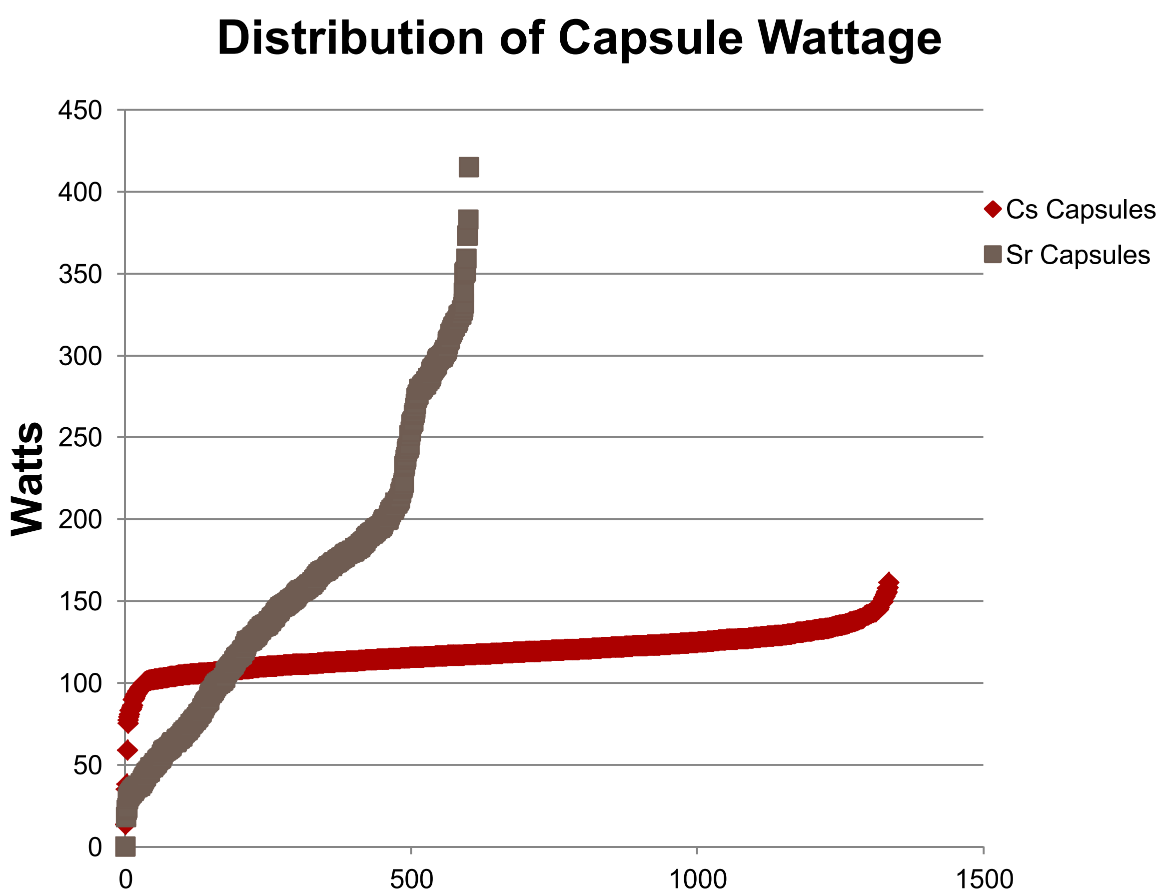
Characteristics of Sr Capsules

- SrF_2 doubly encapsulated in capsules 20.775" long and about 2.6" in diameter
- Gross weight is 6.5 – 10 kg
- SrF_2 is compacted powder
- Inner capsule fabricated from Hastelloy C-276
- Outer capsule fabricated from Hastelloy C-276 or 316 SS
- Is a mixed waste – Ba, Cd, Cr, Pb, Si
- 2.82 x 10^7 Ci total of ^{90}Sr (as of 1/1/16) including daughter product, ^{90}Y
- Average power – 157 W
- Average activity of ^{90}Sr- 2.35 x 10^4 Ci
- Average surface dose rate – 2.92 x 10^4 rem/hour



Picture of Example Capsules

Distribution of Capsule Wattage



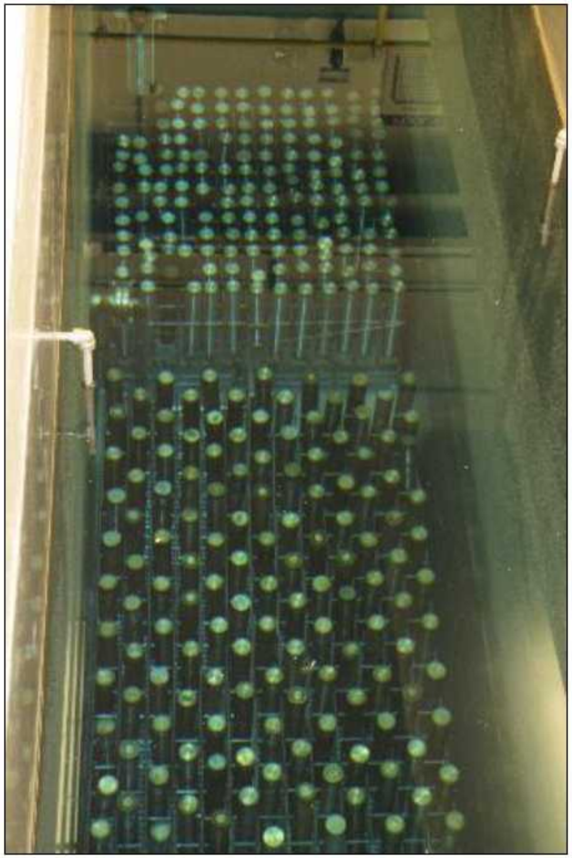
- Plots of radioactivity would look identical
- Sr capsules have greater variability in wattage than do Cs capsules
- Sr capsules are, in general, hotter than Cs capsules

Overview of Presentation

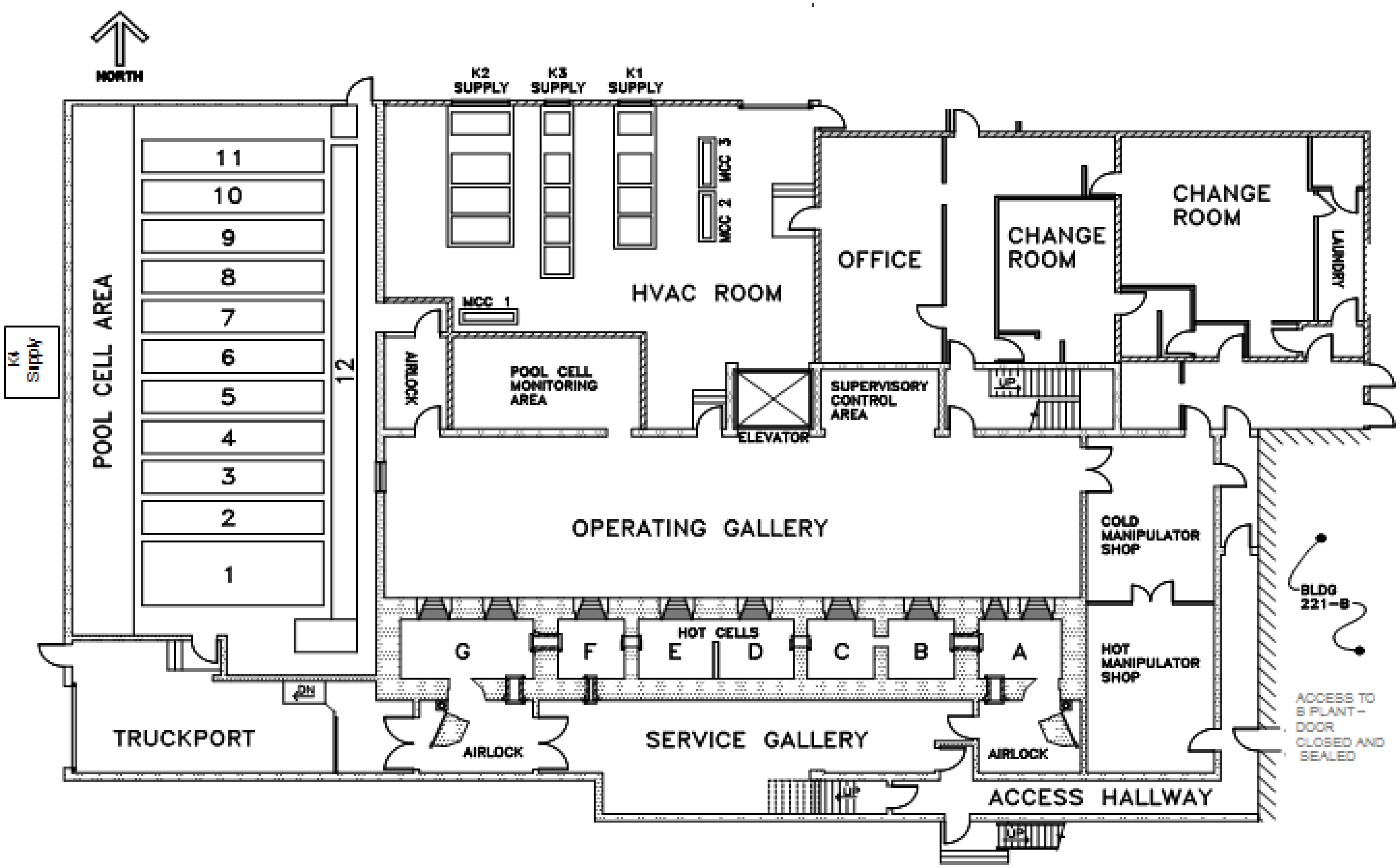
- History of cesium and strontium capsules
- Characteristics of Capsules
- Current and proposed storage
- Transportation of capsules
- Considerations for deep borehole disposal
- Regulatory considerations

Storage of Cs and Sr Capsules

- Capsules currently stored under water at the Waste Encapsulation and Storage Facility (WESF) on the Hanford Site
- WESF began operation in 1974 with 30-year design life
- Concrete in the pools has begun to deteriorate
- A request for proposal for a cask storage system was published on 3/3/2016
- Bids were due April 28, 2016
- Contract scheduled to be awarded 1st quarter FY2017
- Capsules placed in extended storage in 2022



First Floor of the WESF



Current WESF Limitations

- Hot cell G has a heat load limit of 1,800 W
- Hot cell G has a capsule inventory limit of 150,000 CI of ^{90}Sr and 150,000 Ci of ^{137}Cs
- Hot cell G is 8 ft. x 16 ft. x 12 ft.
- Weight limit for hot cell G is 23,000 lb.
- Weight limit for hot cell G manipulators: 100 lb. vertical, 50 lb. horizontal
- Overhead canyon crane weight limit: 15 tons
- Truck port door: 10 ft. wide x 12 ft. high

Scope of Capsule Extended Storage Project

- Acquire a Cask Storage System (CSS), including storage and transfer systems
- Construct a new Capsule Storage Area (CSA)
- Complete WESF modifications needed to support retrieval, packaging, and transfer to the CSA for extended storage
- Perform capsule transfer operations: retrieval, packaging, transfer, and placement into the extended storage configuration
- Storage canister to be based on a design previously approved by the Nuclear Regulatory Commission

Additional Requirements for Deep Borehole Disposal

- Universal canister – maximum outside diameter of 6.5 inches and maximum height of 196 inches
- Maximum weight of filled universal canister - 1,900 lb
- No organic or hydrocarbon-based material
- Maximum decay heat of 213 watts per foot of universal canister height at time of loading (assumed to be 2022)
- System to be designed for removal of universal canister from CSS without cutting welds
- Universal canister top lid must have lifting feature
- Universal canister to be fabricated from Type 300-series SS
- Requirements for vacuum drying, welding, markings
- Requirements for weight bearing

Basis for Additional Requirements

- Thermal load at time of disposal (assumed to be 2041) can be no more than 137 W/foot to meet 250° C temperature limit at the waste package wall in a deep borehole
  - Assumes an ambient temperature of 170° C in the borehole at a depth of 5 km
  - Assumes each waste package holds nine lengths of capsule with three capsules per layer, 27 capsules.
  - Assumes borehole backfill chosen has thermal properties similar to that of bentonite
  - Models only conductive heat transfer
- Currently modeling both conductive and convective heat transfer

Overview of Presentation

- History of cesium and strontium capsules
- Characteristics of Capsules
- Current and proposed storage
- Transportation of capsules
- Considerations for deep borehole disposal
- Regulatory considerations

Transportation of Cs and Sr Capsules

- Capsules transported via the Beneficial Uses Shipping System (BUSS)
- Other currently certified transportation packagings exist
- Cost/capacity tradeoff usually favors largest possible cask for transportation
- If CSS chosen is a dual purpose system, then it will be used to transport the capsules

Overview of Presentation

- History of cesium and strontium capsules
- Characteristics of Capsules
- Current and proposed storage
- Transportation of capsules
- Considerations for deep borehole disposal
- Regulatory considerations

Considerations for Deep Borehole Disposal

- Waste package loaded with canisters at the disposal site
  - Transfer capsules from transportation package to waste package
  - Provide short-term storage during transfer and disposal
- Temperature limit during surface operations and during disposal operations?
  - Prevent boiling of drilling fluid
  - Limit initial temperature of waste package when disposed

Overview of Presentation

Sandia National Laboratories

- History of cesium and strontium capsules
- Characteristics of Capsules
- Current and proposed storage
- Transportation of capsules
- Considerations for deep borehole disposal
- Regulatory considerations

Requirements

- DOE Order 435.1 for storage and transfers
- RCRA requirements, as implemented by the State of Washington
- Transportation governed by Department of Transportation, which requires compliance with NRC's 10 CFR 71
- Disposal subject to EPA's 40 CFR 191 and undefined NRC requirements, as well as RCRA requirements

Conclusions

- Cs and Sr capsules, though small, are highly radioactive and produce significant quantities of heat
- Process for designing and building capsule dry storage system has started
- Transportation packages are likely to be large and to contain dozens to a few hundred universal canisters
- Thermal limits on the waste package at depth and the borehole diameter limit diameter of the universal canister
- Other thermal limits may affect surface handling facilities at the borehole disposal site
- A waste package for disposal has yet to be designed