

U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

**PRESENTATION TO
NUCLEAR WASTE TECHNICAL REVIEW BOARD**

**SUBJECT: ARE NUCLEAR "EXPLOSIONS" A
RISK IN A GEOLOGIC
REPOSITORY**

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Outline

- Description of the issue
- Plans to address the issue
- Applicability to a possible repository at Yucca Mountain
- Rationale for proceeding with the program in the meantime

Scenarios of Bowman and Venneri

- Accumulate a homogenous mixture of:
 - Plutonium-239
 - SiO₂
 - Water
- Gradual approach to criticality
- Assembly confined by surrounding rock
- Positive feedback increases reactivity quickly
 - Nuclear “explosion” - yield “0.3 kilotons”

Waste Forms in Bowman and Venneri

- 44 - 100 kg of weapons grade plutonium in a borosilicate glass log
 - 2 feet diameter
 - 12 feet long
- Degrades, disperses, and reassembles
- “Commercial spent fuel ...appear[s] to be susceptible”

Recent Discussions of Nuclear “Explosions” in a Geologic Repository

- References:
 - Bowman and Venneri,; Underground Autocatalytic Criticality from Plutonium and Other Fissile Material, LA-UR-94-4022 (late 1994)
 - Canavan, et. al.; Comments on “Nuclear Excursions” and “Criticality Issues,” LA-UR-95-0851 (March 7, 1995)
 - Parks, Hyder, and Williamson; Consequences of the Bowman-Vanneri [sic] Nuclear Excursions Thesis on the Prospects for Placing Vitrified Plutonium Canisters in Geologic Repositories, WSRC-TR-95-0036 (January 25, 1995)
 - New York Times, etc

Plans to Address Possible “Explosions”

- Ongoing program to evaluate criticality
- Seriously consider any possible risk from nuclear “explosions”
- Include “explosion” scenarios in long-term criticality analysis
 - Look beyond the Bowman-Venneri scenarios for credible event sequences
 - Perform detailed technical work if required

Program Plans to Address Possible “Explosions” (continued)

- Analyze any scenarios with non-negligible risks
- Include credible risks in decisionmaking

Los Alamos National Laboratory Internal Review of Bowman & Venneri's Report

(Canavan et. al., March 7, 1995)

- “Does not describe a credible sequence of geologic events”
- “Probability of each of the necessary steps...is vanishingly small”
- “Probability of occurrence of all three [steps] is essentially zero”
- “Even if these steps should occur, any energy release would be too small and slow to produce any significant consequences either in the repository or on the surface”

Los Alamos National Laboratory Internal Review of Bowman & Venneri's Report

(Canavan et. al., March 7, 1995)

(continued)

- Real Materials are less reactive:

Real Materials

Weapons material

Volcanic tuff

Bowman and Venneri

Pure Plutonium-239

Pure SiO₂

- Positive feedback would not occur
 - Confining stresses are small
 - Rock is compressible
- “Explosion” would not occur
 - Energy release would be slow

Consequences of Bowman & Venneri Parks, et. al.

- 134 kg of weapons-grade plutonium in a borosilicate glass log
- Defense high-level waste in borosilicate glass logs - “completely unaffected” - amount of fissionable material “orders of magnitude too small”

Consequences of Bowman & Venneri Parks, et. al.

- Criticality physics calculations are correct*
- [Energy] yield equations “not checked here but appear reasonable”
 - Calculated yield - approximately 1.5 kilotons
- Probability per unit time “must be quite small” but “criticality must be prevented...essentially forever”

* LLNL and other calculations also confirm this

How Does This Apply to a Potential Repository at Yucca Mountain?

- Waste Forms:
 - Commercial spent nuclear fuel
 - » Low enrichment of Uranium -235
 - » Inseparable from Uranium-238
 - 100 times more material
 - Neutron absorber
 - » Small amount of plutonium -239
 - High-level waste
 - Small amount of plutonium-239
 - Any other waste forms must meet Program's criticality requirements

How Does This Apply to a Potential Repository at Yucca Mountain? (continued)

- **No confinement**
 - Large open drifts even if collapsed

Justification for Proceeding With the Program in the Meantime

- Reports addressed weapons material
- No significant “explosion” risk has been identified in a repository containing:
 - Spent nuclear fuel
 - High-level waste
- Likelihood of credible risk seems very low

Justification for Proceeding With the Program in the Meantime (continued)

- Risks will be evaluated in ongoing program
- We will take any appropriate action needed to protect public health and the environment