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

NUCLEAR WASTE TECHNICAL REVIEW BOARD
FULL BOARD MEETING

SUBJECT: REPOSITORY-RELATED TECHNICAL ANALYSES SUPPORTING THE DISPOSITION OF SURPLUS WEAPONS USABLE PLUTONIUM

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Outline

- DOE Joint Participation
- Plutonium Disposition Forms
- Repository Analysis Approach
- Repository Analysis Results
- Ongoing and Future Work

DOE Joint Participation

- Office of Civilian Radioactive Waste Management (RW) is supporting the Office of Fissile Materials Disposition (MD) by
  - Analyzing the feasibility of accepting plutonium disposition waste forms in a High-Level Waste (HLW) repository
    - » Develop data for the Storage and Disposition of Weapons-Usable Fissile Materials Programmatic Environmental Impact Statement (PEIS)
    - » Conduct analyses for MD's Record of Decision
- For this work, RW is funded separately by MD
  - *Not* from the Nuclear Waste Fund

Plutonium Disposition Forms

- Reactor Disposition Forms
  - Spent nuclear fuel
    - » Boiling Water Reactor (BWR) Mixed Oxide (MOX)
    - » Pressurized Water Reactor (PWR) MOX
- Immobilization Disposition Forms
  - Plutonium immobilized in borosilicate glass
    - » Defense Waste Processing Facility (DWPF)-like form (2 variants)
    - » "Can-in-canister" form
  - Plutonium immobilized in crystalline ceramic
    - » "Can-in-canister" form (2 variants)
  - Plutonium immobilized in glass-bonded zeolite

Mixed Oxide (MOX) Boiling Water Reactor (BWR) Spent Nuclear Fuel (SNF)

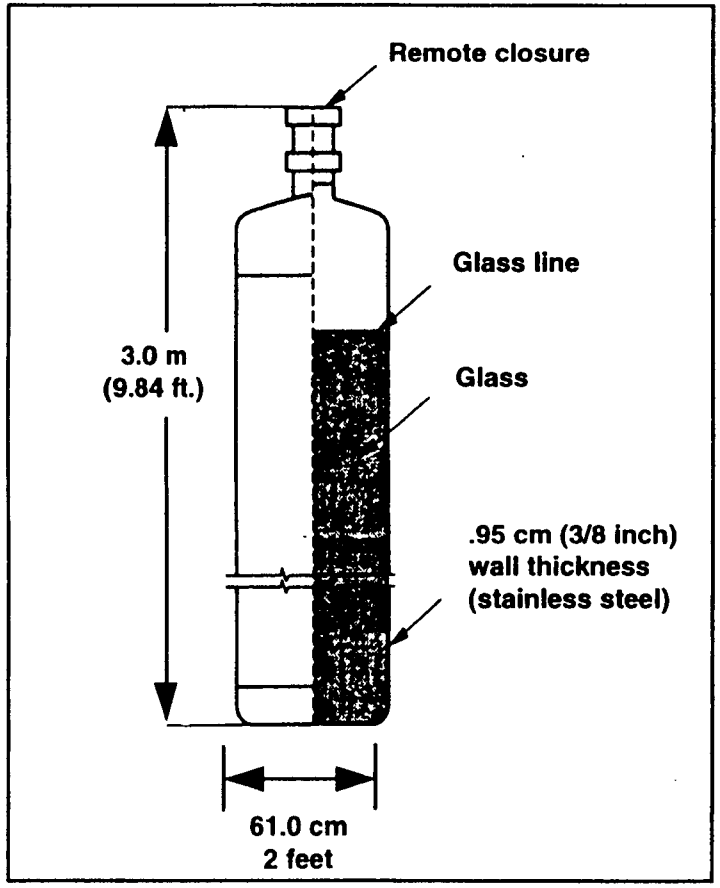
	MOX-BWR	UO2 BWR
Model	GE BWR-5	CRWMS Criticality Design Basis Fuel
Fresh MOX Fuel Assembly Characteristics		
Pu content (kg Pu/assembly)	5.334	
Total Heavy Metal (kg/assembly)	178.60	
MOX fuel characteristics at discharge		
Burnup (GWd/MTHM)	37.61	21
Pu content (kg Pu/assembly)	3.388	
Total Heavy Metal (kg/assembly)	172.15	
Commercial Fuel Characteristics for comparison		
Initial Enrichment		3%

Mixed Oxide (MOX) Pressurized Water Reactor (PWR) Spent Nuclear Fuel (SNF)

	MOX-PWR	UO2 PWR
Model	CE-80+	CRWMS Criticality Design Basis Fuel
Fresh MOX Fuel Assembly Characteristics		
Pu content (kg Pu/assembly)	27.68	
Total Heavy Metal (kg/assembly)	409.47	
MOX fuel characteristics at discharge		
Burnup (GWd/MTHM)	42.6	20
Pu content (kg Pu/assembly)	20.15	
Total Heavy Metal (kg/assembly)	392.10	
Commercial Fuel Characteristics for comparison		
Initial Enrichment		3%

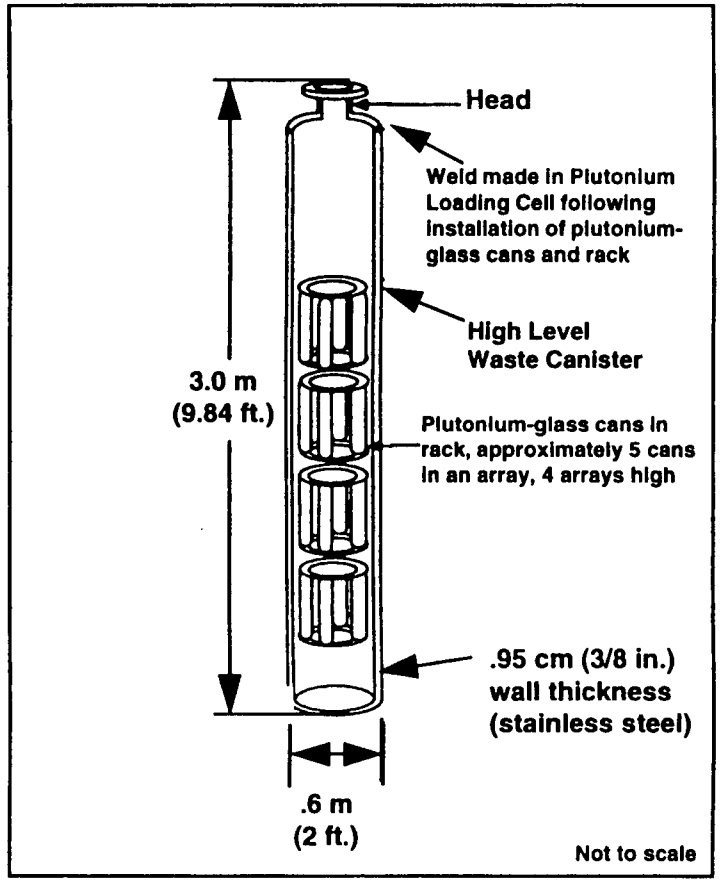
Plutonium Immobilized in Borosilicate Glass: DWPF-Like Form

Data	Borosilicate glass with ^{137}Cs [or HLW]
Packaging Type	DWPF canister
Canister Weight	1680 kg
Plutonium	84 kg
Gadolinium	55.4 kg
Radiation Barrier	^{137}Cs 1 kg (87,000 Ci) [or HLW sufficient to provide 1000 R/hr at 1 m for 30 y]



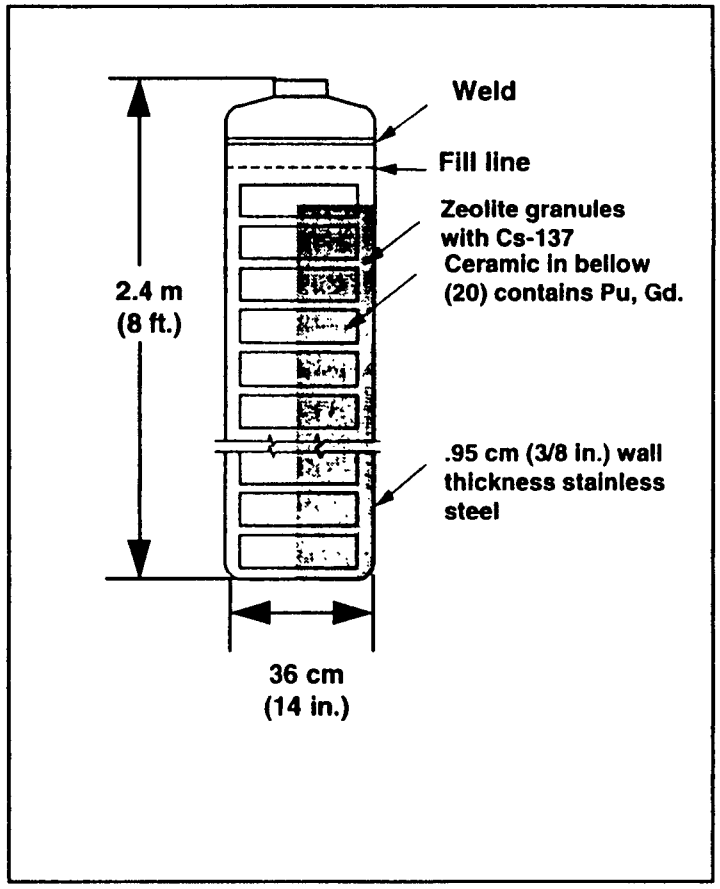
Plutonium Immobilized in Borosilicate Glass: Can-in-Canister Form

Data	Borosilicate glass with HLW
Packaging Type	Can-in-canister in DWPF canister
Canister Weight	
Plutonium	51.2 kg
Gadolinium	34kg
Radiation Barrier	HLW sufficient to provide 1000 R/hr at 1 m for 30 y



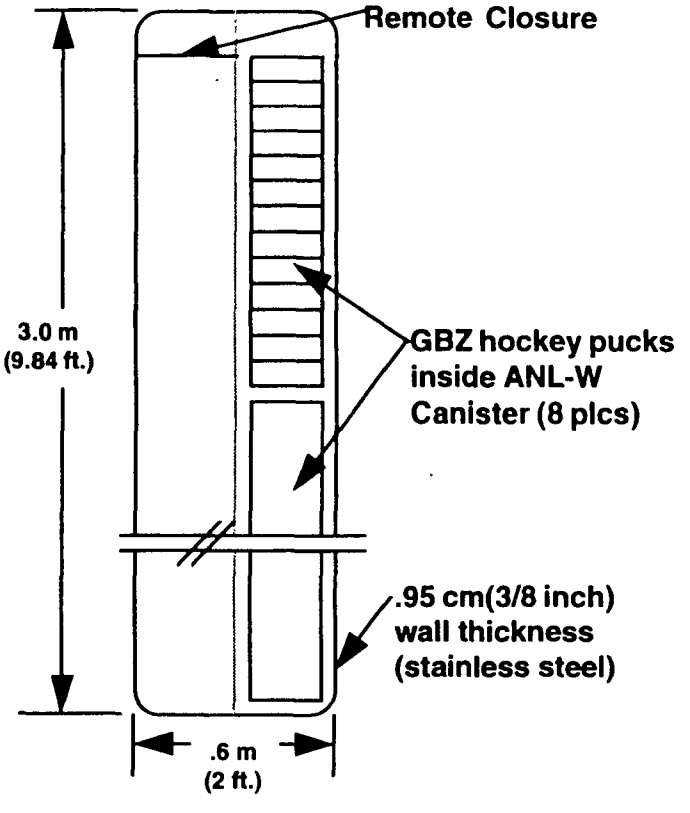
Plutonium Immobilized in Crystalline Ceramic: Can-in-Canister Form

Data	Ceramic with ^{137}Cs
Packaging Type	20 cans (bellows) in small canister
Canister Weight	660 kg
Plutonium	79.2 kg
Gadolinium	52 kg
Radiation Barrier	^{137}Cs 1 kg (87,000 Ci) sufficient to provide 1000 R/hr at 1 m for 30 y



Plutonium Immobilized in Glass-Bonded Zeolite (GBZ)

Data	GBZ with ^{137}Cs
Packaging Type	8 ANL-W HLW canisters in Modified DWPF canister
Canister Weight	1040 kg
Plutonium	52 kg
Gadolinium	21 kg
Radiation Barrier per DWPF canister	^{137}Cs 1 kg (87,000 Ci) sufficient to provide 1000 R/hr at 1 m for 30 y



Repository Analysis Approach

- Assumed an existing NWPA-licensed repository
- For each waste form
  - Evaluate regulatory/statutory implications
  - Develop a process flow for handling plutonium waste
  - Evaluate long-term performance of waste forms
    - » Criticality
    - » Total System Performance Assessment
- Performance measure is
  - Comparison against commercial SNF and DHLW

Regulatory/Statutory Results

- NWPA permits consideration of MOX spent fuel for disposal in a geologic repository
- Immobilized disposition forms will require rulemaking or clarification in authorizing legislation
- No special environmental or licensing requirements were identified for plutonium disposition forms
- NEPA process will have to be followed for disposing plutonium waste forms

Processing Results

- 50 metric tons plutonium
- 13-17 years receipt schedule for MOX spent fuels
- 10 years receipt schedule for immobilized waste forms
- Within the repository operational period

Criticality Analysis Results
(Undegraded)

Reactor Alternatives Disposition Form	Assemblies per Waste Package	Number of Waste Packages	Pu-239+241 per Waste Package (kg)	Effective Multiplication Factor (k_{eff})
MOX BWR SNF	40	234	80	0.74
MOX PWR SNF	21	93	321	1.04
MOX PWR SNF	12	163	183	1.01
MOX PWR SNF	4	488	61	0.93
For comparison:			Total Fissile material	
UO2 PWR	21	4041		.79 - .98

Criticality Analysis Results
(Undegraded)

Immobilization Alternatives Disposition Form	Total Canisters	Canister per Waste Packages	Number of Waste Packages	Pu-239+241 per Waste Package (kg)	Effective Multiplication Factor (k_{eff})
DWPF-like glass	600	4	150	325	0.2-0.5
Can-in-canister glass	1000	4	313	198	in work
Can-in-canister ceramic	640	8	79	613	0.5-0.7
Glass-Bonded Zeolite	962	4	236	201	0.1-0.2
for comparison:					
DWPF glass	12000	4	3000	16x10-3	

Repository Analysis Results

- No special issues associated with shielding, structural, or thermal evaluations
- Total System Performance Assessment calculations did not show any significant differences when the plutonium disposition forms were added to a repository containing spent nuclear fuel and high-level waste
- Know very little about plutonium glass and plutonium ceramic waste forms
  - Plutonium solubility in different types of glass
  - Relative dissolution rates of plutonium and gadolinium
  - Degradation modes for glass and ceramic logs

Ongoing and Future Work

- Focus on developing degraded mode scenarios for immobilized forms and for conducting criticality calculations
- Interface with research and development (experimental) program
  - Obtain data for repository analysis
  - Provide repository requirements for glass/ceramic formulation
  - Iterative process
- General support to MD
  - PEIS public review and comment
  - "Second and third phase" analyses and inputs
  - Screening of waste forms for Record of Decision (ROD)