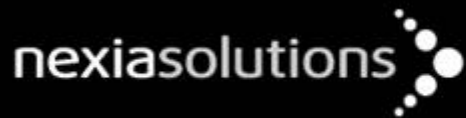


Plutonium Disposition

Project overview

Presented by : Joe Small



Nuclear expertise intelligently applied

Background

- ***CoRWM Recommendation 7:*** *If a decision is taken to manage any uranium, spent nuclear fuel and plutonium as wastes, they should be immobilised for secure storage followed by geological disposal.*
- The UK civil stock of separated plutonium resulting from Magnox and THORP reprocessing operations will eventually comprise over 100 tonnes of Pu.
- Currently, Pu is safely and securely stored.
- No strategy for its long term management.
- This presentation provides an overview of underpinning R&D on the options for Pu disposition and
- the wasteforms that may be produced.

Pu disposition

- Two main Pu disposition options both leading to final disposal:
 - Re-use for energy generation – producing spent fuel.
 - Direct immobilisation – yielding new wasteforms for disposal.
- NDA funded research has started to inform a decision focussing on:
 - technology feasibility of the options,
 - knowledge and research gaps,
 - discriminators for option decision making,
 - including safety and environmental consequences of discharges, long-term storage and final disposal.

Pu disposition project: tasks and options

- Re-use
- Immobilisation
 - Ceramic
 - Glass
 - Disposal MOX
- Strategic tasks
 - Operational research to support macroeconomic studies
 - Scenario Analysis - of safety & environmental indicators

Immobilisation

- A significant amount of knowledge has resulted from the US weapons Pu R&D programme,
 - but this is aligned to specific US Pu compositions, disposal concepts and requirements (e.g. spent fuel standard).
- Current programme focused on UK needs.
- The wasteform should ideally demonstrate:
 - proliferation resistance
 - suitability for disposal : durability, criticality control
 - tolerance for high levels of radiation damage
 - economic waste loading
 - ease of processing
 - chemical flexibility to accommodate impurities.
- At a minimum, an immobilisation technology is likely to be required for contaminated Pu unsuitable for re-use.

Ceramic Phases

- Several ceramic phases fabricated and tested:
 - Titanates – zirconolite and pyrochlore
 - Silicates/Phosphates – britholite and kosnarite.
- Use of Pu surrogates such as Ce and U.
- Waste loading levels >10% shown to be feasible.
- Range of phases shown to accommodate Pu surrogate and neutron poisons such as Gd and Hf.
- Criticality issues - ^{238}U added to dilute ^{235}U produced by decay to below fissile limits.
- Radiation damage studies on Synroc made 20 yrs ago at Harwell using ^{238}Pu to accelerate damage equivalent to 6000yrs ^{239}Pu .
 - Samples still intact, but become amorphous.

Ceramic Fabrication Processes

- Cold press and sinter chosen by US DoE
 - Similar to oxide fuel manufacture
 - Small volume high temperature
 - Would require further canister
- Hot Isostatic Pressing (HIP)
 - Under development for Pu residues
 - Larger scale demonstrated
 - Lower porosity
- Both routes require mixing and milling of PuO_2 and precursor powders – avoid any aqueous steps



Vitrification Options

- The viability of the existing BNFL (MW) borosilicate composition and new formulations are being evaluated in lab scale melts using Ce, Hf, Gd surrogates:
 - Alkali tin silicate, calcium borosilicate and alumino-borosilicate.
 - Lanthanide borosilicate, lanthanide alumino-silicate.
 - Iron phosphate, lead iron phosphate and sodium aluminium phosphate.
- Durability investigated by Soxhlet and MCC1 testing.
- Some compositions already ruled out on basis of below average durability and/or waste loading e.g. MW, calcium borosilicate and lead iron phosphate.
- Current technology for HLW immobilisation is not directly transferable, mainly due to criticality issues.

Disposal MOX

- R&D examines the feasibility of using un-irradiated MOX as a wasteform for plutonium.
- Potential to utilise existing technology,
 - Sellafield MOX Plant (SMP).
- Un-irradiated UO_2 is generally regarded as a durable material for geological disposal.
- However, it readily dissolves under oxidising conditions.
- Leach testing of un-irradiated MOX samples is currently being undertaken (ITU, Germany).

Scenario Analysis

The comparison of various Pu disposition routes requires a quantitative, repeatable technique considering:

- Environmental impact
- Health and safety impact
- Economic impact
- (Societal impact)

Utilising an EU 6th Framework Programme (Red-Impact) a list of indicators covering safety and the environment has been selected for analysis.

Example indicators

- Proliferation risk – quantity of separated Pu
- Worker dose
- Discharges from plants – collective dose
- Repository (HLW, ILW, LLW)
 - human intrusion – radiotoxicity
 - groundwater pathway – biosphere radiotoxicity flux
 - Time periods (y) 0-300, 300- 10^4 , 10^4 - 10^6 , $> 10^6$

ORION Scenario Analysis model

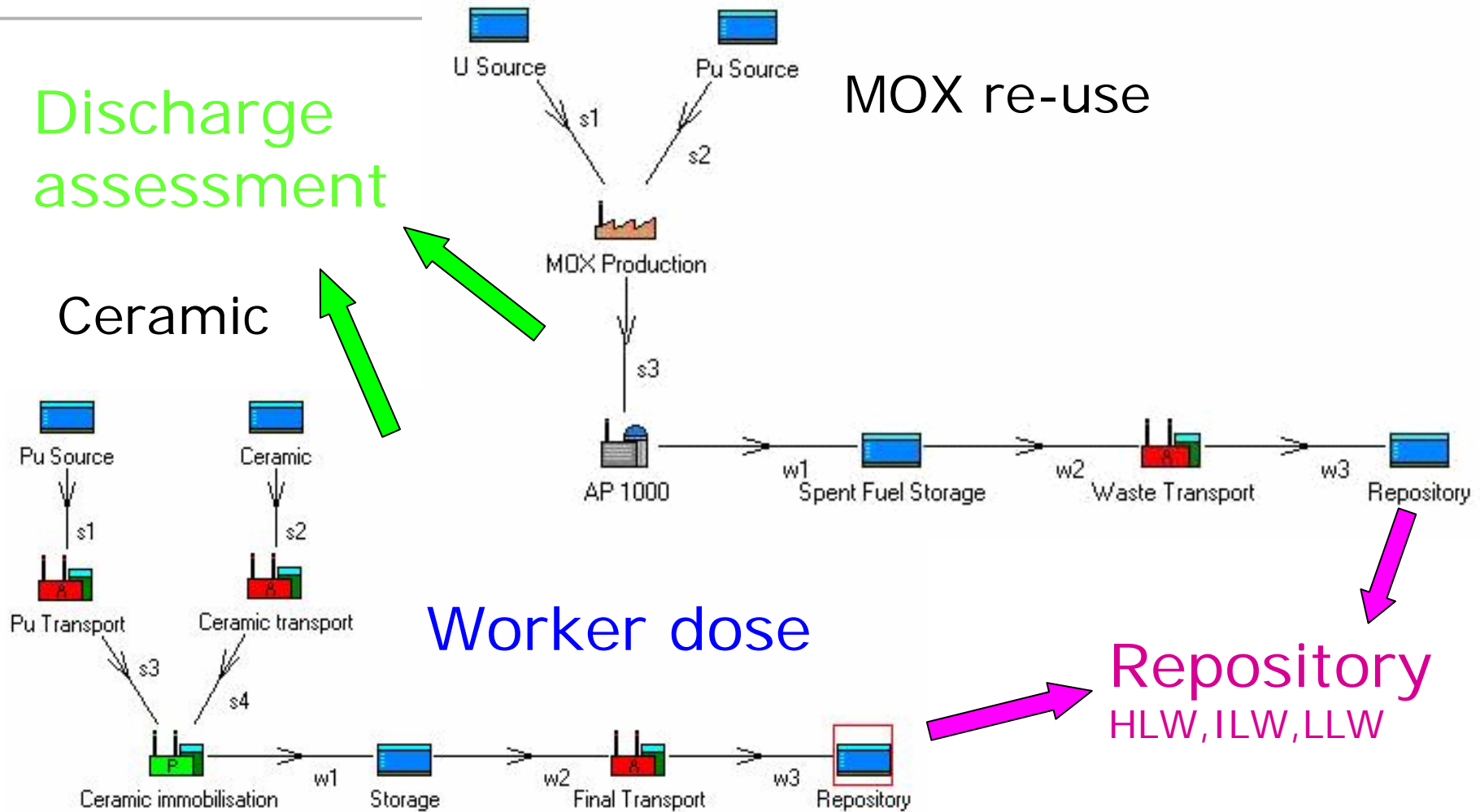
Discharge assessment

Ceramic

MOX re-use

Worker dose

Repository
HLW, ILW, LLW



Summary and implications for disposal

- An R&D programme is underway to support the NDA in the management of the UK Civil Pu stock.
- Immobilisation options will generate further wasteforms for long-term disposal, which at this stage include,
 - ceramics, vitreous materials, un-irradiated MOX.
- Research on these materials includes study of wasteform durability and measures to control criticality in the repository.
- Other research considers the processing technologies.
- A Scenario Analysis methodology has been developed in order to provide a comprehensive comparison of the environmental and safety impact of immobilisation and re-use options.

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