

The UK's plutonium package surveillance programme: Long-term storage and aging of PuO₂ powder up to 50 years old

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The UK has accumulated a large inventory of separated plutonium from spent fuel reprocessing operations that is largely stored as plutonium dioxide (PuO₂). The PuO₂ has been in storage for up to 50 years already and continued storage will be required until an immobilisation technology is implemented. Consequently, some materials may require storage for over 100 years.

During storage, the PuO₂ powder and the storage containers are subject to conditions of elevated temperature and intense radiation. To understand the effects of long-term storage, Sellafield Ltd undertakes a package surveillance programme that, in addition to inspections within the storage facilities, includes a programme of destructive examination of PuO₂ packages. Characterisation is performed in the High Alpha Inventory Laboratories within the United Kingdom National Nuclear Laboratory's (UKNNL) Central Laboratory.

In the UK, PuO₂ powder was mainly produced by either the reprocessing of Magnox metallic fuel in the Magnox reprocessing plant or from reprocessing oxide fuel in the THORP reprocessing plant. Magnox PuO₂ is packaged in a screw-top aluminium inner can that holds the PuO₂, a layer of polythene that is used to contain the inner can when it is removed from the glovebox and a welded stainless-steel outer can. The THORP package is an all-stainless-steel package design with a screw-top stainless-steel inner can, a breathable intermediate stainless steel can fitted with a sintered metal filter and a welded stainless steel outer can. Both package types can be opened for destructive examination.

Packages are punctured, opened, and sampled before conditioning PuO₂ by heating in a furnace and repacking it for continued storage. Characterisation of the PuO₂ includes Specific Surface Area (SSA) analysis, ThermoGravimetric Analysis (TGA), pore-size analysis, powder X-ray Diffraction (XRD), water adsorption, chemical and isotopic analysis. In addition, the gas composition within each package is determined, the polythene is examined and metallographic examination of the cans is performed.

The UK population of PuO₂ powders provides a unique opportunity to study the effects of aging of many decades because there are PuO₂ powders with a range of initial physical properties that were characterised at the time of production. The evolution of the gas composition in storage packages and changes in the physical properties of PuO₂ occur over several years and decades. These changes may influence disposal as well as behaviour during continued long-term storage. The results of these studies will be summarised and the implications discussed.