Wasteforms and Decommissioning

The Nuclear Decommissioning Authority (NDA) is responsible for the clean-up and decommissioning of the UK's contaminated sites being undertaken by the Site Licence Companies (e.g. Sellafield Sites, Magnox). The Governments Managing Radioactive Waste Safely (MRWS) programme, based on the Committee on Radioactive Waste Management's (CoRWM) 2006 recommendations, was initiated in Summer 2008 and provides the framework for the eventual geological disposal of the UKs higher activity wastes. A key recommendation was the need for robust storage in interim period with provision against delay or failure in achieving geological disposal. The situation in the USA, with the halting of the Yucca Mountain programme and the Blue Ribbon Commission's recommendation of improved and extended storage until geological disposal can be implemented, highlights the challenge associated with high level waste management. UK Grand Challenges in Waste Management are listed below and many of the issues have been documented in the RWMDs generic Disposal System Safety Case documents. The Grand Challenges all need to address risks to the MRWS process.

Holistic, Coordinated Waste Management Programme

The UK waste inventory is large and complex and presents multiple challenges. These are associated with recovery from current storage facilities, interim safe storage conditions, development of stable wasteforms for each waste ensuring that when emplaced in a repository they, or their degradation products, do not interact over geological timescales. This requires a coordinated, holistic, approach covering all stages of waste management including recovery of wastes, their process treatment, development of wasteforms and wasteform containers, conditioning, storage, transport and disposal. Specific Grand challenges are:

1. Sellafield Legacy Ponds and Silos

Examination of the proportion of UK's HLW vitrified and its ILW cemented reveals that to date only about 10% in total has been immobilised or encapsulated. One grand challenge is to speed up the rate of progress in stabilising current wastes. Of biggest concern are the extensive and complex ILW's in the legacy ponds and silos at Sellafield. The safety and security threat associated with them means they should be the main focus of research. Challenges include developing in situ characterisation and sensing techniques, actinide sludge chemistry, complex sludge transport behaviour, ageing of nuclear sludge, scale up from lab to practical application, routes to separate different wastes from multi-component sludges, and the development of immobilisation/encapsulation processes to create durable wasteforms for complex heterogeneous wastes. The latter need may require that the regulators redefine (via the letter of compliance process) what is an acceptable wasteform.

Highly Active Liquid Effluent

Sellafield has an agreed schedule for the emptying and decommissioning of the majority of its current inventory of highly active storage tanks (HASTs); down to buffer levels by 2014. Removal of poorly defined solid phases from within the HASTs remains a challenge, as does underpinning future operation, whilst ensuring tank integrity. The mobilisation and transport of solid-liquid wastes from these tanks is not yet defined. As the site progresses with decommissioning facilities, post operational clean out activities will create non-standard HALEs, which could potentially create issues with storage in HASTs. In additional, early HASTs contain non-standard HALEs from the first generation reprocessing activities and long term storage of these liquors may present a range of additional issues for removal and treatment. A full mechanistic understanding is required of the thermo-chemical processes within HASTs.is required to underpinning future operation and decommissioning; as well as an understanding of the effect on downstream processes (e.g. vitrification) of treating non-standards HALEs.

2. Wasteforms for Difficult Wastes

Some wastes present particular challenges because they contain: highly radiotoxic radionuclides emitting high-energy (α) radiation (239Pu, 241Am, 237Np); radionuclides with long half lives (14C 5730y, 239Pu 24110y, 129I 15.7My, 99Tc 213000y); highly mobile (water soluble or volatile) radionuclides (gases: 226Ra, 3H and 14CO2, alkalis: 137Cs, 90Sr, halogens: 36Cl, 129I); or radionuclides easily assimilated with long biological half lives (129I thyroid, 90Sr bones). Wasteforms still need to be developed for many wastes containing these species including e.g. Pu-contaminated Materials, I and Tc containing wastes. Many novel thermal (e.g. plasma melting) and non-thermal (e.g. geopolymers) methods are under development but need significant further work beyond the science, to provide an engineered solution. Other wastes present challenges because they are high volume (graphite, U), are in uncharacterised sludges (LP&S) or have escaped into the environment as mobile species/particles (contaminated land or marine environments e.g. at Sellafield, Dounreay). The UK still has to decide on options for its graphite (treat or dispose directly), U (sell or dispose) and Pu wastes (burn as MOX, immobilise in ceramics). The development of durable wasteforms, coupled with proven, engineered, processes to create these wasteforms is still in its infancy.

3. Issues with Reprocessing and Direct Disposal of Spent Fuel

The decision to halt reprocessing at Sellafield in the next few years means that we can add spent fuel (from various reactors) to the vitrified HLW and cemented ILW that we need to package, store, transport and dispose of. Multi Purpose Containers for all these steps are being examined but the durability of e.g. spent AGR fuel in different environments and the design of a passive store for the spent fuel will need to be technically proven. A mechanistic understanding of the long term behaviour of spent fuel, coupled to the store environment, will need to be developed.

4. Other Research Challenges for Wasteforms from Present Wastes

In addition to the need for new wasteforms there is a need to fully understand wasteform evolution in store and on disposal, corrosion and gas evolution, and the interaction of packaged wasteforms and Engineered and Natural Barrier Systems in a repository. Wasteform durability testing is a key area in particular there is a need for improved: SNF corrosion testing and understanding of UK AGR/exotic SNFs and spent MOX; testing of heterogeneous glass composite material products and Pu-containing ceramics; accelerated testing particularly for cement and SNF systems. Some of the drums of cemented wastes are showing signs of not being as durable as expected and techniques to repackage need development.

5. Wastes from New Build and Future Reactors

Wastes from next generation reactors are not expected to present any additional challenges apart from if the UK chooses to burn MOX the stability of spent MOX on storage and disposal must be understood. Generation IV reactors may require new fuel cycle and waste treatment concepts and waste types. Higher burn ups, radiation environments and operating temperatures, reprocessing to access U/Pu for fast reactors, novel (e.g. non-oxide) fuels will need extensive R&D programmes covering cradle to grave (fuel fabrication to waste immobilisation and disposal) issues. Should we choose to burn Pu in the resulting wastes will need to be understood.

Modelling and simulation

The enormous length and time scales over which wastes have to be considered provide an excellent opportunity for the UK's well respected modelling and simulation community to support this key topic. There is a need for improved predictive multiscale modelling of all aspects of the waste management programme. This is a cross-cutting theme.

Addressing the Grand Challenges

The UKNADM waste group agreed that the best mechanism to address these challenges was to have targeted meetings between RCUK/Academics (who address the fundamental science and engineering) with the NDA and its SLC's (the implementers) and with regulators (whose work is geared to safety cases) to detail how we address the gaps in knowledge underpinning the Grand Challenges. We must understand the fundamental science from waste production through to disposal in order to underpin the safety cases for storage and disposal so we are able to respond to any legal challenge. In addition, as concerned scientists we need to engage with the public and highlight good news stories and successes. There needs to be nationally coordinated and transparent engagement with international programmes.