DISTINCTIVE

Research Project Descriptions

DISTINCTIVE
Decommissioning,
Immobilisation and
Storage soluTIons for
NuClear wasTe InVEntories

A university consortium funded by the Research Councils UK Energy programme

Research Councils UK Energy For a Low Carbon Future
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The University Of Sheffield.
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Content

Introduction

DISTINCTIVE (Decommissioning, Immobilisation and STorage solutIons for NuClear wasTe InVEntories) will link a set of 31 world-leading research projects within the broad area of nuclear waste management, decommissioning and disposal.

In this document, you will find the description for each research project. The projects are organised by programme theme. You will also find associated projects that complement the research objectives of the consortium.

The lead academic for each project is indicated in **bold**, and the contact details of these academics can be found on Page 37.

Please note that details listed in this document are subject to change, and that all details should be confirmed with the project supervisor.

For more information, visit: www.distinctiveconsortium.org

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Themes - Aims and Objectives

The structure of this world-class research programme has been aligned with the strategic needs of the UK industry in the area of nuclear waste management and decommissioning. All research projects fall into one of four identified themes:

- Advance-Gas Cooled Reactor (AGR), Magnox and Exotic Spent Fuels
- Plutonium Dioxide (PuO2) and Fuel Residues
- Legacy Ponds and Silo Wastes
- Structural Integrity

The consortium will encourage and foster interactions across the themes, to maximise opportunities for collaboration and the integration of knowledge

Theme 1 - AGR, Magnox and Exotic Spent Fuels

Aim: To provide technical underpinning to the options for the management of the UK's AGR, Magnox and Exotic Spent Fuels

Objectives:

- To understand the evolution of Magnox and exotic SNF during recovery from aqueous storage, drying and repackaging.
- To develop spectroscopic methods for improved determination of SNF dissolution and corrosion rates in water.
- To determine the optimum drying conditions for AGR fuels and the subsequent surface reactivity and alteration of unclad UO_2 in dry storage.
- To determine the consequences of radiation damage in SNF, cladding and other wasteforms for safe long term storage.
- To determine suitable waste management options for spent carbide fuels.

Theme 2 – PuO_2 and Fuel Residues

Aim: To provide technical underpinning to the options for the UK's civil Plutonium inventory

Objectives:

- To understand how the structure and properties of PuO_2 change with time in the presence of H_2O.
- To understand the roles these processes play in gaseous product evolution from PuO_2 in storage.
- To understand radiation induced amorphisation and dissolution kinetics of Pu wasteforms.
- To develop novel, fast neutron based radiometric methods for the quantification, isotopic composition assessment and remote imaging of Pu bearing materials.

Theme 3 – Legacy Ponds and Silo Wastes

Aim: To develop innovative technical approaches to clean up UK legacy wastes.

Objectives:

- To understand durability of heterogeneous ILW glass/ceramic wasteforms from LP&S wastestreams.
- To develop improved ways to remove radionuclides (RNs) from solution, both novel inorganic ion exchange solids and tailored binding superparamagnetic nanoparticles, to treat complex and variable effluents.
- To develop new micro- and ultra-filtration methods for use with sludges.
- To provide three-dimensional modelling and simulation for sludge disturbance, mobilisation and transport, with supportive experimental studies, and manipulation planning for removing corroding nuclear materials.
- To develop a better understanding of gas hold-up in sludges.
- To develop improved techniques for remote monitoring of sludges and heterogeneous wastes.

Theme 4 – Structural Integrity

Aim: To develop reliable systems for infrastructure characterisation, restoration and preservation, that minimise current, and future, radiation exposure to the workforce whilst providing economically viable technological solutions.

Objectives:

- To develop in-situ ground barriers that could act as a 'second skin' surrounding on-site structures, such as silos and ponds, for prevention of subsurface radionuclide migration.
- To develop smart solutions for remote crack detection, infrastructure health prediction and building preservation that can be retrofitted to existing sites.
- To develop autonomous systems with increased functionality and to coordinate them through a CAD-based real-time management system, to facilitate planning and execution of decommissioning works.

AGR, Magnox and Exotic Spent Fuels Project Descriptions

Project Title	An investigation of wasteform evolution during wet-recovery and drying of SNF
PhD/PDRA	PDRA
Academic Investigator(s)	**Tom Scott**, Keith Hallam, Ross Springell
University	University of Bristol
Project Description	
The project will investigate the physiochemical changes occurring in SNF fuels – specifically uranium metals and exotics – during recovery from aqueous storage, forced drying and repackaging in an 'open' but nominally dry engineered containment system. We will work on non-irradiated U metal and UC samples, corroded under different aqueous conditions using the specialist gas-rig capability in Bristol. We will investigate the physiochemical changes occurring in the corroded materials during drying (over different temperatures) to evaluate transformative reactions occurring at the material surface. Specifically we will seek to understand the developing reactivity and fate of both uranium dioxide and uranium hydride present within the corrosion product.	

Project Title	UO2 surface reactivity and alteration – a fundamental study of photocatalytic and structural effects related to long term storage of SNF.
PhD/PDRA	PhD
Academic Investigator(s)	**Tom Scott**, Keith Hallam
University	University of Bristol

Project Description

This project will seek to understand the surface reactivity of UO2 in simulated dry and wet environments and under irradiation. Specifically we seek to better quantify photocatalytic phenomena that have recently been observed in preparatory experiments. Under irradiation we have observed significantly increased rates of oxide dissolution and surface-mediated splitting of water. Such issues of physical and chemical materials behaviour are of direct relevance to the safe disposal of spent nuclear fuel in both dry and wet environments. The research will combine surface analysis studies of different UO2 surfaces with oxidation, hydrogenation, hydrolysis and radiolysis/photocatalysis experiments.

At Bristol University we have an internationally unique facility, which enables us to synthesize and characterise thin film samples of uranium metal and uranium containing compounds in single and polycrystalline form. The proposed project will also extend our capability, allowing us to make thin films of UO2 from minute targets of spent fuel, using the pulsed laser deposition (PLD) technique. The targets will be prepared at the NNUF and have an acceptable activity for transport and acceptance by the University. Furthermore, the arising SNF thin films will have significantly lower activity and provide invaluable for the project in Bristol, but also provide feedstock samples for other institutions across the consortium.

Project Title	Options for Exotic Carbide Fuels.
PhD/PDRA	PhD
Academic Investigator(s)	**Bill Lee**
University	Imperial College

Project Description

The UKs inventory of exotic fuels includes some carbides for which no waste management decision has been made. This project will build on the capability in non-oxide ceramics in the Centre for Advanced Structural Ceramics (CASC) and the Materials in Extreme Environments (XMat) programme grant at Imperial to examine treatment and immobilisation options.

The aim of this project is to get knowledge on the oxidation mechanism of carbides fuels, and develop a suitable oxide wasteform. The carbide fuels studied in the experimental session will be uranium carbide and mixed uranium – plutonium carbide fuels. The experimental analysis carried out on these materials will suggest a route to oxidise pellets of uranium carbide and mixed uranium – plutonium carbide that were actually stored at the Dounreay site. The stable wasteform obtained from the oxide then needs to be prepared for the disposal and encapsulation. The last goal of this project will be the identification of the best encapsulation and immobilization form for these oxides. Having chosen the most sensible option a modelling project will be developed to underpin its feasibility.

Project Title	Determination of optimum drying conditions for AGR fuels
PhD/PDRA	PhD
Academic Investigator(s)	**Bruce Hanson**, David Harbottle
University	University of Leeds

Project Description

The current declared lifetimes for the AGR power stations from EDF Energy will result in the generation of approximately 8,800t of AGR fuel across the whole fleet. Of this inventory over 2,300t has been reprocessed to date, meaning there is estimated to be about 6,600t spent fuel which needs to be managed [1]. NDA has reported that their preferred option for AGR, outside of current reprocessing contracts in Thorp, is to keep the fuel in interim storage, prior to packaging for disposal in the UK GDF in 2075 [2]. Risks exist with long term wet storage of AGR and so a transition to dry storage may be a preferred option. However, this transition, as well as the dry store environment, may carry unknown risks to cladding integrity and so a better understanding is required before this route can be implemented.
The objective of this project is to answer key questions associated with the transition from wet to dry storage:

1. What effect has the period of wet storage had on the cladding?
2. How much water remains attached/bound to the surface of the cladding after removal from the pond?
3. What is the best regime to remove water from the cladding? Definition of temperature, time, pressure, gas or some other process?
4. Can a drying process remove all the water, or is some still attached/bound to the surface?
5. What effect has the drying process had on the cladding?

To answer these questions we propose a series of small scale tests using a simulant AGR fuel element. The test element will consist of cladding that is representative of that stored in a wet environment with a sealed simulant pellet inside. The testing will be carried out in a bespoke “drying” rig that will be capable of investigating the effect of temperature and pressure, with a range of gases. A key aspect of this project will be a high degree of instrumentation of the sample and rig, to ensure that a full mass balance can be constructed and the physical and chemical processes present can be identified. Materials analysis of the cladding, before and after “drying” to determine any overall effects on cladding integrity, will be carried out using range of techniques at IPSE’s sister the Institute of Materials Research.

An important output from this project will be a process model that will be able to predict optimum conditions for AGR drying. The model will be built up and validated using results from the experiments.

References

1. Topic Strategy: Oxide Fuel, NDA, SMS/TS/C2/G0/001, March 2010
2. Oxide Fuels Preferred Options Paper, NDA, June 2012

Project Title	Use of TRLFS of investigate dissolution rates
PhD/PDRA	PDRA
Academic Investigator(s)	**Nick Evans**, David Read
University	Loughborough University
Project Description	
LU is about to invest in state-of-the-art Time Resolved Laser Fluorescence Spectroscopy (TRLFS) for active work. We propose using this technique to investigate dissolution and corrosion rates of uranium fuels. TRLFS differentiates the chemical species of a fluorescent metal ion through analysis of characteristic excitation spectra and decay (relaxation) lifetimes. The principal advantage over other advanced spectroscopic techniques is the ability to determine *in-situ* metal speciation at environmentally relevant (picomolar) concentrations. This is essential when dealing with incipient corrosion of speciality metals or the alteration of ceramic and other materials used in the nuclear fuel cycle. TRLFS has largely been applied to the analysis of actinide and lanthanide ions having fluorescence decay lifetimes of microsecond duration (e.g. UO_2^{2+}, Cm^{3+}, Eu^{3+}), but continuing development of ultra-fast, cryogenic TRLFS systems offers the possibility for the first time of obtaining speciation information on metal ions with fluorescence decay lifetimes on the order of picoseconds. The technique is not currently available for nuclear materials research in the UK, though it has been used by LU researchers in Germany to identify ultra-thin films of alteration products on the surface of depleted uranium; it could be applied to natural or enriched uranium samples in the same way. It is a much more sensitive technique than XRD, for example, and also provides information on oxidation state; U(VI) phases emit characteristic fluorescence signals and can be distinguished from an unaltered U(IV) subsurface.	

Project Title	Grain boundary damage mechanisms in strained AGR cladding under irradiation
PhD/PDRA	PhD
Academic Investigator(s)	**Enrique Jimenez-Melero**, Simon Pimblott
University	The University of Manchester

Project Description

Second-generation Advanced Gas-cooled reactors (AGRs) make use of UO2 pellets contained in austenitic stainless steel SS 20Cr/25Ni/Nb cladding. During the service life inside the reactor, the cladding undergoes significant damage doses of its microstructure (of the order of a few tens of dpa) due to the constant neutron bombardment at temperatures that may vary between 350°C and 700°C. Neutron irradiation will generate additional vacancies and interstitials in the SS structure. Those radiation-induced defects will evolve over time and give rise to extended defects such as dislocation loops or channels, strain localization and radiation induced segregation (RIS). Those nano-micro scale changes in the SS structure will affect its mechanical integrity and its susceptibility to localised corrosion. In order to be able to potentially extend the lifetime of the AGR reactors and also to store the spent fuel cladding in the cooling ponds safely, we need to develop a thorough fundamental understanding of the radiation damaged SS structures, and how those sub-micron structures govern the possible failure mechanisms of the SS claddings.

Current understanding bases the localised corrosion susceptibility of these materials on the RIS phenomenon that depletes chromium from the grain boundaries, while segregating other elements (e.g. Ni or Si) in the vicinity of the grain boundaries. However, our mechanistic understanding of RIS and its link to the failure mechanisms is very limited, and its effect on GB precipitation at the relevant reactor conditions remains largely unknown. Moreover, neutron damage may also lead to preferred dislocation channels. Those preferred channels would cause plastic instabilities and strain localization near the GBs that will affect the structural integrity and corrosion susceptibility of the cladding. Those localised plastic phenomena are currently being subject to extensive experimental and modelling work in 304 and 316 SS, but have not been considered as a major factor in radiation-induced failure of AGR-type SS so far. To add complexity to this framework, certain parts of the cladding retain significant deformation from the manufacturing route. As a consequence, specific areas in the SS structure may present significant strain localization even before being exposed to neutron bombardment.

Consequently, a systematic study of the GB radiation damage mechanisms in cladding materials at relevant reactor and/or storage conditions is urgently required before extending the time scale of the AGR claddings inside the reactors or in the wet storage ponds. Neutron-irradiated AGR claddings are difficult and expensive to handle and test due to their relatively high levels of activity, requiring specific transport procedures and devoted active labs. Thermally sensitised AGR-type SS materials do not seem to yield equivalent phenomena as those expected in neutron irradiated samples. The alternative proposed in this project is to use systematically ion irradiation to simulate neutron-damaged structures.

Aim

To elucidate the principal radiation damage mechanisms operating at the grain boundaries and their local environment, and to link those atomic-scale mechanisms

to the structural integrity and potential localised failure phenomena of Nb-stabilised 20Cr/25Ni stainless steel claddings in AGR reactors and storage ponds.

Project Title	A Life Cycle Approach as a decision tool for nuclear waste management and decommissioning of existing and future plants
PhD/PDRA	PhD
Academic Investigator(s)	**Paola Lettieri,** Ronald Clift, Andrea Paulillo
University	University College London
Project Description	
This PhD-level project will develop a full life cycle assessment including all stages in the life cycle of decommissioning and waste management of both existing and future plants. The analysis would evaluate plant deconstruction, packaging and storage of the nuclear waste, depositories of low level and high level waste, waste reprocessing at Sellafield, and conditioning of the spent fuel. In parallel to LCA, a life cycle costing (LCC) could be performed. LCC enables to assess all costs associated with all materials and energy flows over the lifetime of a nuclear plant including construction, operating, maintenance, and disposal costs of the systems studied. LCC can be used as an input into the LCA or both tools can be used together in a wider evaluation process. The LCA analysis would be further used as a basis for the design of new plants, including novel separation technologies, for improved decommissioning and waste management characteristics.	

PuO_2 and Fuel Residues

Project Title	Computational modelling of PuO_2 ageing and fuel residues.
PhD/PDRA	PhD
Academic Investigator(s)	**Mark Read**
University	University of Birmingham
Project Description	
Ageing mechanisms associated with the storage of PuO_2 are poorly understood. The generation, stability and mobility of fission products in addition to the role of the surface oxide layer being key factors. Computational modelling techniques would employ robust interatomic potentials derived from empirical fitting to experimental data to predict bulk and surface structures and their defect chemistry. Relative thermodynamic stabilities of fission products would be calculated and compared to bulk and surface sites in order to predict migration pathways and mechanisms. Extended defects such as grain boundaries and their role in fission product migration would be simulated using surface simulation techniques. These simulations would be extended through the application of molecular dynamic techniques to model the effect of radiation damage on the lattice structure and subsequent effect on fission product mobility. The combination of these modelling techniques would provide valuable insight into furthering the understanding of ageing mechanisms associated with PuO_2 at the atomic scale	

Project Title	Current glass-ceramic formulations for Pu disposition
PhD/PDRA	PhD
Academic Investigator(s)	**Neil Hyatt**, Claire Corkhill, Martin Stennett
University	University of Sheffield

Project Description

Zirconium based glass-ceramics and full ceramics are being studied as future wasteforms for plutonium residues. High fraction zirconolite glass-ceramics incorporate a wide range of actinides and rare earth elements in the zirconolite structure whilst retaining remaining miscellaneous material in the glass phase. This makes them very favourable for plutonium residues where the exact composition is unknown and requires a matrix flexible to a vast range of elemental incorporations. The fraction of zirconolite formed has been seen to change with the glass composition whereby a more aluminous glass phase promotes a higher yield of zirconolite.1 This project aims to understand of the mechanisms controlling the crystalline phase formation, in order to find an optimum formulation for the wasteform.

Actinides readily partition into the crystalline phase and CaF2 has been shown to aid the process of waste digestion. However, α-decay of plutonium induces problematic alpha-neutron reactions which are substantially increased by the presence of 19F ions from CaF2. Alpha particles generated by decay react with the 100% abundant 19F ions to produce a high energy neutron and an energetically unstable product. The neutron causes further damage through neutron irradiation and by generating a chain reaction of alpha-neutron reactions. Similarly, the excited ion stabilises itself through the emission of a high energy gamma ray making the overall wasteform difficult to handle during production and would require additional safety measures. This project aims to establish a mechanism underpinning the role of CaF2 as a mineralising agent and thus be able to reduce, if not eliminate, the impact of alpha-neutron reactions by either reducing the concentration of CaF2 or by selecting an alternative.

As a whole, this project aims to develop an understanding of the mechanisms controlling the ceramic phase formation and the partitioning of actinides within. After optimising the formulation, the maximum waste loading without detrimental effects to the structure can be found. The primary consolidation technique throughout the course of the project is hot isostatic pressing (HIPing). HIPing achieves near theoretical density by applying heat and pressure simultaneously. The use of both conditions means lower temperatures can be used and a finer grain structure can be achieved, thus improving the strength and durability of the whole wasteform. Other advantages of HIPing for nuclear wasteforms include minimal off-gas production, homogeneous incorporation of radionuclides and the production of a hermetically sealed wasteform ready for long-term disposal without the addition of another barrier.2

References

1 E. Maddrell, S. Thornber, and N. Hyatt, “The influence of glass composition on crystalline phase stability in glass-ceramic wasteforms,” J. Nucl. Mater., (2014).

2 E.R. Vance, M.W.A. Stewart, and S.A. Moricca, “Progress at ANSTO on SYNROC,” J. Aust. Ceram. Soc., 50 [1] 38–48 (2014).

Project Title	The non-destructive assessment of isotopic composition for in-situ characterisation of aging and criticality risk in plutonium storage
PhD/PDRA	PhD
Academic Investigator(s)	**Malcolm Joyce**
University	Lancaster University
Project Description	
The isotopic composition of plutonium in storage and related special nuclear materials, advanced fuels and exotics changes with time as a result of radioactive decay; one principal example is the in-growth of americium-241 and the presence of curium-244. The latter, given its significant predisposition to spontaneous fission, complicates the ease with which the isotopic composition is assessed via existing methods based on neutron multiplicity. Often, it is necessary to carry out laboratory-based assessments, whilst long-established radiometric methods are currently dependent on ^{3}He gas which is now no longer available. In this project we will research to the use of fast-neutron multiplicity analysis (a technique via which the number of coincident neutrons arising from the fission decay of $^{240}Pu_{eff}$) is used to infer isotopic composition, in-situ. This approach, if successful, will be real-time and more accurate than current ^{3}He-based methods. Specific focus will be made of the ability of the technique to discriminate between $^{240}Pu_{eff}$, ^{252}Cf, ^{241}Am and ^{244}Cm, with a diverse range of potential applications including plutonium accountancy in storage, criticality assurance and proliferation prevention in plutonium management scenarios.	

Project Title	In-situ characterisation of heavily-contaminated plutonium finishing environments
PhD/PDRA	PhD
Academic Investigator(s)	**Malcolm Joyce**
University	Lancaster University
Project Description	
The decommissioning and decontamination of environments that are heavily contaminated with plutonium residues would benefit significantly from an in-situ characterisation technique providing an assessment of the distribution, ideally via an imaging technique with which to complement information derived from laser scans. There are many techniques based on γ-ray collimation that work satisfactorially for fission fragments, particularly ^{137}Cs . These include Radscan, Cartogam and N-Visage, but the γ emission from plutonium is too weak to benefit from such methods. We propose to develop a technique based on the collimation and detection of fast neutrons, based on significant prior art at Lancaster, with which to assess the distribution of plutonium (based on the proportion of spontaneously-fissioning even-	

numbered isotopes). This will enable plutonium content to be separated in decommissioning environments from fission fragment radioactivity without the need for swabbing and man entry. It will provide valuable insight to inform decontamination plans of such environments and the assessment of plutonium material present. It will also be relevant to the security and integrity assessment of plutonium storage environments.

Project Title	Understanding the Interfacial Interactions of Plutonium Dioxide with Water
PhD/PDRA	PDRA
Academic Investigator(s)	**Colin Boxall**
University	Lancaster University

Project Description

More than 100 tonnes of Pu are stored at Sellafield as PuO_2 powder in sealed steel storage cans. Under certain circumstances, gas generation may occur within the can with consequent can pressurisation. This comprises one of the most serious fault scenarios to be considered in the safety cases for PuO_2 storage and avoided in practice. 5 routes to gas production having been suggested:

- Helium accumulation from alpha decay;
- Decomposition of polymeric packing material;
- Steam produced by H_2O desorption from hygroscopic PuO_2 due to self-heating
- Radiolysis of adsorbed water;
- Generation of H_2 by chemical reaction of PuO_2 with H_2O, producing a postulated PuO_{2+x} phase.

The last 3 mechanisms, all involving the interaction of PuO_2 with H_2O, are complex and poorly understood, not least because of the interplay between them. An additional challenge to the safe storage and eventual disposition of Pu is that a substantial portion of the inventory is "out-of-specification" because of impurities (specifically chlorine or carbon) or unfavourable powder properties (moisture content, unusually high/low specific surface area). These must be treated to stabilise them for storage in welded cans in new stores.

Thus, within the DISTINCTIVE theme of PuO_2 behaviour during extended storage, this programme, a collaboration between the universities of Lancaster and Manchester, and UCL, will seek to:

- Understand how the structure and properties of PuO_2 change with time in the presence of H_2O
- Attribute these to the fundamental chemical, physical & radiation driven processes at the PuO_2 surface;
- Understand the roles these processes play in gaseous product evolution at Pu oxide surfaces;
- Understand how the overall 'system' as well as the specific processes are affected by the ageing of the Pu including variations in Pu isotopics;
- Generate data sets for the better underpinning of the Pu storage safety cases.

Additionally, we will study the surface adsorption mechanisms of chloride on PuO_2 and how effects such as radiation, T and adsorbed water affect the surface speciation and consequently desorption of chloride species under conditions to be employed in likely treatment processes.

Project Title	Understanding the Interfacial Interactions of Plutonium Dioxide with Water
PhD/PDRA	PDRA
Academic Investigator(s)	**Simon Pimblott**
University	The University of Manchester

Project Description

More than 100 tonnes of Pu are stored at Sellafield as PuO_2 powder in sealed steel storage cans. Under certain circumstances, gas generation may occur within the can with consequent can pressurisation. This comprises one of the most serious fault scenarios to be considered in the safety cases for PuO_2 storage and avoided in practice. 5 routes to gas production having been suggested:

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- Understand the roles these processes play in gaseous product evolution at Pu oxide surfaces;
- Understand how the overall ‘system’ as well as the specific processes are affected by the ageing of the Pu including variations in Pu isotopics;
- Generate data sets for the better underpinning of the Pu storage safety cases.

Project Title	Ceramic materials for actinide disposition
PhD/PDRA	PDRA
Academic Investigator(s)	**Neil Hyatt**
University	University of Sheffield

Project Description

Building on research conducted in DIAMOND, the central hypothesis of this project is that sensitivity of actinide wasteform ceramics to radiation damage induced amorphisation is governed by the topological relationship between pristine and amorphised structures; topologically disordered (i.e. amorphous) structures are stabilised by polyhedra of low co-ordination number (forming ring structures.) We further hypothesise that radiation induced amorphisation has significant impact on the inherent dissolution kinetics of wasteform ceramics. We propose to test these hypotheses at several time and length scales of damage, combining synchrotron X-ray and neutron scattering studies of ion beam irradiated materials with state of the art MD simulations, and investigation of legacy Pu 238 doped SYNROC ceramics. Research at Sheffield will focus on three key challenges:

1. We will combine energetic heavy ion beams available at GSI Darmstadt with synchrotron and neutron PDF techniques, to make the first total structure determination of macroscopic (ca. 500 mg) ion beam amorphised materials. We will supplement this with element specific XAS studies to develop an unprecedented description of the structure of radiation amorphised materials, making a direct link to MD simulations. MD simulations of multiple damage cascades in the same suite of materials, combined with topological analysis, will be utilised to extract partial PDFs from the amorphised structures, for comparison with the products of ion beam irradiation. We will also continue our study of pressure induced amorphisation of actinide wasteform ceramics, initiated in DIAMOND, to understand to what extent pressure amorphised structures act as representative analogues of the radiation amorphised structures (using PDF, XAS and MD techniques).
2. We will use medium energy ion beam irradiation to amorphise the surface of polycrystalline ceramic or thin film specimens of candidate wasteform ceramics, to a depth of ca. 1-2 microns, using the Surrey Ion Beam and EU SPIRIT network facilities. The dissolution kinetics of irradiated / unirradiated specimens will be investigated in both batch and dynamic alteration experiments and surface retreat studies using AFM. We will carefully select the experimental conditions such that the response of the material arises only from the surface amorphised layer.
3. We will characterise 30 year old legacy Pu-238 doped SYNROC ceramics available at NNL, to understand the extent to which ion beam, MD and pressure amorphised structures are representative of true alpha recoil induced amorphisation. We will use FIB methodology to extract lift outs from different phases (perovskite, zirconolite, pyrochlore) and use TEM / ED to investigate the

nature of the damaged microstructure, e.g. size and extent of residual crystalline domains and gas bubbles; the nature of the interface between damaged and crystalline relic zones; and the speciation constituent elements using EELS and XAS at the Swiss or Diamond Light Sources.

Project Title	Understanding actinide sorption and binding to cement materials for radioactive waste management
PhD/PDRA	PhD
Academic Investigator(s)	**Claire Corkhill,** Neil Hyatt, John Provis
University	University of Sheffield

Project Description

Building on research undertaken by the Fellow as a PDRA in DIAMOND, we propose to investigate the incorporation of Pu and Am in cement materials relevant to the encapsulation and disposal of radioactive wastes (in particular, PCM). Predicting the release of these radionuclides from the GDF is a key factor in developing a robust safety case for the long-term storage of nuclear waste. This requires an understanding of their interactions with the main sorbing components of the cement backfill, including ordinary Portland cement and the binder phase, Calcium-Silicate-Hydrate gel (C-S-H), and also a comprehension of possible transport pathways through the engineered backfill cement. While it is expected that reducing conditions will prevail in the repository, such that actinide species are expected to be present in their reduced, insoluble forms, the initial oxidation state and pH of PCM wastes is poorly defined, largely due to their encapsulation with organic waste products and their acid derivatives[1].

This study will investigate the sorption and incorporation mechanisms of Pu and Am onto engineered barrier cement materials, and the subsequent transport processes under groundwater flow. A mechanistic understanding of Pu and Am immobilisation by cement barrier materials will be determined by investigating the effects of initial pH and redox state on incorporation, using aqueous geochemical and radioanalytical techniques (LSC, ICP) to monitor solution chemistry. The Ca:Si ratio will be varied to determine the role of C-S-H binder phases on immobilisation, and experiments will be conducted under controlled CO_2/carbonate conditions to develop an understanding of carbonation on backfill material-Pu/Am interactions. Information of the distribution and coordination environment of sorbed species will be determined using digital autoradiography and µ-XRF techniques, coupled with µ-XCT (X-ray Computed Tomography) techniques at the Argonne National Laboratory (USA) and the Diamond Light Source (UK) to derive high resolution, detailed datasets, which can be used to develop the first verified conceptual and numerical models of Pu and Am sorption and transport in engineered barrier cement.

Project Title	Modelling the surface chemistry of PuO_2 at the molecular level
PhD/PDRA	PDRA
Academic Investigator(s)	**Nik Kaltsoyannis**, Andy Kerridge
University	University College London
Project Description	
This PDRA-level project will focus on modelling quantum mechanically the adsorption of water onto the surface of PuO_2 in order to obtain detailed information on structure of the surface and near-surface layers, and the energetics of adsorption. It will also address the surface reactivity of water radiolysis products, e.g. OH and HO_2 radicals, and specifically the possible formation of hydroxylated surfaces (PuO_2OH (Pu(V)). As with the experimental programme, these processes will be studied both in the presence and absence of chloride impurities. A fuller description this project, and how it fits into a broader programme entitled "Understanding the Interfacial Interactions of Plutonium Dioxide with Water" is given on the next page. This work would be in collaboration with experimental research led by Lancaster and Manchester Universities.	

Legacy Ponds and Silo Wastes

Project Title	Novel Ion Exchange Materials
PhD/PDRA	PDRA
Academic Investigator(s)	**Joe Hriljac**, Mark Read
University	University of Birmingham
Project Description	
The ion exchange material used in SIXEP to remove Sr and Cs from Sellafield effluent is the natural zeolite clinoptilolite. The changing nature of the effluent due to factors such as accelerating legacy pond clean-up and finite lifetime of the current supply of clinoptilolite justifies research for new and improved materials that might either replace or supplement the clinoptilolite in future operations. The focus of this project would be to investigate other families of porous silicates, for example some related to the CST in IONSIV, as new ion exchangers not only for Sr and Cs but other relevant cations that may require removal from effluent such as actinides or other metals. These materials could find use more widely, both in the UK and internationally. The project would be experimentally led (materials discovery and optimisation, characterisation and exchange testing with both non-active and then active solutions) but incorporate an element of computer modelling (atomistic simulation to predict ion exchange sites, framework response to exchange, and potential migration pathways during exchange) to assist mechanistic understanding and materials performance optimisation.	

Project Title	Development of Raman Spectroscopy techniques for the remote analysis of nuclear wastes in storage.
PhD/PDRA	PhD
Academic Investigator(s)	**John Day**, Tom Scott
University	University of Bristol
Project Description	
The project will build on Bristol expertise in developing fibre optic probes for the remote collection of Raman and fluorescence spectra in medical and aerospace applications. We will extend this technology to develop probes for the characterisation of materials in storage facilities where man-entry is not possible and optimise the design of these devices for remote control in high radiation environments. Our medical designs are working towards disposable probes , which may have application where radiation damage is too severe. We will seek to field-test prototype probes by the end of the project, incorporating the use of fluorescence imaging and Raman spectroscopy in a single instrument.	

Project Title	Durability of Heterogeneous ILW Glass/Ceramic Wasteforms from Complex Wastestreams
PhD/PDRA	PDRA
Academic Investigator(s)	**Bill Lee**, Robin Grimes, Neil Hyatt
University	Imperial College, Sheffield University
Project Description	
Building on previous surrogate trials using thermal methods such as plasma vitrification and joule heated in-can vitrification this project will aim to understand the corrosion mechanisms in the resulting heterogeneous wasteforms. We will use a combination of durability testing and modelling across length scales to examine the impact of local equilibria on corrosion at different locations in the microstructure. The ultimate aim is to provide sufficient understanding to underpin safety case for storage and disposal of Sellafield's legacy pond and silo wastes.	

Project Title	Gas Hold-Up in Sludges
PhD/PDRA	PhD
Academic Investigator(s)	**Tim Hunter, David Harbottle**, Jeffrey Peakall, Michael Fairweather
University	University of Leeds

Project Description

Hydrogen gas retention in nuclear waste sludge is of interest on many nuclear licensed sites. The risk of hydrogen hold-up in either man-made voids or within fracture zones inside a sludge bed and a sudden release of gas following bed disturbance is clear. Despite this, much remains to be understood about the likelihood of large gas pockets forming within sludge and the features of nuclear waste sludge that may increase or decrease the risk of this happening.

Gas hold-up within nuclear waste sludge is a complex issue. The amount of hold-up depends on the physical properties of the sludge, with strong evidence relating gas retention to sludge strength. The exact amount of hold-up depends on a wider range of factors such as rheology, layering, composition, particle size, pressure and depth of sludge. It is assumed in the available industry literature that the sludge is homogeneous with no stratification. This is unlikely given the history of waste deposition. The presence of a layered sediment bed with each layer having different gas generation rates and yield strengths may be important. The development of yield strength over time is also important. Sludge ages slowly with an observed increase in the yield strength. If gas production is rapid, and gas is retained on the particles as they form the sludge bed, then a considerable volume of gas may be trapped during ageing. What effect this has on the development of the yield stress is as yet unknown. It is feasible that this leads to a significant decrease in the aged yield strength. This could have significant impact on the nature of the bed and routes for gas release. The retention and trapping of gas in a sludge bed as it forms may also lead to a low-density bubble/particle mix that is inherently unstable as the density will always be close to that of the fluid. Such a system may be susceptible to 'turn-over' and catastrophic gas release.

Our focus is to develop an improved understanding of how gas is retained and released from nuclear waste sludge. We will explore how gas influences the properties of realistic simulant sludge materials and how ageing of sludge is influenced by the simultaneous production of gas. We expect this project will be closely integrated with known issues at a number of nuclear sites, ensuring interest in the work and relevant outputs for licensed nuclear environments.

Project Title	Characterisation of flocculated waste suspensions with acoustic backscatter
PhD/PDRA	PhD
Academic Investigator(s)	**Tim Hunter, David Harbottle**, Jeffrey Peakall
University	University of Leeds
Project Description	
Essentially, a PhD project is proposed to extend 'measurement and modelling' work, at the University of Leeds, into the use of acoustic backscatter as a method to characterise complex flocculated waste suspensions. A lot of fundamental analysis is required to quantitatively understand both the flocculation of fine magnox and the analysis of settling sludge systems with the acoustic backscatter array (ABA). The PhD will have two major research strands. Firstly, the project will characterise the flocculation of fine magnesium hydroxide with different commercial polymeric agents (e.g. floc size, shape and fractal dimensions). A fuller understanding of these systems is required; both to aid acoustical analysis, but also to help Sellafield assess the appropriateness of flocculation as a method to remove colloidal fines from pond effluent streams. Secondly, the PhD will measure the fundamental relationships between acoustic scattering strength, attenuation and velocity from these types of complex multicomponent species, to aid in developing analytical methods for the ABA. Importantly, the PhD will focus on how to link theoretical scattering-attenuation relationships (currently developed for hard-sphere glass type particles) for use with flocculated waste suspensions.	

Project Title	Measurement and Modelling of Sludge Mobilisation and Transport
PhD/PDRA	PDRA
Academic Investigator(s)	**Mike Fairweather**, Tim Hunter, David Harbottle
University	University of Leeds
Project Description	
Experimental: Current understanding of the flow and settling dynamics of nuclear waste suspensions and sludges is poor due both to the complex nature of the particle phase, its interaction with the fluid phase, the influence of flocculation and other time-dependent properties, as well as a scarcity of useful data for such materials and flows and the physical, chemical and radiological difficulties in gathering such data from real waste repositories. The first PDRA position concerns experimental work using realistic sludge simulants (based on recipes supplied by the National Nuclear Laboratory and Sellafield Ltd.) with a range of particle sizes, densities and shapes, both aggregating and non-aggregating, and their flow behaviour in horizontal and vertical pipes of circular cross-section, and in continuous- and batch-settling vertical columns. Novel, on-line, in-situ ultrasonic methods recently developed will be used to characterise the suspension, settling and segregation of these flows. In particular, the following properties will be investigated: mean velocity and turbulent stress fields, using ultrasonic Doppler velocimetry; particle concentration profiles, using a dual-frequency inversion method and acoustic backscatter strength; limit deposition velocity at which all solids remain suspended, using bed depth measurements (pipe flow only); and pressure drop and rheological properties, using a series of pressure transducers (pipe flow only). Simulation: Predictions of similar flows will be obtained using a coupled large eddy simulation/Lagrangian particle tracking technique, with the influence of levels of turbulence, and the direction of gravity, on particle agglomeration and settling behaviour, and the shear break-up of particle aggregates explored. Model predictions will be compared with the data to be gathered to provide a validated predictive technique for complex particle-laden flows in closed pipes with geometries relevant to nuclear waste processing operations. The techniques developed will also be useful in the formulation and validation of the more pragmatic modelling approaches used within the industry in the design and operation of waste management processes.	

Project Title	One step extraction and quantification of radionuclides using superparamagnetic bead and nanopore technologies
PhD/PDRA	PhD
Academic Investigator(s)	**Nick Evans**, Mark Platt
University	Loughborough University

Project Description

Loughborough University has developed a range of polymeric ligands with the capacity to selectively bind trace radioactive contaminants from solutions containing abundant major cations[1], e.g. Na^{+}, Mg^{2+}, Ca^{2+}. These ligands will be immobilised onto silica-coated superparamagnetic beads which can be quickly removed from solution using a magnetic field. We have the ability to synthesise beads of uniform sizes and magnetic properties[2,3], which allows us to match a bead size with a specific contaminant, e.g. 0.5 µm with a ligand that binds to radionuclide 1 and a 0.55 µm bead with a ligand that binds to radionuclide 2. During the extraction, the different sized beads can be separated from each other allowing simultaneous separation of target species by magnetophoresis[4]. The amount of radionuclides bound to the surface ligands will be quantified using a nanopore technology, as the beads are passing through the nanopore, the change in surface charge and ligand structure caused by the presence of the radionuclide can be accurately measured[5,6] and has recently been demonstrated with biological components using the same technology with ppb sensitivity[7]. Potential to remove trace contaminants from ponds and waste streams, without compromising waste management down-stream.

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Project Title	Enhanced shear micro- and ultra-filtration without recycle pumping
PhD/PDRA	PhD
Academic Investigator(s)	**Richard Holdich,** Marijana Dragosavac
University	Loughborough University

Project Description

During the processes of ultra- and micro-filtration shear is normally generated at the surface of the membrane by rapid recycle pumping of the suspension. This is counter-productive as the entire suspension is being sheared leading to break-up and damage of the suspended material often making it more difficult to filter. It also leads to high pressures and possible problems with seals, tube blockages and other maintenance drawbacks. Moving the membrane is an alternative method for generating shear at the surface between the membrane and suspension, leaving the suspension stationary. Commercially available devices do exist, but they use circular geometry where the shear is minimal at the centre of rotation and they are complex pieces of engineering. An alternative is to use vibrating tubes (filtering outside to inside) hanging vertically being oscillated by a resonant force. The shear rates achievable are very high and the shear is only delivered where it is needed: at the surface of the membrane. The project will investigate different metal and ceramic ultra- and micro-filtration media used in this resonant fashion with a number of simulant materials. It will also look at 'engineering' the package to determine the most effective ways to remove permeate: by suction or by over-pressure on the feed side, options for 'backpulsing' and other mechanical membrane cleaning strategies. The deliverables include a theoretical understanding of a compact but essentially straightforward system that can be used in a modular way for a variety of different filtration applications.

Project Title	Computational simulations of storage pond sludge disturbance
PhD/PDRA	PhD
Academic Investigator(s)	**Andy Kerridge**
University	Lancaster University
Project Description	
This PhD-level project will focus on the atomistic modelling of storage pond liquor in the immediate aftermath of sludge disturbance. Under these conditions, sequestered radionuclides including Pu, Am, Cs, and Sr are likely to be released into the immediate aqueous environment, along with other particulate matter from the sludge. The simulations will be used to investigate the dominant interactions undergone by radionuclides in this environment, including absorption on brucite, artinite and other hydrous magnesium carbonate particulates, along with $M(OH)_n$ colloid formation. Simulations will reveal how such interactions are affected by the presence and concentration of carbonate species, contaminants, and other ions. Further studies will consider approaches to the immobilisation of radionuclides through the introduction of strongly sorbing materials.	

Project Title	Magnetic Nanoparticles for Waste Separation or Sequestration
PhD/PDRA	PhD
Academic Investigator(s)	**Mary Ryan**, Nick Evans, Mark Platt, Luc Vandeperre
University	Imperial College, Loughborough University
Project Description	
The development of magnetic nanoparticles for separation technologies in liquid systems is well-developed and already in use in medical testing. The challenge is to develop surface functionalization to target the species of interest. This project will investigate the potential for core-shell magnetic-sorbent structures to be used in waste form separation, or removal of RNs from liquid streams. Particle development and characterisation will be carried out at Imperial and active sorption work at Loughborough.	

Structural Integrity

Project Title	Production of real-time segmented as-built CAD models for the planning and execution of remote and human intervention tasks
PhD/PDRA	PhD
Academic Investigator(s)	**Rustam Stolkin**, Ales Leonardis
University	University of Birmingham
Project Description	
This project will develop methods for *instant real-time* 3D as-built CAD modelling of nuclear plant, including segmentation of the scene into a collection of salient objects, 3D modelling and *real-time 3D motion tracking* of these objects, to facilitate planning and execution of remote handling and decommissioning operations, spanning multiple UK sites. We will use novel computational vision techniques to recognise (from CAD models) objects in point clouds extracted from optical laser scanners, build new CAD models for unknown objects, and track the 3D poses of objects that move. It currently takes between hours and days to assemble a single CAD model of an environment and the environment is modelled as a single monolithic object, so *real-time 3D motion tracking* of these objects will represent a breakthrough in capability.	

Project Title	Autonomous systems for nuclear decommissioning in extreme radiation environments
PhD/PDRA	PhD
Academic Investigator(s)	**Barry Lennox**, Simon Watson, Simon Pimblott
University	The University of Manchester
Project Description	
The focus of this project will be to develop tomographic methods to autonomously characterize radioactive sludge in legacy storage ponds and silos. The ponds and silos are encased in thick concrete and so traditional non-invasive methods are not suitable. An invasive method will be developed with a view to deploying the system using mobile robots in the future. The initial properties of the sludge that will be characterized will be temperature and density, however other parameters that may be of interest will also be explored. The key research objectives will be to: 1. Investigate the most suitable tomographic method (electrical, acoustic, radiation…etc.) for characterization of sludge. 2. Construct suitable hardware and software to provide temperature and density maps with a cross-sectional area resolution of ~1%, which in the silos will be ~40cm. 3.	

Devise a method of deploying the sensors (not using a robot) which minimizes the disturbance of the sludge. 4. Design and build test rigs at NNL Workington to test the sensors using substitute materials. 5. Investigate the radiation tolerance requirements and design the hardware appropriately. 6. Identify feasible methods that enable the sensors to be deployed remotely using mobile robots. The final deliverable from this project will be the construction of a demonstrator system that will operate in a 3.6m x 3.6m x 2.4m tank located at the National Nuclear Laboratory's rig-hall in Workington.

Project Title	Crack sealing and water transport
PhD/PDRA	PhD
Academic Investigator(s)	**Andrea Hamilton**, Mohamed Saafi
University	University of Strathclyde
Project Description	
This PhD project will focus on developing nanoparticle sealants for cracks in cement and concrete, model water transport in the sealed crack and surrounding concrete and chemically tailor the sealant to have desirable chemo-mechanical properties. The first goal is to model water transport through whole structures made of concrete/brick. This is central to understanding deterioration patterns on existing buildings and can be used to predict the impact of climate change on the building fabric and find the vulnerable areas of structures on site. This PhD project will use a novel FE modeling method to explore water penetration into composite porous facades coupled with laboratory investigation to obtain hydraulic properties from building materials used on site. The ultimate aim is to achieve a full understanding of how buildings at Sellafield weather and explore potential materials science solutions for preservation including nanoparticle cements and biomineral consolidants.	

Project Title	Nano-cracking of cement phases: reactivity and dissolution.
PhD/PDRA	PhD
Academic Investigator(s)	**Andrea Hamilton**, Shangtong Yang, Dimitrios Lamprou
University	University of Strathclyde
Project Description	
This project will focus on understanding the chemistry and mechanics of fracture nucleation in chemically complex materials and will work towards incorporation of novel self-healing technologies. Cement stability will be explored at the nanoscale using atomic force microscopy (AFM), an exciting technique capable of looking at mineral growth and dissolution in real time and in realistic wet environments for the first time. The mechanical effect of chemical alteration will be quantified using high energy X-ray diffraction. The goal of this project is to establish a model for understanding the development of strain induced in cement/concrete by chemical alteration through time. Emphasis is given to the long-term durability of cement for crack sealing.	

Project Title	In-situ ground contaminant containment (Physical barrier)
PhD/PDRA	PDRA and PhD
Academic Investigator(s)	**Grainne El Mountassir**, Becky Lunn
University	University of Strathclyde
Project Description	
Current research at Strathclyde (Biogeochemical Applications in Nuclear Decommissioning and Waste Disposal, EPSRC consortium, EP/G063699/1) has developed proof of concept for novel grouting technologies. These include microbially-mediated mineral precipitation for sealing fractured rock, colloidal silica for grouting fractures and sediment stabilisation, and novel cementitious grouts which enable remote detection of grout penetration (patent application submitted). This project will focus on the development of low viscosity (large penetration distances) colloidal silica based grouts for inhibiting radionuclide migration in groundwater. The grouts will be used to create an injected barrier that can act as a secondary skin (containment layer) surrounding and beneath existing legacy containment vessels. The grout should be detectable from the ground surface to allow penetration mapping. This project will also investigate the potential for hydraulic drainage of the soil volume between the legacy containment vessel (pond or vault) and the injected barrier, applying a similar concept to draining the gap between the primary and secondary concrete skins on double-skinned storage ponds. This project, involving both a PDRA and PhD student, will use experimental testing	

from batch experiments up to full-scale field trials. Initial laboratory batch experiments will investigate the gelling behaviour of colloidal silica under varied environmental conditions, such as groundwater pH, salinity and composition of near-surface soils. Penetration experiments will be trialled in a variety of soils with varying grain size distributions, including sediments similar to those sampled at the Sellafield site. The project will also investigate how the colloidal silica grout interacts with radionuclides (e.g. Tc, Sr). Large scale 3D laboratory testing and field testing (with BAM Ritchies) will be used to design and test the grout injection strategy and to validate the efficacy of the hydraulic barrier.

Associated Projects

Project Title	Irradiated Sludge's
Theme	Legacy Ponds and Silo Wastes
PhD/PDRA	2 PhDs (Potentially a 3rd)
Academic Investigator(s)	**Fred Currell**
University	Queens University Belfast
Project Description	
The experimental side of the project will involve irradiating sludge samples of interest, using a variety of radiation sources (e.g. at the Dalton Cumbrian Facility, the Diamond Light Source, QUB X-ray source) with a range of radiolytic products being assayed at a rate of about 1 sample every 30 seconds (subject to dose rate) to develop a comprehensive database of the products formed under a wide range of conditions. In parallel, PhD student on the theoretical side will perform atomistic simulations of the interactions between radiolytic products (particularly those found in high concentrations within the first microsecond of interaction with ionizing radiation) and clay - water interfaces. These simulations will be conducted for a range of radiolytic products and clay materials. They will then be analysed using machine-learning algorithms in order to generate a library of 'likely chemical processes.' The outputs from the two sides of the project will be combined in a Monte Carlo framework to provide a predictive model of the radiochemistry of sludges.	

Project Title	Monitoring of moisture and chloride in contaminated storage structures
Theme	Structural Integrity
PhD/PDRA	PhD
Academic Investigator(s)	**Mohamed Saafi**, Andrea Hamilton
University	University of Strathclyde
Project Description	
This PhD project is aimed at the development of advanced sensor technologies to monitor/measure moisture and chloride in built structures (mainly concrete). The application of this work is relevant to remediation of structures used to house contaminated waste, sustainable development of civil infrastructure and possibly monitoring cement used to encapsulate intermediate level radioactive waste. The project particularly focuses on the design, fabrication and evaluation of embeddable moisture/chloride sensors for applications in concrete. The embeddable sensors will be developed using various systems such as graphene, carbon nanotubes (CNTs) and MicroElectroMechnical Systems (MEMS). Small scale samples and field trials will be used to evaluate the performance of the sensors in terms of durability, sensitivity and resolution.	

Project Title	Thermal treatment of PCM and ILW
Theme	Legacy Ponds and Silo Wastes
PhD/PDRA	PhD
Academic Investigator(s)	**Neil Hyatt,** Claire Corkhill, Martin Stennett
University	University of Sheffield

Project Description

The projected UK plutonium contaminated material (PCM) waste volume is >30000 m3 with 70% arising at Sellafield. The current baseline treatment is supercompaction / cement encapsulation. However, a BPEO study for Sellafield Ltd. highlighted "concerns regarding the composition of the conditioned wasteform and… stability during long term storage". Thermal treatment, i.e. in-container or plasma vitrification, was identified as "the main alternative technology" with "advantages in terms of… stability of final product and improved volume reduction". Although proof of concept studies by Sheffield University and others have demonstrated PCM compatibility with thermal processes, a fundamental understanding of waste incorporation reactions and the impact of waste inventory on product quality remains to be established. This generic understanding is clearly critical to successful technology deployment.

Laboratory scale experiments using mock ups of PCM waste (using Ce as a Pu surrogate) and glass forming additives have been performed in order to understand the reactions / processes of waste digestion and incorporation during thermal treatment.

The focus of this project is thermal treatment of PCM wastes relevant to four sites across the NDA estate. Since the aim is to develop a fundamental mechanistic understanding of waste incorporation reactions during thermal treatment, the research will be transferrable to treatment of wastes within the UK ILW envelope (which could also be co-treated with PCM).

The project investigates the credibility of vitrifying various ILW streams. In particular the project investigates vitrifying Pond Scabbling Wastes, which is contaminated concrete (ILW) originating from scabbling of fuel ponds at various NDA sites. It is known that some ILW themselves possess the key oxides for glass making, chiefly SiO_2. Therefore some, or possibly all, of the SiO_2 in the vitrified product could originate from the ILW itself. One of the objectives of this project is to evaluate whether masonry waste removed from the decommissioned silo ponds as scabblings contain sufficient amounts of glass forming oxides, mainly SiO_2, to aid vitrification of a passive glass wasteform.

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