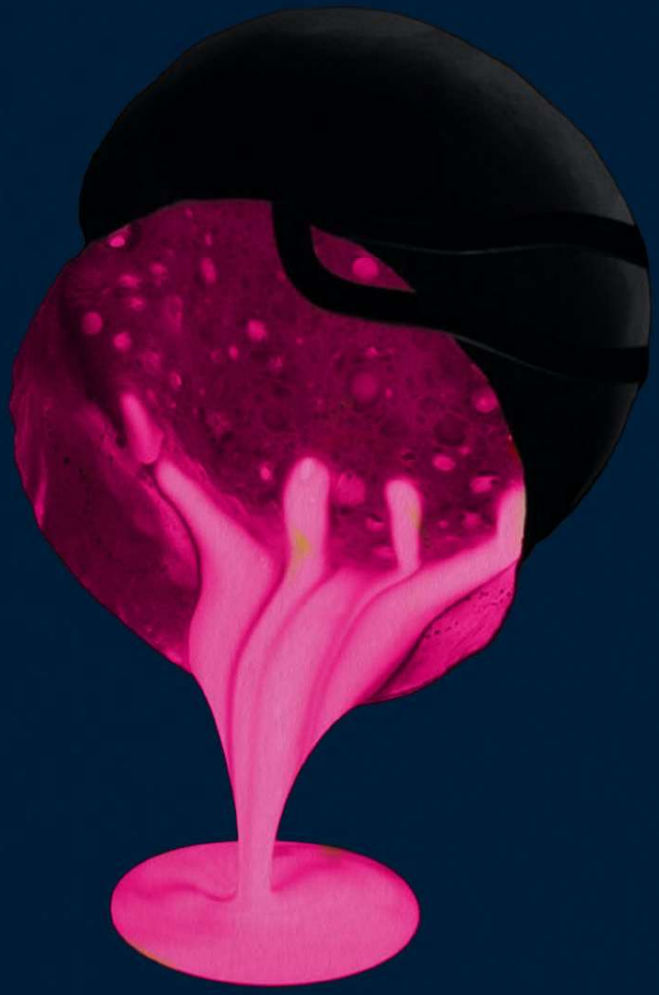
02 | Core Science

Establishing a centre of excellence in **thermal treatment** technology.



Environmental restoration is a challenge that the UK is tackling with allies around the world. This is why, at NNL, we are constantly driving new research routes into the way legacy wastes and future used materials are processed. Our foundations as a laboratory lie within this vitally important work, helping to leave the planet stronger and more sustainable.

We have pioneered the use of thermal treatment which forms one of the twelve areas of Core Science within our Science and Technology Agenda. Thermal treatment involves mixing nuclear materials with glass or ceramic precursors and consolidating by heating at high temperatures. It offers several advantages over conventional processes, including reducing the final volume of waste and improving stabilisation – making it more affordable as a result.

"I am proud to be involved in work that is helping to create a more environmentally sustainable future for the UK and benefiting the wider nuclear industry. Being in the early stages of my career, it is a fantastic opportunity for me to be a part of this world-leading team and learning from colleagues who are experts in the field of thermal treatment."

Beth Sunderland
Hot Isostatic Pressing (HIP) Laboratory Technician at NNL

Quality

What we have achieved:

Key Highlights

Thermal treatment isn't a new technology but it hasn't yet been deployed at scale across the nuclear sector. Typically, vitrification is the *de facto* process used around the world to stabilise the highly radioactive liquid arising from reprocessing. Thanks to the innovative and quality science we're undertaking at our Central Laboratory, key industry partners including Sellafield Ltd and the Nuclear Decommissioning Authority *(NDA)* are now looking to incorporate thermal treatment as part of their broader waste management toolkit.

To demonstrate the significant benefits of this transformative technology, a crucial part of our work involves thermal product sampling, characterisation and analysis, for which we are establishing a Centre of Excellence. Not only does this enable us to qualify the process, ensuring that the final products are as expected, but it means we can provide Nuclear Waste Services with the essential information they need to manage these materials.

Through trials of a Resodyn Acoustic Mixer *(RAM)*, we have confirmed that this technology improves the consistency of precursor materials before they undergo Hot Isostatic Pressing *(HIP)* – a specialised thermal treatment process that applies heat and pressure to transform powders into a highly robust and durable ceramic. HIP is currently being developed to help immobilise our nation's supply of surplus nuclear material. By improving the precursors, we can produce a higher quality product faster helping to reduce the surplus more quickly.

We are also investigating new techniques to assess this final product, along with vitrified nuclear material produced through vitrification, which includes the novel use of Raman spectroscopy. This technique enables us to scan across solid samples to assess their uniformity and confirm whether they contain any unwanted species or unreacted precursor material.

As well as pioneering technical advancements, in the past year we have made five journal submissions, presented our learnings at several international conferences and become a member of the prestigious Society of Glass Technology's Basic Science and Technology Committee.

Partnerships

Working with experts in the UK and across the globe

To ensure we are building a new clear future of the UK and for our planet, it is important that we work in tandem with specialists all over the world.

Examples of our recent collaborations include:

Working alongside nine other international laboratories to assess a new leach test method being developed by Pacific Northwest National Laboratory *(PNNL)* in the US. Collectively, our findings will feed into the publication of a new international standard to ensure radioactive species that have been immobilised within glass or ceramic materials are not rapidly released when they come into contact with water.

Partnering with the French Alternative Energies and Atomic Energy Commission *(CEA)* to build a UK model for glass dissolution. Based on the CEA's own state-of-the-art model, this has the potential to enable us to predict the behaviour of thermally treated glass or ceramics in water over tens of thousands of years.

We also have long-established partnerships with the NDA and Sellafield Ltd which extend to this area of work. Our advancements in thermal treatment have helped to develop the HIP capability that is now part of a multi-year NDA programme to ensure the long-term security of the UK's special nuclear material.

It has also supported experimental trials on new vitrification technologies as part of a collaborative project between the NDA and Theramin – a consortium of twelve European partners of which NNL is a part. These technologies are now being used by Sellafield Ltd to develop full-scale demonstrators for the treatment of key waste streams supported by NNL personnel and establishing the thermal product analysis Centre of Excellence.

Top
RAM trials taking place at our Workington Laboratory.

Bottom
An in-situ image of the GeoMelt® process showing a mixture of molten materials, with electrodes in each corner used to generate heat.

"Working within NNL's CINDe framework has enabled me to gain access to state-of-art technology and key technical knowledge offered by subject matter experts, both of which have been invaluable to me during my PhD. This programme has also given me the opportunity to see what it is like to work in an industrial facility in rural Cumbria. I can definitely say that the importance of the work, coupled with the general team atmosphere, has inspired me to want to continue working here."

Einan Solomon
PhD student at the University of Liverpool, who is in place at The Centre for Innovative Nuclear Decommissioning (CINDe), our PhD hub at Workington Laboratory

Talent

Creating a collaborative workforce with the necessary nuclear skills and experience

As the UK's national laboratory for nuclear fission, we want to give our nation's brightest young minds an avenue where they can develop their scientific curiosity and make a positive difference to society.

Within our thermal treatment programme, several early careers team members have taken a lead on the main technical tasks. They, along with some of our apprentices, have received training on our state-of-the-art equipment in the laboratory, including a new desktop scanning electron microscope *(SEM)* and associated grinder/polisher used for sample preparation, developing their practical, hands-on experience.

As well as progressing our own people, we are also fostering talent outside of NNL by providing individuals from other organisations and sectors with access to our specialist facilities. Three PhD students from the Universities of Sheffield, Manchester Dalton Cumbria Facility and Liverpool have been working with our experts at NNL on various research projects relevant to this field of work.

Impact

The future of thermal treatment

Our ambition is to establish a Centre of Excellence in active thermal product sampling, analysis and characterisation. This is key to enabling NNL to successfully support the deployment of thermal treatment on the Sellafield site and more broadly across the NDA estate, and ensure we're continuing to deliver sustainable impact.

We will continue to build our capability in this area of Core Science, exploring the application of existing and new analytical equipment and identifying and finding solutions for needs as they arise.

Our technical work will focus on the following three areas:

Thermal product performance – exploring advanced microscopic techniques, developing glass/ceramic dissolution models and new leach test methodologies, and supporting capability for the UK's Geological Disposal Facility;

Thermal product analysis – developing our alpha thermal treatment capability in Central Laboratory, supporting Sellafield's thermal demonstrators, and carrying out vitrified product compositional analysis and Raman measurements;

Providing the necessary technical underpinnings to NNL's Advanced Fuel Cycle Programme (AFCP), developing thermal processes and advanced glasses and ceramics for immobilising nuclear material.