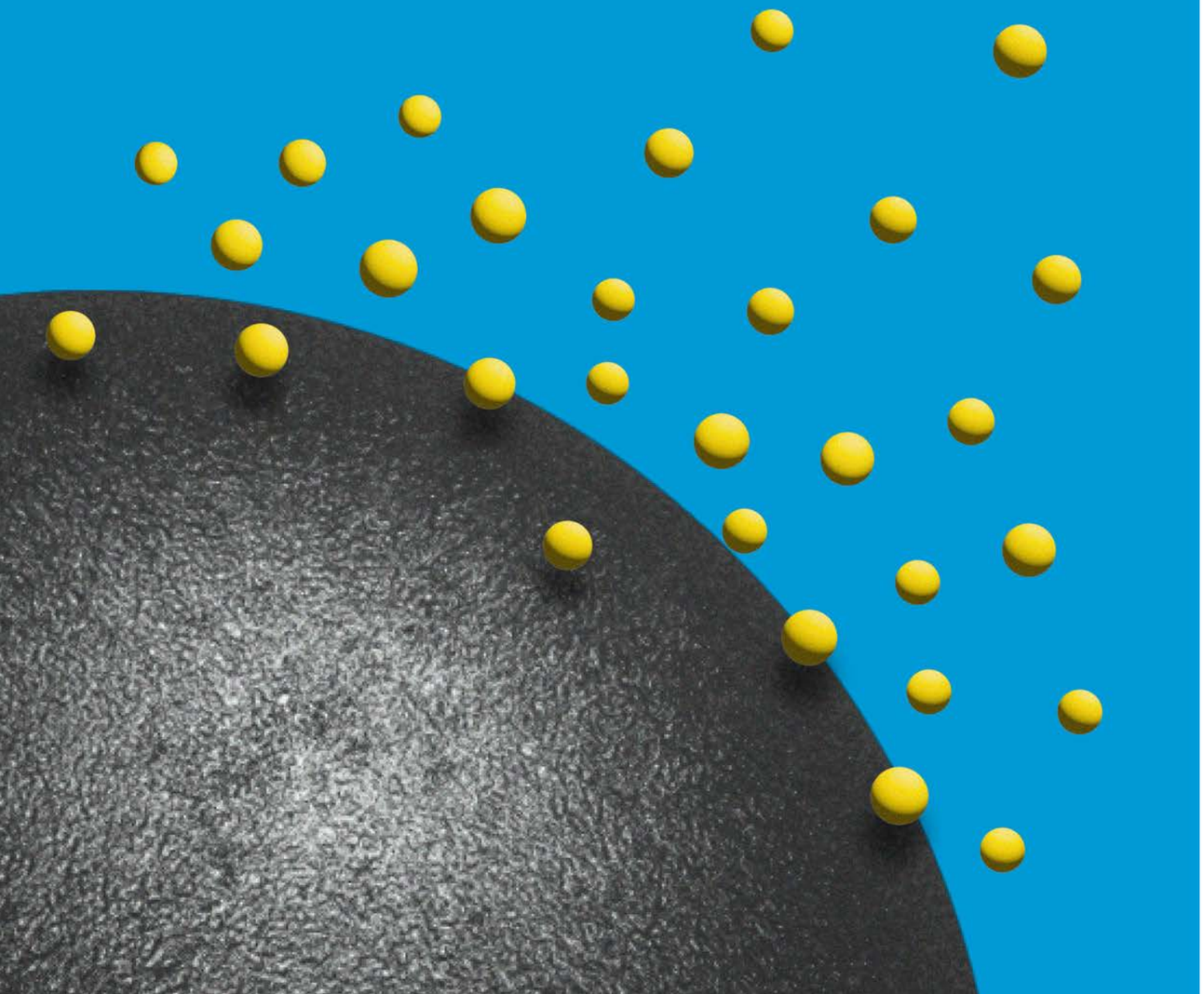
2 | Innovation

Driving towards **a sustainable future** through a novel approach to decontamination



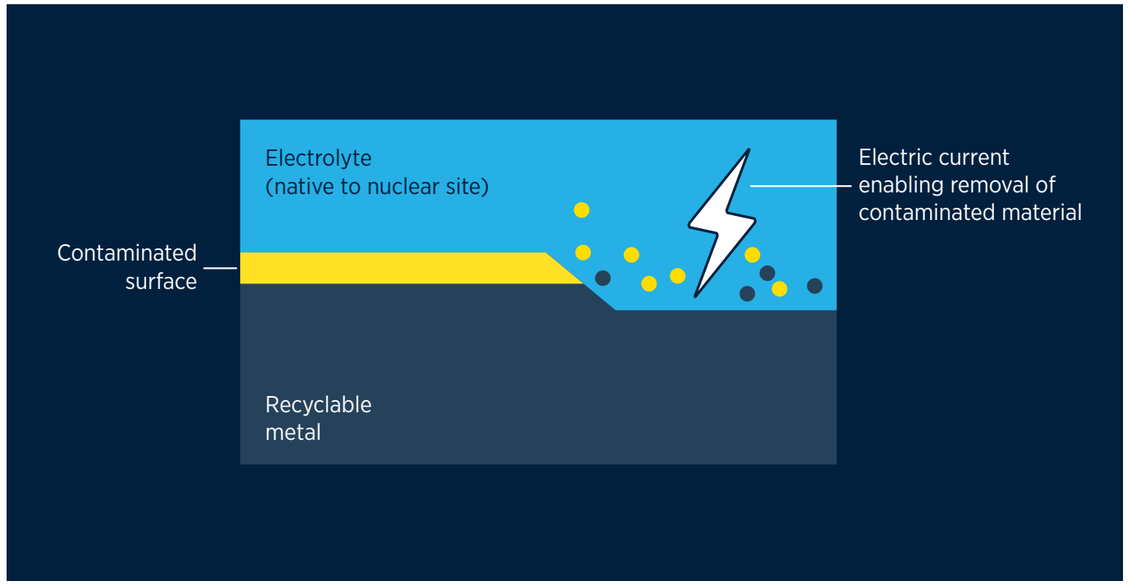
As our global industries move towards a future of zero waste, approaches to managing all materials as valuable assets are evolving. In the nuclear industry, removing contaminated portions of materials that have reached the end of their useful life will enable the uncontaminated portion to be reused.

High-quality metalwork is used extensively in the nuclear industry, as pipework, storage tanks and more. Over the long timeframes associated with nuclear operations, the surfaces of these metals can become embedded with radionuclides. If these radionuclides are not removed, large volumes of metallic waste must be handled, treated and stored.

Removing this contaminated surface layer can dramatically reduce the amount of waste and means that the vast majority of the metal can be returned into the supply chain for reuse.

As part of NNL's environmental restoration work, we research technologies that can tackle this challenge, and are developing Electrochemically Assisted Surface Decontamination (EASD) with our partners. EASD is an innovative technology that enables decontamination work to be carried out in situ, which enables decommissioning operations to be accelerated and supports sustainable nuclear operations.

Schematic representation of electrochemical surface decontamination.



Quality

Providing an effective solution to a key decommissioning challenge

Specialised metallic components are routinely used in industry as they are corrosion resistant and perform well in a variety of extreme environments. In some environments, such as inside nuclear reactors, corrosion resistance is essential. In steel, this can be achieved by adding chromium to the metal alloy. The chromium on the surface interacts with oxygen to create a corrosion-resistant surface. This surface successfully resists degradation and ensures that the steel is long-lasting.

The final stage in the life cycle of any industrial plant is decommissioning. The parts can be dismantled, useful components can be reused, and other materials disposed of. During the decommissioning of nuclear facilities, radioisotopes must be separated from non-radioactive materials so that the non-radioactive materials can be handled safely, giving them the potential to be reused. The robust nature of the surface of metals means that radionuclides embedded in the surface require special consideration.

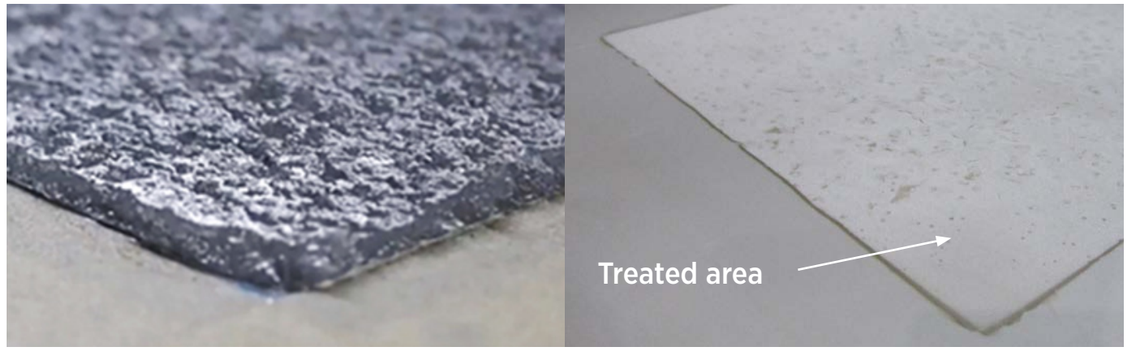
We have worked with C-Tech Innovation and Sellafield Limited to develop a novel, cost-effective solution to remove the corrosion-resistant surface layer, thereby separating the radionuclides from the non-radioactive metal and reducing waste volumes. The technology relies on a technique known as electrochemistry. Here, an electric current is passed through the metal surface, enabling the surface to rapidly dissolve into a liquid or gel that is applied at the same time. Both the liquid and gel used are compatible with existing on-site waste management practices, which ensures that new waste streams are not produced and that EASD can be deployed in a wide range of settings.

Prototype of the EASD jet system for cleaning vessel walls.

"The EASD technology has many benefits. The electric current can be passed through nitric acid, a reagent commonly used on the Sellafield site. This makes waste routing straightforward as a new chemical process does not have to be developed. With EASD the treatment is fast and decontamination is very thorough. The technique can be employed in different ways which means we can work on sections of our historic reprocessing plants that are hard to access. This helps speed up Sellafield's mission to clean out redundant facilities safely, securely, and at pace."

Sarah Bibby
Technical Manager for Sellafield Limited

EASD gel can remove localised spots of contamination. The gel turns dark during the treatment process. Once it's removed, you can clearly see the difference it makes to the surface of the metal.



Partnerships

Working locally and internationally to drive innovation

Our expertise in the management of materials and chemicals that are widely used in the nuclear industry has been combined with the expertise of C-Tech Innovation, a small–medium enterprise based in the North of England, to deploy electrochemical techniques. The success of this partnership has been assured by our collaborative approach in which our scientists have worked alongside C-Tech scientists and engineers to develop different deployment methods and demonstrate these within a nuclear setting.

Investment in EASD has led to numerous opportunities to deploy the technology, helping to drive value for the industry. We have worked with industry partners to develop the right solution for them and to train their technical experts to operate EASD prior to deployment. Different deployment techniques have been developed from the core technology. Where localised 'hot spots' of surface contamination are detected, a gel can be applied to mediate the electrochemical reaction. For larger areas of contamination, a jet of liquid can be used instead of the gel and a pipe-crawling robot has also been developed.

We have also fostered international collaborations to benchmark EASD against other decontamination technologies deployed in a range of nuclear operational scenarios. More widely, we have partnered on international research programmes such as the EU PREDIS (pre-disposal management of radioactive waste) programme and developed discussion of an alliance across other national laboratories.

"It was only by working in partnership with NNL that the development of the EASD technology (Electrochemically Assisted Surface Decontamination) was made possible. The combination of NNL's comprehensive understanding of the decommissioning requirements coupled with C-Tech Innovation's electrochemical expertise was the ideal platform on which to develop the technology. We now have a jointly owned patent portfolio that will support commercialisation in the UK and around the world."

Bob Crawford,
Technical Director for C-Tech Innovation

Talent

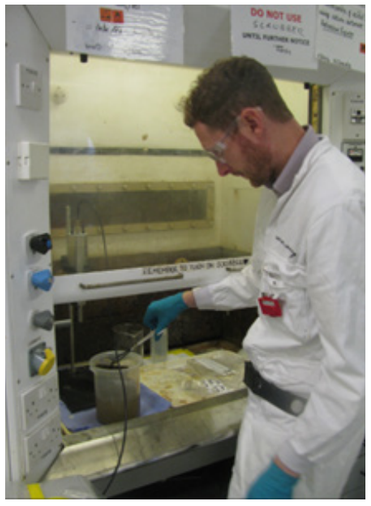
Providing opportunities for the next generation of experts to flourish

Collaboration with project partners has led to unique opportunities to develop our people. Working with Sellafield Limited to build on initial development work at C-Tech's facilities in addition to our Central and Preston Laboratories, we designed a project that saw a researcher augment the core electrochemical technology. The researcher deployed the technology, and proved its effectiveness, at our Workington Laboratory. Further work will see the technology deployed on the Sellafield and Dounreay sites. This project, funded by the Development of Alpha Resource and Technical Skills (DARTS) programme, enables the researcher to gain significant experience in deploying new technology, thereby helping to retain key skills in the nuclear workforce.

Deployment at our Workington facility also enabled technical experts who will use the EASD technology to be trained in an environment that comes close to actual conditions experienced on a nuclear licensed site, and further deployment at our Preston Laboratory proved the technology on contaminated materials gathered from decommissioning of nuclear facilities. Not only do these experiences build confidence in the technology, but they expand the skill sets of many key workers on nuclear sites.

> " I had the opportunity to learn about electrochemistry and how it can be beneficial for decontamination projects. I was also in the unique position to be the first to deploy the EASD technology on a nuclear licensed site so it was great to pioneer something new. I verified the technology on a real-life example of contaminated material and it was satisfying to see how effective the technology is. Separately, I demonstrated the technology to others which was a very rewarding experience. "

Peter Durham,
Senior Research Technologist,
NNL



Peter Durham testing the EASD technology at our Preston Laboratory on materials gathered from decommissioning of nuclear facilities.

Impact

Driving sustainability by fostering a circular economy

The 2022 UK Radioactive Waste inventory shows that approximately 26,000 cubic meters of material is contaminated metallic intermediate-level waste. These metallic items were developed to meet exacting standards for strength and durability. Decontamination means that they can retain classification as high-value items and be returned to the supply chain, rather than being disposed of as waste.

This avoids the high costs associated with building interim storage and reduces the size of the geological disposal facility (GDF). In the future, new-build reactor components could be made from recycled steel that previously operated in a nuclear setting for decades.

Recycling of used metals means that fewer natural resources need to be mined from the Earth. This means that the environmental impact of metal production can be reduced as land does not need to be disrupted for mining operations. Recycling also represents a significant cost saving if waste is diverted from long-term disposal facilities such as the GDF.

Specifically, this year the EASD project has achieved

progress towards active demonstration on the Sellafield site for waste treatment

practical evaluation alongside other commercially available decontamination approaches by a researcher under the Development of Alpha Resource and Technical Skills (DARTS) programme, providing the early career researcher with a unique development opportunity early in their career.

The science

Contamination of metals is usually limited to the top few micrometres near the surface.

Metallic vessels and pipework can be much thicker than this. Removing a very small fraction of the thickness can enable reuse of most of the material. The ratio of the original volume of material to final waste volume, known as the waste volume reduction factor, is high (approximately 1000:1).

Metals used in the industry have a protective layer on the surface which makes them corrosion resistant; conventional chemical treatment will not be effective in removing surface layers.

Applying an electrical current facilitates a chemical reaction that temporarily disrupts the protective layer and leads to rapid, controlled dissolution of the surface without the need for aggressive chemicals or the creation of challenging secondary waste.

EASD technology enables the surface to be removed using non-contact electrochemical treatment; electrodes do not need to be in contact with the metal. Treatment can take between 5 and 30 minutes.

The technology is scalable and can be applied in a range of formats including

- *immersion baths for treatment of items that have been removed from the operating environment*
- *pipe crawlers that can treat the internal or external surface of pipework or ducts*
- *a 'jet' version that passes a current through pairs of hoses to treat surfaces at a distance without the need for immersion of the target areas*
- *gel application for treatment of hotspots in operational environments that do not permit the use of liquids.*