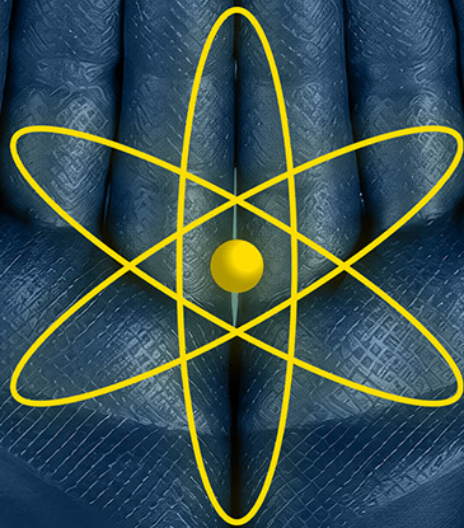


3 | Core Science

Safety first for the future of clean energy



UKNNL’s safety experts are leading nationally and internationally to develop smarter, more proportionate approaches that protect people and shape the standards for the nuclear industry.

Challenge

Safety has always been a key focus for the nuclear industry. It underpins all our active operations to make sure we can achieve our aims without affecting the safety of our colleagues and the public.

Without strong safety performance, trust is undermined – and this affects both our ability to keep existing nuclear operations running reliably and the potential for sustainability and growth in the sector.

New reactors and fuel technologies will only receive investment and regulatory approval if the nuclear industry can be demonstrated to be safe. Fundamentally, we view safety as the foundation on which the nuclear sector’s support for the UK’s sustainable energy goals must be built.

However, if implemented poorly, safety can be a barrier to getting things done. We have a legal and moral responsibility to conduct operations safely, but this must be done in a proportionate and fit-for-purpose manner to help us enable a clean energy future.

The recent Strategic Review by the UK Government’s Department for Energy Security and Net Zero (DESNZ) alluded to this, noting that “UKNNL must reliably implement programmes effectively and efficiently”.

Similarly, the Nuclear Regulatory Review 2025 (the Fingleton Report) found “three fundamental regulatory drivers of high cost and delay in the nuclear sector: risk aversion, priority for process over outcome, and the lack of incentives aligned with the public interest”, all of which can be related back to the challenge of ensuring safety while maintaining efficiency and innovation.

Solution

To enable us to tackle this challenge head-on as recognised leaders in nuclear safety, the UKNNL Nuclear Safety Core Science Theme vision is to be:

An internationally recognised capability that leads on fit-for-purpose nuclear safety approaches and solutions.

Three core pillars in delivering this vision are: our leadership in national and international forums, UKNNL subject-matter experts (SME) tackling technical challenges and nurturing the development of the next generation of nuclear safety experts.

National and international leadership

As the UK’s national laboratory, we are uniquely placed to play a leading role in nuclear safety, bringing together key stakeholders from safety disciplines worldwide.

This enables the UK to maintain authority in criticality safety, radiation shielding, and radiologic and chemotoxic safety, as the sector adopts novel fuel types and advanced reactor designs.

We collaborate with expert groups worldwide, driving the development of standards and guidance which help set the Relevant Good Practice. RGP refers to methods, standards, or approaches that are widely accepted across the industry as being effective in delivering particular safety, security, or safeguards outcomes, and which the regulator expects us to consider in showing our operations are safe.

This guidance therefore has a top-down influence across all nuclear safety assessments.

Senior Criticality Safety Consultant Lauren Flint is the UK Technical Lead on criticality safety ISO standards development.

She is a recognised member of the ISO/TC 85/SC 5 subcommittee, focused on nuclear installations, processes and technologies, which also allows her to assume the role of Head of UK Delegation representing the British Standards Institute as the national standard body.

This role is a prestigious appointment that involves Lauren acting as a key liaison with UK industry via the UK Working Party on Criticality (WPC) and collaborating with a wide range of international experts.

Deborah Hill, Head of Fellows and Senior Fellow for Criticality, has collaborated with American Nuclear

Society (ANS) nuclear safety experts for many years, regularly hosting sessions at ANS conferences. She is currently secretary to the ANS-8 Standards Committee, which produces guidance that shapes regulatory expectations in the US and informs Relevant Good Practice for the UK regulator.

As far back as 2017, the WPC stressed the importance of securing UK input into standards and Relevant Good Practice at an early stage. The WPC cautioned that failing to engage early could lead to overly conservative or prescriptive safety case requirements, which could in turn have an impact on the viability of operations.

UKNNL’s active involvement in this project directly supports our work in shaping emerging standards and ensures the needs of the UK nuclear industry are represented.

Radiation Physics and Shielding Capability Manager Anton Murfin is the UKNNL member of the UK Shielding Forum and was, until recently, its chair.

The Shielding Forum is the premier UK working group on radiation shielding, and sets best practice across industry.

Anton led the technical work that identified that the British Standard on shielding from gamma radiation (BS4094 1:1966) requires significant updates, and he is currently leading collaboration across the Shielding Forum to address this.

In addition to collaborating in working groups, the UKNNL nuclear safety team continues to spearhead further initiatives for the benefit of the worldwide safety community. It is leading the establishment of an international version of the criticality safety Learning from Experience database, used to record, share and analyse information relating to nuclear criticality safety, the UK version of which UKNNL was instrumental in setting up.

In the past five years, the UKNNL Nuclear Safety Core Science Theme has produced:

4 journal articles

1 ANS standard with UKNNL leading

2 ISO standards with UKNNL co-ordinating the UK contribution

9 conference papers with UKNNL lead authors

“ Simply put, the UK criticality safety community (including the UK WPC) would be struggling without the outstanding and highly respected role that UKNNL contributes. It demonstrates exemplary technical leadership in initiatives that are important to the WPC members and wider industry, including the Sensitivity/Uncertainty subgroup, ISO standards and the Criticality Learning from Experience database. UKNNL’s commitment to professional development is equally impressive, leading and contributing to recent WPC continued professional development (CPD) workshops on ALARP (as low as reasonably practicable) and safety assessment methods while also spearheading the internationally recognised CPD webinar series. In addition to its technical leadership, UKNNL has been key in developing the next generation of professionals, through support and guidance to the Early Careers Criticality Safety Network and the activities it is delivering. Through this combination of expertise, leadership and dedication, UKNNL not only strengthens collaboration and promotes good practice but also ensures the UK criticality safety community remains at the forefront of safety, knowledge and technical excellence by sharing valuable insights from their networks and encouraging the next generation to be developed. ”



Liam Payne
Safety Case Lead in Criticality Safety,
Dose and Shielding and WPC Chair,
Nuclear Waste Services



Deborah Hill was awarded the prestigious position of American Nuclear Society Fellow in May 2024, in recognition of her outstanding technical and professional accomplishments in Criticality Safety and her work with the society.

Technical expertise

When technical challenges arise in the production of nuclear safety assessments, one option is to apply conservative assumptions, increasing the margin of safety to compensate for any uncertainty.

However, this can lead to more onerous safety cases, thereby restricting operations. Instead, these challenges can be tackled with national and international collaborations.

UKNNL is currently leading a UK WPC subgroup on code validation using novel techniques, and collaborating with Lawrence Livermore National Laboratory (LLNL) on a world-first low-temperature criticality safety benchmark experiment.

“UKNNL is a vital contributor to the USDOE Nuclear Criticality Safety Program. The high-priority low-temperature critical benchmark experiment being advanced in partnership with LLNL and Los Alamos National Laboratory (LANL) is fundamentally important in addressing transportation challenges, and UKNNL’s technical expertise has been instrumental in overcoming the demanding cooling requirements associated with this equipment, ensuring progress on an issue of strategic international significance. However, their contribution extends far beyond this work. Through active support of the international Criticality Learning from Experience database under your leadership, UKNNL is fostering stronger global collaboration and facilitating access to a powerful shared learning resource for the international criticality safety community, helping to further strengthen criticality safety worldwide.”



Dr Angela Chambers
Nuclear Criticality Safety
Program (NCSP) Manager,
US Department of Energy

Criticality code validation

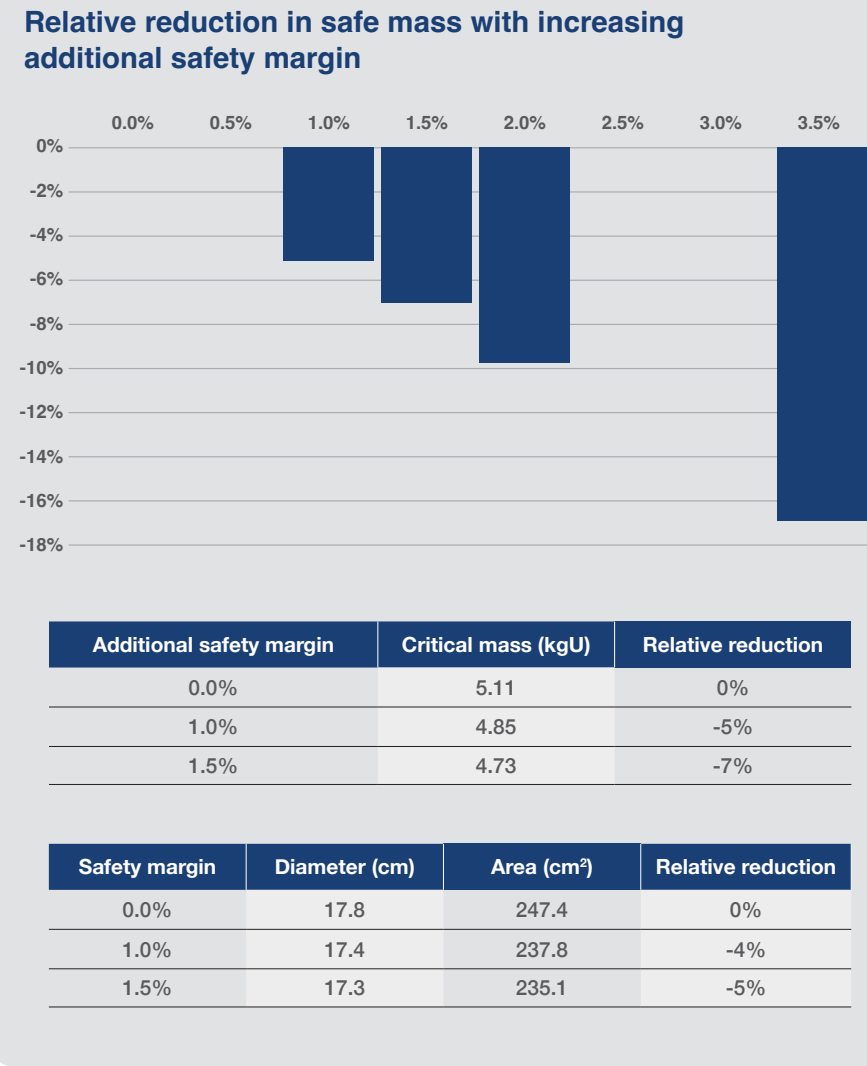
New technologies and novel fuel types, such as coated particle fuel (CPF) and high-assay low-enriched uranium (HALEU), must undergo rigorous assessment to ensure that they meet the required safety standards.

Simulation and modelling of these new systems require valid criticality safety codes and nuclear data, which are used to assess the safety of nuclear systems. It is important that we ensure these safety codes provide an accurate representation of real nuclear systems in action.

Any uncertainty about the safety codes or data used for testing may increase safety margins, which can adversely affect the viability of a new future technology. The graph (right) shows the effect of any additional safety margin on typical HALEU parameters.

There are few nuclear safety code validation experts in the UK, and new tools that automate the validation process frequently suggest a larger safety margin than necessary for real-life systems, potentially delaying new systems. We need to strike a delicate balance to deliver systems of the future both safely and efficiently.

The UKNNL nuclear safety team leads a WPC subgroup that aims to develop a consensus approach to the use of sensitivity and uncertainty (S/U) tools and techniques in the validation of criticality codes and data.



Modern tools and techniques that serve to (at least partially) automate the validation process are attractive and give the impression of a step forwards for the industry, but we need to understand their real-world impact and any potential shortfalls before fully embedding them. The subgroup has already done much to open up honest conversation and knowledge sharing

on this topic. This has helped to overcome a traditional reluctance to engage due to potential commercial impacts and low suitably qualified and experienced person (SQEP) comfort levels. The subgroup will produce a Good Practice Guide, and provide industry education, to shape how the UK nuclear industry embeds S/U tools and techniques.

Low-temperature critical benchmark experiment

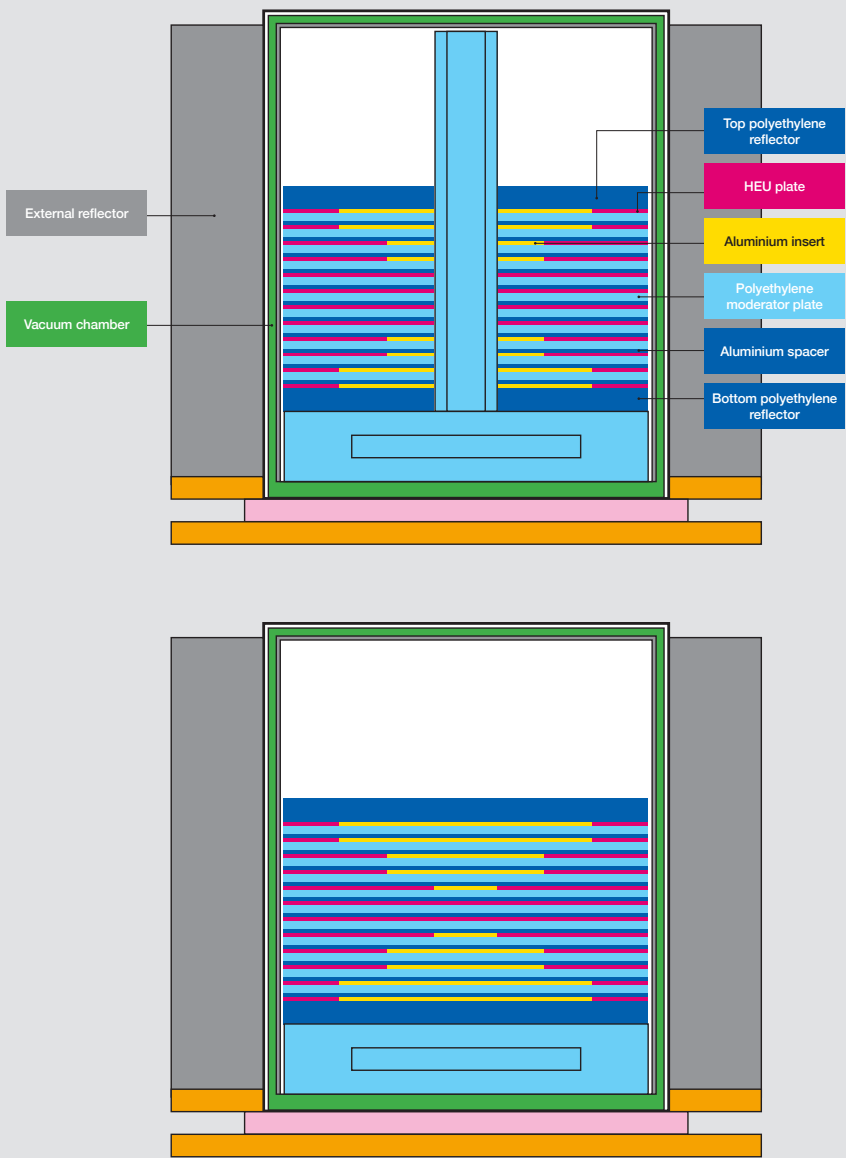
Under the Nuclear Safety Core Science Theme, UKNNL is supporting Lawrence Livermore National Laboratory on a multi-year project to design and run a world-first low-temperature critical experiment to take place at -40°C.

This will support the validation of transport assessments, required by international regulation to demonstrate safety down to subzero temperatures.

The validation of codes and nuclear data at this temperature range could pave the way for a reduction in safety margins, which in turn could allow more material to be loaded into a package or consignment and so reduce transport costs.

Following the experiment in 2026, its results will be published in the International Criticality Safety Benchmark Evaluation Project (ICSBEP) Handbook, a programme sponsored by the Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency (NEA), making the work available for use in future validation applications.

Schematic of the Low-Temperature Thermal Epithermal eXperiments (LT-TEX), showing configurations with and without a central spindle to improve cooling of the stack



Skills development

SMEs issue guidance from the highest levels of national and international working groups, and this sets strategic direction for nuclear safety.

But only by developing the next generation of safety assessors can we ensure this guidance is put into practice effectively. Inexperienced assessors may be more likely to adopt a cautious and conservative assessment approach, so training to a high industry standard is vital for ensuring safety cases remain fit for purpose.

Through our Nuclear Safety Core Science Theme, we are always looking for ways to support the development of early-career safety assessors, both internally and on behalf of the wider industry.

In 2023, UKNNL led a WPC workshop on Approaches to ALARP, which was attended by about 70 early career safety assessors, with contributions from other UK companies and the Office for Nuclear Regulation (ONR). The workshop focused on ensuring assessments are fit for purpose and not overly pessimistic, while providing suitable safety margins. In 2024, we supported another workshop on Safety Assessment Methodologies, which provided multiple training sessions.

UKNNL has supported the establishment of early careers networks for both the WPC and the Safety Case Forum, providing opportunities for early-career safety assessors to network and gain wider experience, and to amplify their voices within the industry.

What the future holds

Through its consistent call for a more practical, outcomes-focused and proportionate approach to nuclear delivery, the Fingleton Report encourages pragmatism as the industry evolves and novel fuels and applications continue to come thick and fast.

UKNNL will ensure that nuclear safety approaches keep up with the pace of innovation in the sector, by leading the national and international debate, taking up specific technical challenges when they arise and – perhaps most importantly – ensuring the next generation of assessors have the tools and experience needed to ensure nuclear safety remains an enabler of, rather than a barrier to, the industry of the future.

Milly Jarvis-Stiggants, Dose and Shielding Consultant, is a good example of this continuous professional development.

Milly attended the ANSWERS Software Service Seminar, an annual three-day nuclear industry event focused on radiation shielding, reactor physics and

nuclear criticality, on behalf of UKNNL.

There, she presented a shielding validation study assessing a code's ability to model neutron transport through concrete. The experiment used dosimeters within a concrete block to record neutrons in a heavy water reactor.

Milly's experiment was recreated with the shielding code MCBEND, developing an innovative approach in the face of limited experimental information.

Further validation work is now being proposed, thanks to Milly's insight.



Milly Jarvis-Stiggants
Dose and Shielding Consultant,
UKNNL