NIRO
NUCLEAR INNOVATION AND RESEARCH OFFICE

UK Nuclear Fission R&D Catalogue: Facilities, Equipment and Capabilities

SECOND EDITION - JULY 2022

This catalogue is regularly updated and optimised for online viewing, where each page contains links to websites and brochures providing more information to that presented on the following pages. To view latest version online version, please visit www.nirab.org.uk/useful-links where a link to download this catalogue can be found or scan the QR code below

I’m delighted with the response by UK organisations in support of this request from BEIS for a second edition to showcase UK fission R&D facilities.

The production of this catalogue follows a recommendation from the Nuclear Innovation and Research Advisory Board (NIRAB), that the UK government through the department for Business Energy and Industrial Strategy (BEIS), should commission the production of a catalogue of the UK civil nuclear research facilities and capabilities.

NIRAB recommended to include clear and precise access arrangements (where applicable) for both academic and industrial users. This catalogue responds to this by bringing together and building on existing information about UK nuclear fission R&D facilities. It aims to provide a comprehensive list of all equipment and capabilities, updated contacts for users and access requirements.

The information in these pages has been provided by the organisations listed, NIRO have complied these submissions into the catalogue to give an overview of UK nuclear fission R&D facilities, equipment and capabilities.

Issue 1, published in August 2021, received excellent feedback and it is hoped that this second edition of the catalogue will continue to be of use to small and large companies, government departments, laboratories and academic institutes alike to better inform projects, programmes and investment decisions regarding the potential for collaboration and shared use of facilities and expertise.

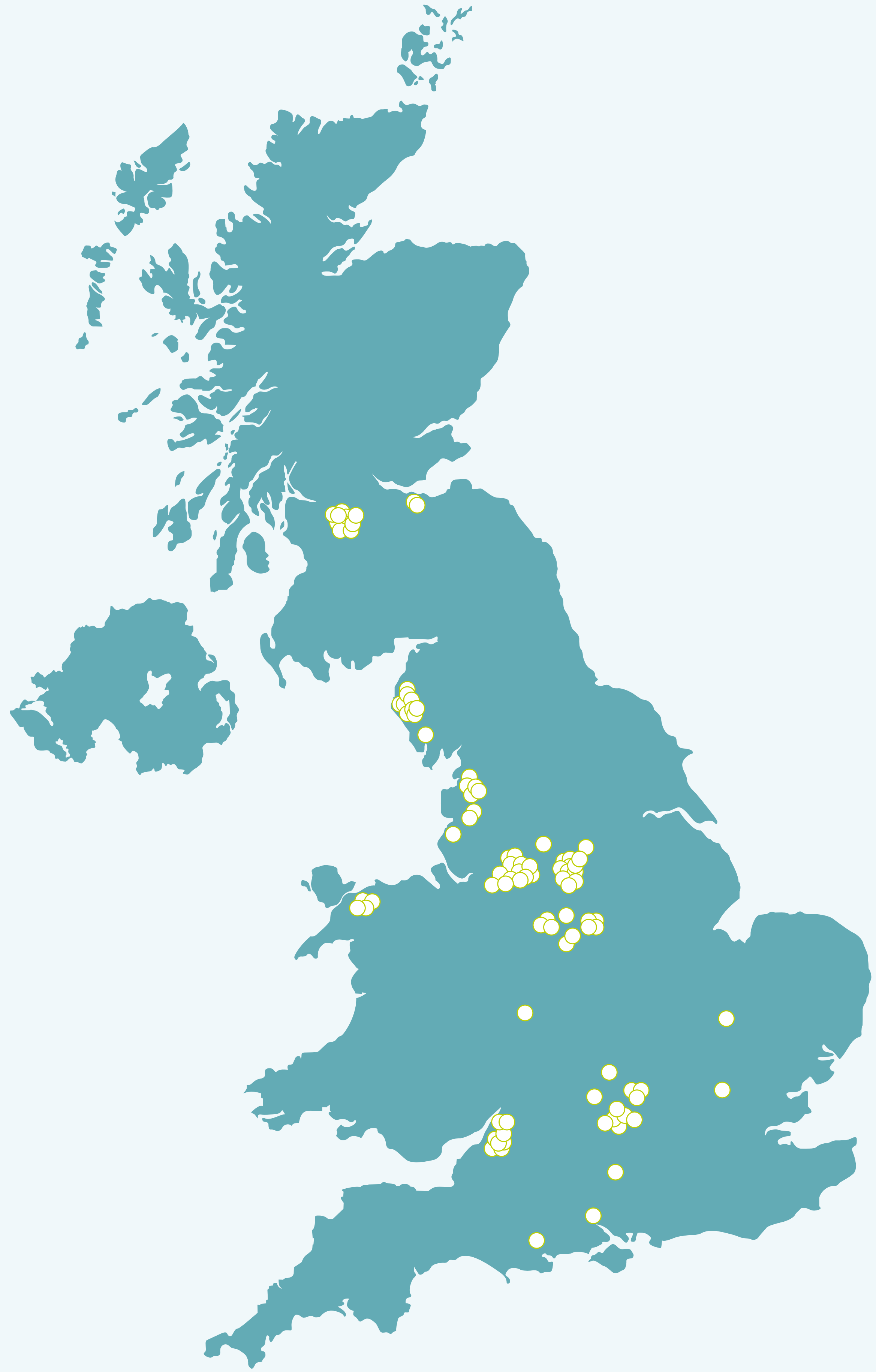
I hope that you find this second edition catalogue as useful as the first edition with its increase from 95 to 166 items, increasing the breadth of facilities showcased from within the UK. Whatever has brought you to this catalogue, I have confidence you will find it useful.

Dan Mathers

Executive Director
Nuclear Innovation and Research Office (NIRO)

The page opposite illustrates how the Facilities, Equipment and Capabilities are spread out across the UK demonstrating how nuclear fission R&D is being undertaken across the length and breadth of our shores. This catalogue is presented with all the industrial facilities first in alphabetical order of company and then academic facilities also in alphabetical order.

The following contents pages will help direct you if you are looking for something specific or feel free to browse through the whole catalogue. Do enjoy using the catalogue and we look forward to working with the contributors to update and further show case our excellent nuclear fission R&D Facilities, Equipment and Capabilities.



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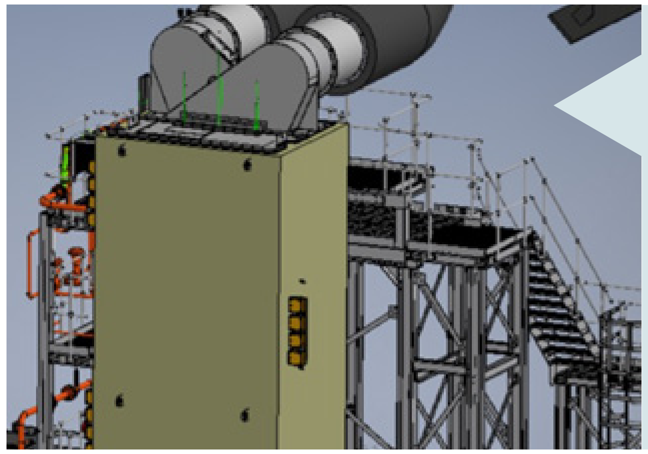
Industrial Facilties



Organisation
Ansaldo Nuclear Limited

Facility
Passive Heat Removal Facility

Location
Wolverhampton, UK

Summary of capability/facility

The Passive Heat Removal Facility (PHRF) is currently being built as part of the Advanced Modular Reactor (AMR) Feasibility and Development Project to test passive heat removal systems for innovative liquid metal reactors, notably lead fast reactors (LFR). The main body of the PHRF houses heating plates which by means of radiative heat transfer transmit the heat to surfaces representing the containment vessels of the Reactor Coolant System. In front, an enclosure that can be filled with water with a separation baffle simulates the Reactor Cavity. The main body is connected by ducting with the environment, with an outlet chimney at a height of almost 30 meters from the ground floor.

The facility allows to test radiative heat transfer, water boiling on large surfaces, transition from water to air and natural circulation/convection of air within the reactor cavity.

Instrument specification

General aspects
The facility is part of the Ansaldo Nuclear production site in Wolverhampton, on an existing infrastructure. The plant is equipped with a dedicated transformer with a global power of 1 MVA for the electrical heating of systems and components, as well as to energise the electrical loads of the plant and the main services. The facility has a footprint of approximately 3 x 2 m² and a total elevation of approximately 30 meters.

Heating section
The main heating section consists of a wall of heating plates 2 meters wide and 8 meters high, capable of producing a total power of about 500 kW. The plates are arranged on 20 heights, and the control system can regulate the power or set a constant temperature on each of the heights independently.

Ducting system
The air and steam collection system consists of 900 mm diameter ducting, equipped with temperature, pressure and flow rate measurements. The system is able to simulate natural circulation at variable pressure loss, or impose a constant air flow rate by installing an inverter controlled blower, with a flow rate up to 3 kg/s.

Auxiliary circuits
Demineralised water and compressed air.

Nuclear material capabilities (i.e. activity limits)

PHRF is a non-nuclear facility

Related instrumentation/capabilities

The facility is equipped with about 300 signals for the measurement of:
- fluids and wall temperature
- Air flow rate
- absolute, relative and differential pressure
- The total mass of the PHRF when filled with water during operational is approximately 45 tonnes.

External user access arrangements

Please email the Key Contact to discuss your access needs. The facility is partially available for the development of experimental campaigns within private contracts or national / international research and development projects.

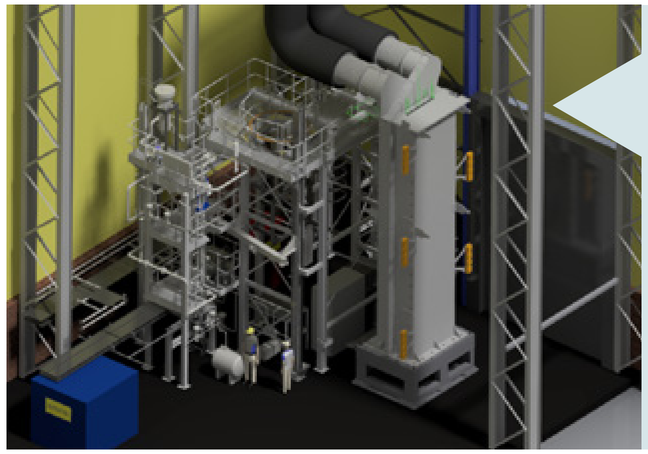
Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	Under construction
Other (please specify)	
Available/ unused	

Other relevant information

Contact

Charles Mendes
Charles.Mendes@AnsaldoNuclear.com



Organisation
Ansaldo Nuclear Limited

Facility
Versatile Loop Facility

Location
Wolverhampton, UK

Summary of capability/facility

The Versatile Loop Facility (VLF) is currently being built as part of the Advanced Modular Reactor (AMR) Feasibility and Development Project as a facility for testing key components for lead fast reactors (LFR) technology. It consists of a non-isothermal lead circuit with interchangeable test sections suitable to investigate electrically heated fuel bundles, innovative heat exchangers, liquid metal pumps or other components/systems. the facility is completed by a system for the control and conditioning of lead chemistry. The VLF is cooled by a supercritical water circuit.

The facility is primarily focused on evaluating the thermo-hydraulic performance of systems and components, with the production of experimental data for the qualification of components, the validation of calculation codes for design and safety analysis or support for licensing.

Instrument specification

General aspects
The facility is part of the Ansaldo Nuclear production site in Wolverhampton, on an existing infrastructure. The plant is equipped with a dedicated transformer with a global power of 1 MVA for the electrical heating of systems and components, as well as to energise the electrical loads of the plant and the main services. The facility has a footprint of approximately 10 x 10 m² and a total elevation of approximately 10 meters.

Primary circuit
The primary circuit contains approximately 3.5 tons of lead. It currently has an electrical core simulator of about 500 kW which allows lead to perform a thermal cycle between 390 and 650 °C. The circulation pump guarantees a maximum flow rate of about 40 kg/s, generating a velocity in the loop between 0.3 and 3 m/s. The heat transfer system consists of a micro-channel heat exchanger.

Secondary circuit
The cooling circuit is a supercritical water loop that interfaces with the lead loop through the primary heat exchanger. The system allows, through control valves, a fine adjustment of the flow rate up to about 0.5 kg/s, at a pressure of 300 bar and maximum temperature up to 620 °C.

Auxiliary circuits
The facility has a process system for melting lead and for conditioning/controlling the chemistry by injection of argon, hydrogen and air. Further auxiliaries are demineralised water and compressed air.

Nuclear material capabilities (i.e. activity limits)

VLF is a non-nuclear facility

Related instrumentation/capabilities

The facility is equipped with about 300 signals for the measurement of:
- fluids and wall temperature
- flow rate of each loop in different locations
- absolute, relative and differential pressure
- oxygen concentration in lead

External user access arrangements

Please email the Key Contact to discuss your access needs. The facility is partially available for the development of experimental campaigns within private contracts or national / international research and development projects.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	Under construction
Other (please specify)	
Available/ unused	

Other relevant information

Contact

Charles Mendes
Charles.Mendes@AnsaldoNuclear.com

Organisation
Cavendish Nuclear

Facility
Field Services

Location
Building A12, Gloucestershire Science & Technology Park,
Berkeley, GL13 9FB

Summary of capability/facility

Cavendish Nuclear field services offers expertise in gaseous filter technology gained over more than 40 years of close association with major licensed nuclear facilities, helping nuclear plant operators to meet their legal obligations concerning gaseous discharges to the environment.

- High Efficiency Particulate Air (HEPA) filter testing using DOP (Dispersed Oil Particulate)
- Manufacture of radioactive methyl iodide sources for testing of carbon filters and beds in the field including mobile and Laboratory based Gamma spectroscopy of sample results
- Supply and efficiency testing of nuclear grade bulk carbon for filters and beds
- Nuclear fuel transport flask, leak testing equipment maintenance, calibration and recertification
- Testing, repair and calibration of Halide detectors
- Cleaning and testing of sintered metal candle filters
- Local Exhaust Ventilation (LEV) system efficiency testing and survey including commissioning testing
- Provision of radiological characterisation and assay work
- Theory and practical training courses in the care, installation and replacement of HEPA system filters

Instrument specification

Nuclear material capabilities (i.e. activity limits)

Related instrumentation/capabilities

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	

External user access arrangements

Other relevant information

Contact

berkeley.admin@cavendishnuclear.com

Organisation
Cavendish Nuclear

Facility
Greeson Court Laboratories Environmental Analytical Services

Location
Westlakes Science Park, Whitehaven, Cumbria

Summary of capability/facility

Cavendish Nuclear's facility at Greeson Court on the Westlakes Science and Technology Park near Whitehaven in Cumbria, is an internationally recognised provider of specialist radiometric analysis for the analysis of a wide range of environmental, biological and effluent matrices.

The laboratory is equipped to conduct an extensive range of radiometric and radiochemical tests on a wide range of different sample materials. Many of the analytical methods fall within the laboratory's scope of accreditation to ISO 17025:201, General requirements for the competence of testing and calibration laboratories. The laboratory is UKAS Testing Laboratory No. 1604.

The facility consists of 8 chemical laboratory/sample preparation areas and 4 dedicated instrument laboratories. The total ground floor area of the facility is 3,675 m^2.

Instrument specification

Liquid Scintillation Counters: LKB1217 RackBeta x2, 1219SM RackBeta, Packard 2200 Tri-Carb, Packard 2250 Tri-Carb, Packard 2750 Tri-Carb, LKB1220 Quantulus, PerkinElmer 1220 Quantulus, Packard 2750TR/SL

Gas flow Proportional Counters: Tennelec LB5100, Tennelec LB4100, Canberra LB4100, Canberra LB4200

Alpha scintillation counters: x40 Harwell 6000 electronics ZnS detector

Gamma Spectrometers: GEM-30195-PLUS, GEM 65210-P, GEM-90200P-S, GEM-FX-7025-S, GC7521-7500SL, GC7520-7500SL, GC9021-7500SL-RDC-LB, GX7522-7500-SL (LEPS), GL2020-7915.30S (LEPS), GCW10023/S-7500SL-RDC-6-ULB, IGP-1510 (LEPS)

Alpha Spectrometers: 7200 Dual Alpha Spectrometer, 7404 Quad Alpha Spectrometer, Octete Alpha Spectrometer

ICP-MS: PerkinElmer Sciex Elan DRC II, PerkinElmer NexION 350D

ICP-Optical Emission Spectrometer: Varian Vista-Pro

Ion Chromatograph: Dionex ICS 3000, Metrohm IC Vario Two

GC-MS: Thermo Trace 1300+ISQ 7000

Nuclear material capabilities (i.e. activity limits)

The laboratory is primarily a low-level facility, but is organised to be able to handle radioactive samples up to the following single-sample limits:

Uranium Alpha	300 kBq
Other Alpha	50 kBq
Beta/Gamma	1 MBq
Carbon-14 / tritium	10 MBq

Related instrumentation/capabilities

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	100
Other (please specify)	

External user access arrangements

Enquiries about our services can be made via:
George Phillips - Operations Manager
01946 551800 - Greeson Court Reception
Cavendish Nuclear Website

Other relevant information

See Cavendish Nuclear Website

Contact

George Phillips
george.phillips@cavendishnuclear.com
01946 551779

Organisation
Cavendish Nuclear

Facility
Greeson Court Laboratories Internal Dosimetry Analysis & Berkeley ADS

Location
Westlakes Science Park, Whitehaven, Cumbria & Berkeley

Summary of capability/facility

Cavendish Nuclear's facility at Greeson Court on the Westlakes Science and Technology Park near Whitehaven in Cumbria, provides an Health and Safety Executive (HSE) Approved Dosimetry for internal analysis (H3, Pu, Am, U, Sr90 in urine, faecal, human tissue, nose blow) and have 24 hour call out availability in the event of an emergency.

The Berkeley Approved Dosimetry Service (ADS) includes a Personal Dosimetry assessment Service (PDS) and a Co-ordination and Central Dose Records Service (CDRS). The ADS is a leading provider to the UK nuclear industry, is approved for IRR17 (Ionising Radiation Regulations 2017), REPPIR (Radiation Emergency Preparedness and Public Information Regulations) and is a working member of the European Radiation Dosimetry Group (EURADOS).

Instrument specification

Alpha scintillation counters: x40 Harwell 6000 electronics ZnS detector

Alpha Spectrometers: 7200 Dual Alpha Spectrometer, 7404 Quad Alpha Spectrometer, Octete Alpha Spectrometer

ICP-MS: PerkinElmer Sciex Elan DRC II, PerkinElmer NexION 350D

Nuclear material capabilities (i.e. activity limits)

The laboratory is primarily a low-level facility, but is organised to be able to handle radioactive samples up to the following single-sample limits:

Uranium Alpha	300 kBq
Other Alpha	50 kBq
Beta/Gamma	1 MBq
Carbon-14 / tritium	10 MBq

Related instrumentation/capabilities

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
ADS	100
Other (please specify)	
Available/ unused	

External user access arrangements

Enquiries about our services can be made via:
George Phillips - Operations Manager
Janice Stamper - Bioassay Team Leader
janice.stamper@cavendishnuclear.com
01946 551800 - Greeson Court Reception
Cavendish Nuclear Website

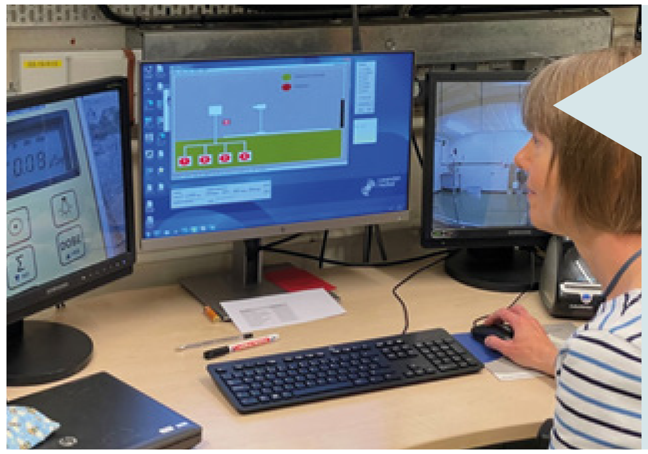
Other relevant information

See Cavendish Nuclear Website

Contact

Greeson Court:
George Phillips
george.phillips@cavendishnuclear.com
01946 551779

Berkeley ADS:
John Haykin
John.Haykin@cavendishnuclear.com
01453 707620



Organisation
Cavendish Nuclear

Facility
Metrology

Location
Building A12, Gloucestershire Science & Technology Park, Berkeley, GL13 9FB

Summary of capability/facility

Cavendish Nuclear provide a comprehensive high quality support service for all types of radiometric, radiological and radiation protection instrumentation.

The Metrology department is a specialist team based at Berkeley which delivers a full range of repair, maintenance, and calibration and testing services for Portable Radiation Protection Instruments to support customers in meeting the requirements of the Ionising Radiations Regulations 2017.

The calibration and testing services undertaken at the Berkeley laboratory are detailed below.

For those services labelled with a UKAS laboratory number, details of the current accreditation status of those services and the capabilities in each area should be referenced from the Schedule of Accreditation, published on the UKAS website.

Instrument specification

Calibration Service	UKAS Lab No.
Air samplers	N/A
Electronic personal dosimeters	0542
Environmental monitors	0542
Neutron monitors	N/A
Particulate activity-in-air monitors	N/A
Portable and semi-portable gamma monitors	0542
Surface contamination monitors	N/A
Surface emission rates from plaque reference sources	0542
Tritium-in-air monitors	0542

Testing Service	UKAS Lab No.
Criticality Incident Detection Alarm System boards	5621

Nuclear material capabilities (i.e. activity limits)

Related instrumentation/capabilities

Areas instrument used over last 12 months

Area	% Usage
Waste Management	5
Advanced Nuclear	70
Environmental	25
Other (please specify)	
Available/ unused	

External user access arrangements

Other relevant information

Contact

berkeley.admin@cavendishnuclear.com

Organisation
Computational Engineering Group, Computational Science and Engineering, Scientific Computing Department, STFC, UKRI

Facility
Code_Saturne / ChapSIM / neutronics modelling

Location
Daresbury Laboratory, Cheshire, WA4 4AD

Summary of capability/facility

The numerical simulation tools are used to model multi-physics phenomena occurring in nuclear fission reactors. The physics considered include fluid dynamics, thermal hydraulics, conjugate heat transfer and neutronics. The reactors modelled include: Advanced Gas Reactors, High Temperature Gas Reactors, Molten Salt Fast Reactors, Sodium Cooled Fast Reactors, Pressurised Water Reactors and Supercritical Water Cooled Reactors. We use High Performance Computing (HPC) facilities such as Archer2, Cirrus, Scarf, Scafell Pike, etc to enable us to thoroughly examine the phenomena of interest. We wish to highlight the importance of role in the numerical modelling in the support of the design and safety of experiments and facilities.

We regularly offer training in the use of Code_Saturne on HPC facilities, as well as the coupling of software with different physics.

Instrument specification

The software we use for simulations of nuclear reactor technology include:
- Code_Saturne, EDF, France (https://www.code-saturne.org/cms/)
- Serpent, VTT, Finland (http://montecarlo.vtt.fi/)
- OpenMC, MIT, USA (openmc.org)
- MUI, STFC and Brown University (https://github.com/MxUI/MUI)
- OpenFOAM, OpenFOAM Foundation, UK (openfoam.org)

Nuclear material capabilities (i.e. activity limits)

Coupled numerical modelling of pressurised water reactors and molten salt eutectics comprising fuel and carrier salts that are heated by neutronic reactions.
Thermal hydraulic simulation of large solid fueled reactor cores using Subchannel CFD. This is a computational fluid dynamics (CFD) based coarse-grid subchannel framework combining features of both CFD and subchannel codes. Subchannel CFD provides 3-D predictions of coolant flow and heat transfer with greatly reduced computing cost and it also allows multi-scale/multi-physics modeling when coupled to either highly resolved CFD in specific regions and porous media methods.
Modelling of compressible flows that occur in loss of coolant accidents in HTGR reactor cavities with the mixing of helium and air.

Related instrumentation/capabilities

Monte Carlo neutron transport solvers such as Serpent and OpenMC for the preparation of neutron cross-sections.

External user access arrangements

Collaborative R&D projects with academic and industrial partners. This can include user applications and software development for specific physics.

Training in the use of: thermal fluid dynamic software - Code_Saturne; visualisation tools - ParaView; code coupling - MUI.

Areas instrument used over last 12 months

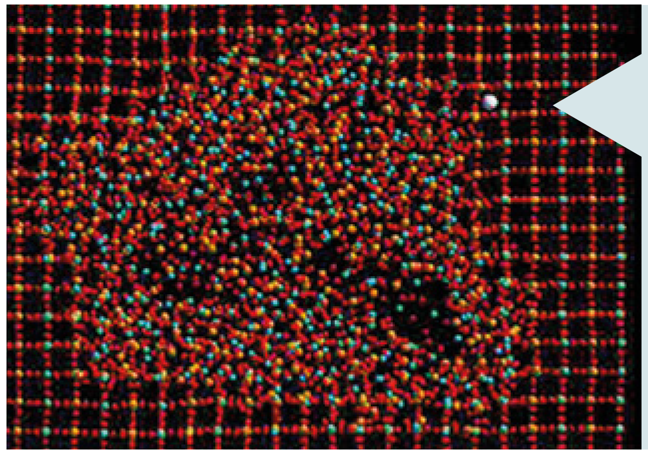
Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Available/ unused	

Other relevant information

Archer2: https://www.archer2.ac.uk
Cirrus: https://www.cirrus.ac.uk/
Scafell Pike: https://www.hartree.stfc.ac.uk/Pages/Our-systems-and-platforms.aspx
Scarf: https://www.scarf.rl.ac.uk/

Contact

Dave Emerson - David.Emerson@stfc.ac.uk



Organisation
Computational Chemistry Group, Computational Science and Engineering, Scientific Computing Department, STFC, UKRI

Facility
DL Software molecular simulation suite (modelling)

Location
The software is available for the user to exploit at their own institution

Summary of capability/facility

The suite of molecular simulation packages (e.g. DL_POLY, DL_MONTE, DL_MESO). A complete list of software and their capabilities can be found at https://www.ccp5.ac.uk/software). Materials modelling allows for the study of the behaviour of materials on an atomic scale where experiments are either difficult due to toxicity or very expensive. Virtual testing of samples with varied chemical composition under different irradiation dosages allows for the investigation of the evolution of properties such as radiation hardness, healing, segregation, amorphisation and stress induced crack propagation. Expertise of modelling of glasses, ceramics and metals has been developed to understand what defines better waste forms for the safe encapsulation and retention on geological scales of used nuclear fuel and decommissioned plutonium. The same techniques can be applied for understanding and selection of materials within fission and fusion reactors.

We regularly offer training in the use of DL_Software on HPC facilities, as well as on demand training and computational support and engineering.

Instrument specification

The software we use for simulations of materials response to irradiation includes:
- DL_POLY - particle/molecular dynamics and statics
- DL_MESO - mesoscopic Dissipative Particle and Lattice-Boltzmann dynamics
- DL_MONTE - atomistic Monte Carlo for statistical physics and thermodynamics
- ChemShell - advanced QMMM environment for reactive chemistry
- ACDC - Accelerated Crystal Dynamics Calculator (atomistic adaptive kinetic
- Monte Carlo) for long processes timescales

The DL_Software suite normally requires access to a linux computer such as a university cluster. The amount of resources required depends on the size of the simulation cell. Advice can be obtained from the contacts.

Related instrumentation/capabilities

Nuclear material capabilities (i.e. activity limits)

Most classes of materials can be modelled irrespective of their activity and include fuel materials, metals, radioactive waste, ceramics and polymers.
Possible applications are:
- (i) Molecular dynamics and analysis including laser induced and high-energy Alpha-particles damage in metals,
- (ii) Monte Carlo - thermodynamic stability,
- (iii) Kinetic Monte Carlo - damage recovery rates
- (iv) DFT with semi-classical methods for nuclear induced oxidation (zircon encapsulated fuel cells).

External user access arrangements

Software is mostly available without the need for a specific licence and freely available to UK academics. However, bespoke projects can be developed with academic, government and private organisations. These could include user applications as well as software development for specific physics and chemistry.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Aerospace	
Equipment Qualification	
Available/ unused	

Other relevant information

Archer2: https://www.archer2.ac.uk
Scafell Pike: https://www.hartree.stfc.ac.uk/Pages/Our-systems-and-platforms.aspx
Scarf: https://www.scarf.rl.ac.uk/

Contact

Ilian Todorov - ilian.todorov@stfc.ac.uk 01925 60 3681
John Purton - John.purton@stfc.ac.uk 01925 60 3785

Organisation
Diamond Light Source

Facility
Diamond Active Materials Laboratory

Location
Diamond Light Source Ltd, Diamond House, Harwell Science & Innovation Campus, Didcot, Oxfordshire, OX11 0DE

Image: Overhead view of Diamond Light Source © Diamond Light Source

Summary of capability/facility

Diamond offers analytical instruments for active materials research. However the construction of a new Active Materials Laboratory significantly improves the capabilities for researchers ranging from those involved in construction materials for nuclear energy facilities to waste management.

The new building has both wet and dry laboratories for handling a wide range of active materials, plus a counting room for active materials to be characterised and a secure storage.

Beamline I12 and DIAD have procured loading rigs with tension, compression and cyclic capability. These have a 10 kN capacity for time-resolved tomography and imaging (to accommodate the broadest range of requirements, from soft biomaterials and polymers to high-strength engineering alloys.)

Bespoke cells have been procured to contain samples to go in the I12 rig, which will be fitted with an infra-red furnace to enable testing of active material under controlled environments at temperatures up to at least 800°C. These are being commissioned.

Related instrumentation/capabilities

External user access arrangements

N.B. Diamond staff can run some low activity experiments on behalf of external users if required (depending on the exact nature of the experiment).

Diamond do not charge facility access fees for peer-reviewed academic research, wherever the user is based.

Academic users
- For use of the Active Materials Laboratory as part of an experimental programme on the synchrotron, you should apply as usual via the Diamond user office, and mention use of the Active Materials Lab in your proposal and when submitting your experimental risk assessment
- To apply for standalone use of the Active Materials Laboratory, please use Diamond's Offline Laboratories scheme

Users from UK-based Higher Education Institutions (Higher education institutions (HEIs)) and other organisations that are eligible to apply for UKRI funding:
- Travel/subsistence (T&S) support is available from Diamond for UK users who have obtained beamtime through the peer review system
- Funding for sample transport and T&S (where not already covered by Diamond) can be applied for through NNUF, until March 2023 (please see https://www.nnuf.ac.uk/diamond-active-materials-laboratory)

Industrial users
- Please contact the Diamond Industrial Liaison Office (https://www.diamond.ac.uk/industry.html) at industry@diamond.ac.uk

Instrument specification

Diamond Light Source has a variety of X-ray beamlines. The principal ones (but not the only ones of interest in the active materials fields of research) are:
- I11: High resolution powder X-ray diffraction (XRD), where there is also a long term facility able to house small experiments for up to two years with regular (weekly) data collection;
- I12: High energy beamline (up to ca 100 keV) for XRD and tomography with I13 and I14 beamlines with resolution in the tens of nanometres for tomography, and XRD and X-ray fluorescence (XRF) imaging;
- I18: a micron scale imaging beamline for XRF, X-ray absorption spectroscopy (XAS) and XRD;
- B18 and I20: scanning bulk XAS and XAS/X-ray emission beamlines;
- I22 a small angle scattering beamline

Nuclear material capabilities (i.e. activity limits)

The sample activity limits at Diamond depend on the element and isotope. Generally a synchrotron requires only small samples as x-ray beams are typically sub mm in size.

Other relevant information

Please consult:
https://www.diamond.ac.uk/Instruments.html
https://www.diamond.ac.uk/Science/Integrated-facilities/active-materials-laboratory.html
https://www.nnuf.ac.uk/diamond-active-materials-laboratory
for further information.

Areas instrument used over last 12 months

The figures below are an estimate of the areas of science for active sample users at Diamond in the last 12 months.

Area	% Usage
Waste Management	50
Advanced Nuclear	
Environmental	35
Materials science related to nuclear energy production	15
Other (please specify)	
Available/ unused	

Contact

fred.mosselmans@diamond.ac.uk
01235 778568

Organisation
Health and Safety Executive (HSE)

Facility
Science and Research Centre

Location
Buxton, UK

Summary of capability/facility

HSE, through its Science Division (HSE SD), is one of the world's leading providers of health and safety solutions to industry, government and professional bodies. HSE SD has over 360 scientific, medical and technical specialists.

With respect to the nuclear industry, the main focus of our work has been on understanding and reducing health and safety risks. We provide health and safety consultancy, research, specialist training and products to customers worldwide. We excel at complex challenges that benefit from a multi-disciplinary response.

Our extensive facilities facilitate scenario-based/large-scale testing, such as the thermal and drop tests defined within IAEA SSR-6. These are supplemented by an extensive range of engineering and analytical capabilities consistent with a state-of-the-art laboratory.

Related instrumentation/capabilities

A wide range of technical expertise encompassing: engineering safety; process safety; explosion safety; risk sciences; personal safety; human factors; occupational hygiene; analytical sciences; mathematical sciences.

Please refer to our website (www.hsl.gov.uk) for a comprehensive overview of capabilities.

External user access arrangements

Other relevant information

Instrument specification

The vast majority of the work that HSE Science and Research Centre has performed to date for the nuclear sector pertains to thermal/drop testing as noted in the capability summary.

In addition to this HSE unique expertise would tend to be on scenario based/bespoke testing or complex challenges that benefit from a multi-disciplinary response.

HSE Science and Research Centre can provide a multidisciplinary service to develop client's understanding of industrial risks (including those in the nuclear industry) and assist in developing fit-for-purpose solutions to ensure employees and the general public are not harmed.

Nuclear material capabilities (i.e. activity limits)

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Available/ unused	

Contact

David Johnson - Head, Centre for Asset Integrity
david.johnson2@hse.gov.uk
02030281926

Organisation
Jacobs Clean Energy

Facility
Active Metallography Lab

Location
MCLR Building, Birchwood

Summary of capability/facility

The Active Metallography Lab is a fully fledged analytical facility, capable of supporting complex metallographic and polymeric failure investigations. The laboratory is a designated C2 contamination-controlled area, allowing for higher activity specimens to be examined than a supervised area. The inclusion of two fume cupboards allows for the handling of yet more active or hazardous material.

The lab features a full suite of Struers sample preparation equipment, including two automatic cutting machines, a mounting press, and both automatic and manual grinding and polishing machines. A wide range of material analyses can be carried out using the equipment listed in the "Instrument specification".

Instrument specification

Hitachi S-3400N SEM, Oxford Instruments Inca x-act EDX, Nikon MA200 Inverted Optical Microscope, Future Tech FV-810 Microhardness Tester, Hitachi Foundry-Master Pro2 OES.

Related instrumentation/capabilities

The lab is fully equipped to carry out complex metallurgical or polymeric failure investigations and characterisation of active materials.

Nuclear material capabilities (i.e. activity limits)

Samples are typically <20 µSv/hr, however we have OPEX for handling samples with much higher dose rates (>1 mSv/hr) and activities.

	Sample Activity Limits (kBq)	
	Work bench	Fume cupboard
Uranium	30	300
Other Alpha	5	50
Tritium / C-14	1000	10000
B-emitters	100	1000

External user access arrangements

Visitors to the facility will be provided with appropriate PPE and dosimetry before being briefed on the area's local rules, along with any additional hazards that may be present in the lab at the time.

A permit to work and work authorisation will be issued based on the visitor's RAMS if the visitor intends to carry out any work in the laboratory.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Failure Investigations	80
Misc. Metallography	20
Available/ unused	

Other relevant information

Depending on the dose rate and form of material, samples may be sectioned and transferred to non-active labs for further characterisation and analysis; this additional capability includes, but is not limited to, mechanical testing of metallic and polymer materials, FTIR, DSC and ICP-MS.

Contact

Steve Rowland - steve.rowland@jacobs.com
John Stairmand - john.stairmand@jacobs.com

Organisation
Jacobs Clean Energy

Facility
Analytical Chemistry Laboratory

Location
MCLR B602, Birchwood

Summary of capability/facility

Radiochemical analysis

- Gross screening analysis
- Gamma-emitter analysis
- Beta-emitter analysis including Tritium, C-14, Sr 90 & 89, etc. And Alpha-emitter analysis such as isotopes of natural U, recycled U, Pu isotopes etc
- Radioisotope analyses from multiple matrices; this can include soils, waters, herbage, cements, building products, asbestos containing materials
- Primarily services are used by decommissioning contractors, contaminated land consultants, local authorities, water companies and defence establishments

Chemical analysis

- Environmental analyses to complement radiochemistry offering
- Metals analysis by ICP-MS and ICP-OES,
- Organic analysis for PAHs, TPHs, PCBs, sVOCs, VOC using GC-MS, GC-FID, 2-dimensional GCxGC, Headspace GC-MS
- Total Organic Carbons in both soils and waters
- WAC testing

Instrument specification

- Quantalus Liquid Scintillation Counters
- Ortec - high purity germanium n-type detectors
- Protean Beta counters
- Berthold Beta counters
- Octet Alpha detectors
- Raddec pyrolisers
- RadProfiler
- Agilent ICP-MS
- Agilent ICP-OES
- Thermo ICP-OES
- Agilent GC-MS
- Agilent GC-FID
- Agilent Headspace GC-MS

Related instrumentation/capabilities

Ion exchange resin reviews, testing and generation of specifications
Surveys of water quality for boilers, stator water and discharge consent
Fouling issues (cooling water systems and standby fuel/diesel tanks)
Corrosion surveys, corrosion failures
Steam sampling reviews
Material compatibility evaluation for materials in harsh environments
Full laboratory back-up support with the latest equipment
Analysis of greases and oils.

Nuclear material capabilities (i.e. activity limits)

Controlled Areas

- U - 30-300KBq
- Alpha emitters - 5-50KBq
- H-3/C-14 - 100 - 10,000 KBq
- Beta emitters - 100 - 1000 KBq

Supervised Areas

- U - 10-100KBq
- Alpha emitters - 1-10KBq
- H-3/C-14 - 300 - 3,000 KBq
- Beta emitters - 30 - 300 KBq

Undesignated Areas

- U - 0.1-1KBq
- Alpha emitters - 0.01-0.1KBq
- H-3/C-14 - 3 - 30 KBq
- Beta emitters - 3 - 30 KBq

External user access arrangements

By request.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	40
Advanced Nuclear	10
Environmental	30
Decommissioning	20
Other (please specify)	
Available/ unused	

Other relevant information

Contact

Nicola Summers - nicola.summers@jacobs.com
John Stairmand - john.stairmand@jacobs.com

Organisation
Jacobs Clean Energy

Facility
Co-60 Gamma Irradiation Facility

Location
Harwell, Oxfordshire, UK

Summary of capability/facility

The facility accommodates a wide range of experimental programmes for the waste management, nuclear power generation and aerospace industry. It offers variable dose rates, sample geometries ranging from individual components to large assemblies, ability to heat components during irradiation, high pressure, inert, vacuum or aqueous environments, together with power supply options to enable real-time component operation and monitoring. The capability is routinely used for both long and short-term testing programmes, to simulate relevant service conditions or meet specified standards.

Instrument specification

4 × Co-60 gamma sources
Wide range of gamma dose rates up to 2 kGy/h
(sample geometry dependant)

Related instrumentation/capabilities

Co-located corrosion laboratories to carry out post-mortem analysis or in situ radiation-corrosion studies.

Nuclear material capabilities (i.e. activity limits)

Only non-active samples/components are accepted at the irradiation facility.

External user access arrangements

Due to the nature of the facility, operation is strictly via the Jacobs Materials Science team. Clients may be granted access during experimental set-up or for periodic monitoring/ oversight and dismantling, but must be accompanied by authorised Jacobs staff at all times.

Areas instrument used over last 12 months

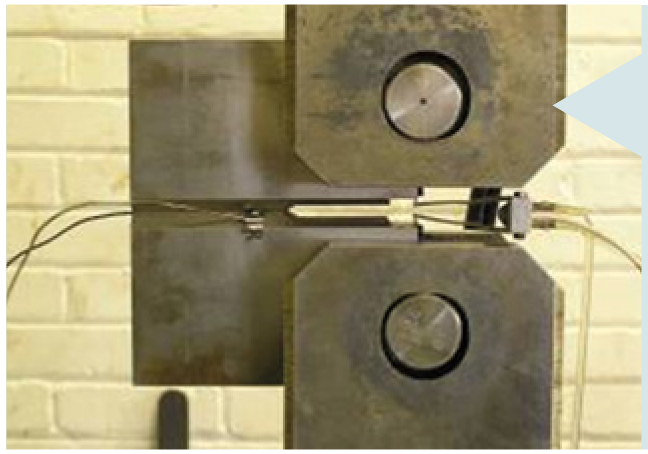
Area	% Usage
Waste Management	65
Advanced Nuclear	
Environmental	
Aerospace	10
Equipment Qualification	25
Available/unused	N/A*

Other relevant information

*The facility operates 24/7, but the variety of dose rates and generous facility size offer the flexibility to test multiple samples/components simultaneously.

Contact

Victoria Smith - victoria.smith2@jacobs.com
John Stairmand - john.stairmand@jacobs.com
John Dawson - john.dawson@jacobs.com



Organisation
Jacobs Clean Energy

Facility
Fracture Testing Laboratory

Location
Newton House, Birchwood

Summary of capability/facility

Jacobs' Fracture Mechanics testing laboratory provides a comprehensive range of materials research services aimed to deliver complex mechanical performance and evaluation experimental testing programmes. These programmes typically assess the deformation and fracture behaviour of structural materials for both existing nuclear fleet and new nuclear build.

This facility includes all of the necessary equipment and trained personnel to undertake fatigue pre-cracking and fracture toughness testing (ductile J-R & T0 reference temperature), tensile, and Charpy impact testing, to a variety of international testing standards including ASTM and BS EN ISO. Testing is undertaken within UK Accreditation Service (UKAS) accredited (ISO/ IEC17025:2005) laboratories and both the fracture toughness and tensile testing are UKAS accredited.

In support of our testing capability we have our own dedicated on-site manufacturing facility for the extraction and manufacture of standard CT/ SENB specimens or more bespoke test pieces, including two electro-discharge machines (EDMs) for precision engineering as well as optical/touch probe dimensional inspection capability.

Instrument specification

On site we have a number of servo-electric and servo-hydraulic fracture toughness test machines spanning 50 kN - 250 kN force capacities, and through the use of scanning electron microscopy (SEM) assisted metallography/ fractography can provide complementary in-depth mechanistic understanding of material deformation and fracture behaviour, alongside the supply of test data. Testing can be performed at temperatures ranging from -170°C to +350°C; we routinely test at ~300°C.

- Two ±100kN electromagnetic resonance vibrophores for fatigue precracking;
- Two ±20kN electromagnetic resonance vibrophores for fatigue precracking;
- Schenck Trebel 250kN servo-electric Fracture Toughness machine;
- Mayes 100kN servo-electric Fracture Toughness machine;
- Instron 100kN servo-electric Fracture Toughness machine;
- Instron 50kN servo-electric Fracture Toughness machine;
- Instron 250kN servo-electric Fracture Toughness machine;
- ESH 250kN servo-hydraulic Fracture Toughness machine;
- Avery 6705CA Charpy test frame (300 J capacity)

Related instrumentation/capabilities

Ability to machine and precrack bespoke test pieces for the purpose of fracture toughness testing. Ability to perform both multi-specimen and single-specimen fracture toughness testing, using unloading compliance to predict crack extension and R-curve generation. We are currently developing our DCPD capability in order to provide a secondary method of monitoring crack growth.

Nuclear material capabilities (i.e. activity limits)

The Fracture Mechanics Testing Laboratory is located within an Environment Agency (EA) permitted facility for the handling of open source radioactive material (EA permit TB3530DC), with the following permitted limits:

Isotope	Max Activity
Co-60	20 MBq
Fe-55	20 MBq
Ni-63	20 MBq
H-3	100 MBq
C-14	100 MBq
Alpha	1 MBq
Beta/ Gamma	20 MBq

The Fracture laboratory is operated in conjunctions with two other permitted facilities on site (Walton House TB3095DA, and MCLR EPR/KB3439DR), with larger permit limits. These facilities not only allow for the receipt and processing of higher activity items/ consignment but also have additional testing and radioactive material handling capabilities, including:

1. Radioactive material machining (including wire EDM and mechanical machining)
2. Lead lined glove boxes
3. Radiochemical analysis (UKAS accredited)
4. 100N to 2.5 MN mechanical testing (tensile, fatigue, creep, 3- and 4-point bend, Charpy, etc.), at temperatures between -180°C and 1200°C, (UKAS accredited)
5. Thermal property testing between RT and 1500°C

In addition to the laboratories, Jacobs RPA body is located on site and can provide radiological support advice including shipping guidance, with a number of Class 7 DGSAs.

External user access arrangements

Due to the nature of the facility, operation is strictly via the Jacobs Materials Science team. Clients may be granted access during experimental set-up or for periodic monitoring/ oversight and dismantling, but must be accompanied by authorised Jacobs staff at all times.

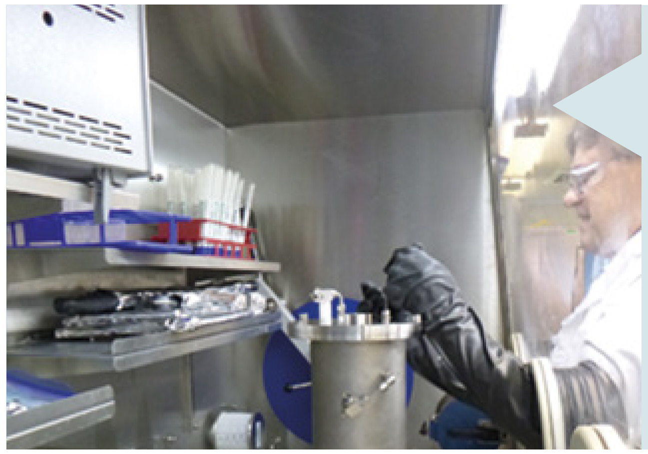
Other relevant information

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
New build	60
EDF Reactors	40
Available/ unused	

Contact

Adam J Cooper - adam.cooper@jacobs.com
John Stairmand - john.stairmand@jacobs.com



Organisation
Jacobs Clean Energy

Facility
Harwell Corrosion Laboratories

Location
Harwell, Oxfordshire, UK

Summary of capability/facility

Dedicated corrosion testing facility in the Harwell Science Park, located in proximity to a dry walk-in Co-60 γ irradiation facility. Ability to design and operate small- to medium-scale material degradation experiments in a range of relevant conditions, including conditions of controlled temperature, relative humidity, oxygen concentration and γ-radiation levels.

The capability is routinely used for the in-situ and ex-situ analysis of purposely-designed corrosion tests in support of radioactive waste management and disposal programmes worldwide, including tests at elevated temperatures and in different environments (e.g. anoxic conditions, humid air, water, acids and alkalis). It is also able to perform a range of standardised analytical corrosion tests (e.g. ASTM).

The laboratory has easy access to a closely located irradiation facility to perform radiation-assisted corrosion studies when required.

Instrument specification

Braun glovebox (to carry our experiments under anoxic conditions)

Electrochemical potentiostats (ACM and Solartron models)

Precision mass balances

Laboratory ovens

Fume hood

Autoclaves for low-pressure testing

Related instrumentation/capabilities

Access to 4 × Co-60 γ sources, (See details of Jacobs Co-60 gamma irradiation facility).

Nuclear material capabilities (i.e. activity limits)

Non-active samples only.

External user access arrangements

The operation of lab is via the Jacobs Materials Science Team, based at Harwell. External access is only granted as an escorted visitor, with commercial agreement in relation of experimental setup or disassembly.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	100
Advanced Nuclear	
Environmental	
Other (please specify)	
Available/ unused	

Other relevant information

Contact

Bharti.reddy@Jacobs.com

Organisation
Jacobs Clean Energy

Facility
High Temperature Facility

Location
Newton House Birchwood

Summary of capability/facility

The High Temperature Facility is a Department for Business, Energy and Industrial Strategy BEIS funded materials test laboratory established to support the development of Advanced Modular Reactors. It is currently providing test data relevant to current class Advanced Gas Reactors (AGRs) and Pressurised Water Reactors (PWRs), and to future High Temperature Gas Reactors (HTGRs) and Lead-cooled Fast Reactors (LFRs) reactors. Many of the tests are UKAS-accredited, and comply with relevant international standards (ASTM). The lab operates under closely-controlled constant temperature conditions and is equipped with flexible advanced instrumentation of test specimens.

Jacobs welcomes the use of the High Temperature Facility by suitably trained staff from other organisations.

Instrument specification

Load capacity for fatigue is 10kN-2.5MN.
Testing can be in air, liquid lead, helium and other media may be feasible.
The maximum temperature is nominally 1000°C.

Related instrumentation/capabilities

The test rigs instrumentation include digital image correlation, electrical potential different crack detection and acoustic emission. Heating is available from several techniques.

Nuclear material capabilities (i.e. activity limits)

It is possible to accommodate low level activity.

External user access arrangements

Can be accessed under National Nuclear User Facility (NNUF) arrangements for universities and some other organisations. However, direct contracting with Jacobs for commercially sensitive is also possible.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	20
Environmental	
Other (please specify)	30 New Build
Available/ unused	

Other relevant information

The mechanical testing laboratories at Jacobs have been operating and providing nuclear design and safety justification data for more than 50 years.

Contact

Mark Callaghan - mark.callaghan@jacobs.com
Andrew Wisbey - andrew.wisbey@jacobs.com
John Stairmand - john.stairmand@jacobs.com

Organisation
Jacobs Clean Energy

Facility
Jacobs Beckermet Large Rig Facility

Location
Unit 28, Beckermet Industrial Estatel Haile, CA22 2NH

Summary of capability/facility

Beckermet is a flexible facility suitable for large scale test rigs, prototype trialing, verification and validation.
It has a rig hall with 1300 m^2 of floor space, a 30m tall high bay, a 6m deep test pit, 20 and 60 tonne overhead cranes, conferencing facilities and office space.
The facility works with clients and suppliers, developing new technology or adapting established systems from industries to find safer, faster and more cost-effective ways to dismantle and decommission nuclear facilities. Our solutions will minimise human intervention, make waste characterisation and handling more cost-efficient, and reduce waste volumes.
The facility provides capabilities in concept and detailed design, manufacturing, assembly, test, installation and commissioning for the nuclear decommissioning, waste management, new build and defence markets.
It will also support innovative problem solving to speed up hazard reduction at Sellafield and other nuclear sites in the UK

Instrument specification

The Beckermet facility has

A rig hall with 1300 m^2 of floor space

A 30m tall high bay

A 6m deep test pit (6m*6m*6m)

20 tonne overhead crane facility in the high bay

60 tonne overhead crane (with 20 tonne auxiliary hoist) that covers all of the rig hall floor space

Compressed air ring main

415V power supplies

Conferencing facilities

Office space for up to 75 resources

Separate mess and shower facilities
Perimeter security fence with access-controlled security

Related instrumentation/capabilities

See the Instrument Specification section

Nuclear material capabilities (i.e. activity limits)

Zero - it is a clean facility

External user access arrangements

Please contact Mark Ritchie to access the facility.
The facility has security gates and pass system for users to gain access.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	50
Advanced Nuclear	
Environmental	5
Op Reactors	
Other (please specify)	
Available/ unused	45

Other relevant information

Also available for non-decommissioning rigs such as SMR, AMR and fusion.

Contact

Mark Ritchie - Waste & Technology Director
mark.ritchie@jacobs.com
Tel: 07808631941

Organisation
Jacobs Clean Energy

Facility
Walton House Active Laboratory

Location
Walton House, Birchwood

Summary of capability/facility

The facility has been developed to support radioactive waste management and disposal programmes worldwide. The facility can design and operate small- to medium-scale tests using both radioactive and non-active samples.
It is routinely used for experimental studies which include:

- Cement-based materials - encapsulation grouts and backfills
- Organic materials - cellulosics, polymers, ion exchange resins plus organic complexants, cement additives
- Glasses/vitrified products
- Bentonite
- Geological materials - crystalline rocks, mudrocks/clays, single minerals
- Irradiated graphite

Studies typically include sorption and solubility, diffusion, leaching, degradation, chemical evolution and interactions between waste simulants and barrier materials.
The laboratory has access to other local facilities to allow further analytical testing to be completed using both active and non-active samples.

Instrument specification

2x Negative pressure N_2 glovebox
Saffron negative pressure CO_2 in N_2 glovebox
Shielded negative pressure glovebox (air)
Hidex 300SL liquid scintillation counter
Beckman Coulter Avanti JXN high-speed centrifuge
Fume hood
Precision mass balances
Non-active samples only:
2x positive pressure glovebox
Lab ovens

Nuclear material capabilities (i.e. activity limits)

The active laboratory is located within an Environmental Agency (EA) permitted facility for the handling of open source radioactive material (EA permit TB3095DA), with the following permitted limits.

Isotope	Max Activity
H-3	100 GBq
C-14	10 GBq
Co-60	10 GBq
Cs-137	10 GBq
Other beta/gamma emitters	10 GBq
Non-uranium alpha emitters	100 MBq
Uranium alpha emitters (excluding U-235)	16 MBq
Depleted uranium	10 kg
U-235	1 MBq
Natural uranium	10 kg

In addition to the laboratories, Jacobs RPA body is located on site and can provide radiological support advice including shipping guidance, with a number of Class 7 DGSAs

Related instrumentation/capabilities

Jacobs also provides a one-stop shop for independent advice and consultancy on NDT, including research, development, consultancy, qualification and related services, coordinated by our Monitoring and Inspection Design (MID) team.
We provide a complete service which saves time and cost by avoiding downtime. Our solutions cover non-standard areas and novel methods and techniques, including advanced ultrasonics.

External user access arrangements

Due to the nature of the facility, operation is strictly via the Jacobs Materials Science team. Clients may be granted access during experimental set-up or for periodic monitoring/ oversight and dismantling, but must be accompanied by authorised Jacobs staff at all times.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	100
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

Other relevant information

Contact

Cristiano Padovani - cristiano.padovani@jacobs.com

Organisation
Jacobs Clean Energy

Facility
High Temperature Water Corrosion Lab

Location
Walton House, Birchwood

Summary of capability/facility

Internationally leading facility for carrying out materials degradation test in high temperature water under static or dynamic loading conditions. In addition to an extensive suite of state-of-the-art test rigs, there are several bespoke rigs that fulfil specialised and unique test following customer plant interests and international kNowledge gaps.

Instrument specification

Most test rigs operate at a load of up to 100kN. The feedwater can simulate most of the lightwater reactor coolant composition (BWR, PWR, CANDU, other), and can handle out-of-spec contaminant levels. Test rigs are fabricated in stainless steel, titanium or hastelloy. The operating temperature can be up to 360°C. There are currently 35 test rigs with various specifications.

Related instrumentation/capabilities

Scanning Electron Microscope (SEM), 3D microscope, X-ray.

Nuclear material capabilities (i.e. activity limits)

Case-by-case basis.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	20
Environmental	
Op Reactors	80
Other (please specify)	
Available/ unused	

External user access arrangements

Operations by Jacobs.

Other relevant information

Contact

Stuart Medway - Stuart.Medway@jacobs.com
John Stairmand - John.Stairmand@jacobs.com

Organisation
Jacobs Clean Energy

Facility
Inspection Validation Centre (IVC)

Location
Lovell House, Birchwood

Summary of capability/facility

The Inspection Validation Centre (IVC) provides independent third-party Inspection Qualification (IQ) to high integrity industries. Conceived in the late 1970's the IVC was formed to support the manufacture of the UK's first Pressurised Water Reactor (PWR), and later formed the methodology for inspection qualification that is now used throughout Europe, ENIQ (European Network for Inspection Qualification).

The facility houses a large number of test pieces which are representative of a range of actual plant components. These test pieces, implanted with real and artificial flaws, are used to validate that inspection systems meet the customer's requirements.

With its team of expert NDT personnel, the IVC review the complete inspection systems to be deployed on the high-integrity components.

We ensure the inspection systems deployed will detect the defects of concern with high reliability. Providing confidence to the owner, site operator and regulator that the plant is free of defects that could cause significant concern during operation.

Instrument specification

Various

Related instrumentation/capabilities

Jacobs also provides a one-stop shop for independent advice and consultancy on NDT, including research, development, consultancy, qualification and related services, coordinated by our Monitoring and Inspection Design (MID) team. We provide a complete service which saves time and cost by avoiding downtime. Our solutions cover non-standard areas and novel methods and techniques, including advanced ultrasonics.

Nuclear material capabilities (i.e. activity limits)

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
New build	100
Other (please specify)	
Available/ unused	

External user access arrangements

Other relevant information

- Fully independent from other part of Jacobs, plants licensee's and inspection vendors
- UKAS accredited to BS EN ISO 17020

Contact

Christopher Curtis - chris.curtis@jacobs.com - 07815 620868
John Stairmand - john.stairmand@jacobs.com

Organisation
Jacobs Clean Energy

Facility
Mechanical Materials Test Lab

Location
High Temperature Facility and Walton House, Birchwood

Summary of capability/facility

This is a National Nuclear User Facility (NNUF) facility, providing the range of mechanical testing capabilities for tensile, creep, creep crack growth, stress relaxation, impression creep (miniaturised test), fatigue, creep-fatigue, thermo-mechanical fatigue, corrosion fatigue, stress corrosion cracking and fracture. Multiple test stations are available - ~65 creep stations, ~20 fatigue & ~5 fracture. Testing up to 1000°C is feasible with higher temperatures in some cases. Tests can be in air or in other environments - including vacuum, liquid lead and potentially other liquid metals or molten salts. Much of this is focussed upon coupon testing, generating material behaviour understanding but some larger scale facilities are also available. Both standardised mechanical tests (UKAS approved), undertaken to international standards, and also bespoke tests are also provided, including with multi-axis capability.

Instrument specification

Load capacities for fatigue of between 10 kN and 2.5 MN is available and these utilise both servo-electric and hydraulic systems. Local strain measurement use side-loaded extensometry. Fracture testing using systems from 25 kN to 250 KN load capacity. Creep testing is mostly undertaken using constant load systems of 20-30 kN load capacity and with “drop-leg” extensometry for strain measurement.

Related instrumentation/capabilities

Range of associated equipment, including digital correlation, electrical potential difference crack length measurements, acoustic emission for cracking. Multiple heating methods are available.

Nuclear material capabilities (i.e. activity limits)

Low level activity is possible to accommodate.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	20
Environmental	
Plant life extension	30
New build	30
Available/ unused	20

External user access arrangements

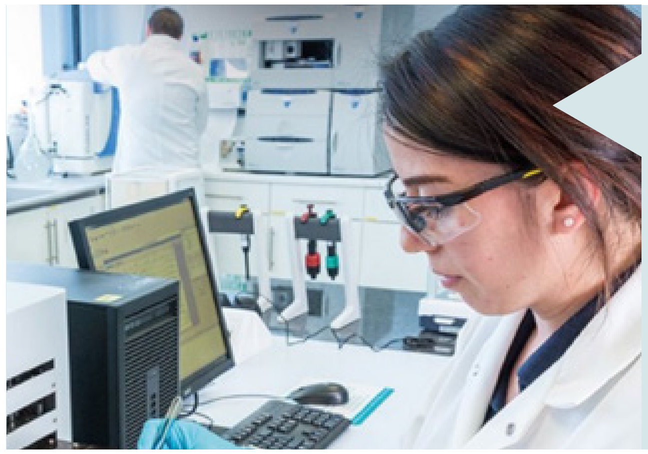
Can be accessed under NNUF arrangements for universities and some other organisations. However, direct contracting with Jacobs for commercially sensitive is also possible.

Other relevant information

The mechanical testing laboratories at Jacobs have been operating and providing nuclear design and safety justification data for more than 50 years.

Contact

Mark Callaghan - mark.callaghan@jacobs.com
Andrew Wisbey - andrew.wisbey@jacobs.com
John Stairmand - john.stairmand@jacobs.com



Organisation
Jacobs Clean Energy

Facility
Equipment and Material Qualification Facilities

Location
Birchwood, Warrington

Summary of capability/facility

Equipment Qualification (EQ) is vital to ensure reliable, predictable operation of safety related systems. Jacobs takes a programmatic approach to ensure that equipment can perform its designated function and safety role on demand, in mild, harsh and accident environments, throughout its operational life. At Birchwood, Jacobs provides the facilities and expertise required.

We offer:

- Qualification of structures, systems and components through a range of testing regimes, either using fixed equipment or bespoke testing programmes and rig build
- In-depth knowledge of selection and qualification of materials and equipment to globally recognised standards
- Testing strategies and programmes - all designed to establish, preserve and upgrade your equipment qualifications
- Expertise in the operation and maintenance of existing plans including consultancy services on seismic assessments, plant walk-downs and maintenance schedules
- Extensive experience of the qualification of EC&I equipment including programmable electronic and SMART instruments in line with SC45a standards.

Instrument specification

Our facilities include:
Thermal ageing ovens
Irradiation ageing facility
Environmental aging and testing
A range of CE testing and CE Notified Body certification

Other testing is also available using existing alliance partners.

Related instrumentation/capabilities

On request

Nuclear material capabilities (i.e. activity limits)

Alliance partners:
www.eqservicesalliance.com

Areas instrument used over last 12 months

Area	% Usage
Waste Management	20
Advanced Nuclear	20
Environmental	10
Other - fission	50
Other (please specify)	
Available/ unused	

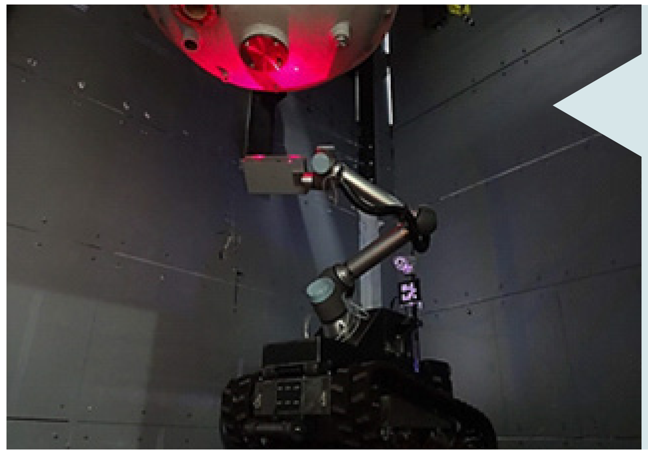
External user access arrangements

Email for details

Other relevant information

Contact

Jessica.gwyther@jacobs.com



Organisation
Jacobs Clean Energy

Facility
Large Scale Rig and Engineering Development Facility, Birchwood

Location
Newton House, Birchwood, Warrington and General Engineering Laboratory, Birchwood Warrington and Building 210 B/C, Birchwood, Warrington

Example project (IIND):

Summary of capability/facility

Multiple facilities providing excellent flexible use space for large scale test rigs, mock-ups, prototyping and robotic trials, supported by highly experienced nuclear specialist multidisciplinary technicians, scientists and engineers with a long pedigree of nuclear R&D.

Newton House Rig Hall
Originally built to conduct liquid sodium thermal hydraulics tests in support of the Fast Reactor project, Newton House High Bay operates as a general-purpose rig hall. At any one time there is a diverse collection of semi-temporary test rigs. It is equipped with a deep pit and large shutter doors at each end of the rig hall. Most of the floor space can be reached with an overhead crane.

The General Engineering Lab (GEL)
GEL comprises several low elevation (7m) lab spaces, and a large height test space (17.5m).

Building 210 B/C
Specialist rigs and robotic testing facilities along with a testing ground for remotely operating equipment and vehicles.

Instrument specification

Newton House has:
A rig hall with (40mx17.5m) floor space.
17m/23m tall high bay.
A pit below floor level (3m*5m*3m+).
5 tonne overhead crane facility that covers all of the floor space.
Compressed air ring main and low capacity cooling water
415V power supplies power rating 576kW
Separate mess and shower facilities.
Smaller additional construction and workshop spaces

The General Engineering Lab has:
A rig hall with (21mx24m) floor space.
A 20m tall high bay.
A 6.5m deep pit.
2 tonne overhead crane facility that covers all of the floor space.
Compressed air ring main
415V power supplies power rating 288kW
Additional low headroom laboratories

Related instrumentation/capabilities

See the Instrument Specification section.

Nuclear material capabilities (i.e. activity limits)

Glove boxes for specific applications.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	25
Advanced Nuclear	25
Environmental	
Other (please specify) - robotics	40
Other (please specify) - fusion	10
Available/ unused	

External user access arrangements

By email request to above contacts.

Other relevant information

Use is flexible, therefore please contact Jacobs to discuss.

Contact

mike.bradshaw@jacobs.com
colin.wilson@jacobs.com

Organisation
Lucideon Ltd

Facility
Field Enhanced Sintering

Location
Queens Road, Stoke-on-Trent, Staffordshire

Summary of capability/facility

Flash Sintering is the application of an electric field to a ceramic material during the sintering process using either direct contact or contactless electrodes.

Flash Sintering reduces the processing time and furnace temperatures from those required by conventional sintering, increasing throughput and reducing energy consumption and cost. It also enables a high degree of microstructural control, which can influence the performance of ceramic components. Furthermore, early evidence suggests that Flash Sintering can be effective for improving certain properties, including mechanical performance.

Lucideon are experts in Flash Sintering. This is the only facility in the world to have the capability for Flash Sintering technology development and demonstration at manufacturing scale. We are innovating and commercialising this technology for many sectors including for the production of nuclear fuels, solid-state battery components / thin films and joining dissimilar materials.

Instrument specification

All instrumentation is bespoke & proprietary, designed by Lucideon for the development of the technology to a given application. Key instrumentation includes:

- Proprietary Non-linear real time Flash Sintering control software
- Flash Sintering hardware including furnaces and electrode interfaces
- Real time control PC and robotics
- Range of technologies for different applications: Contact Flash Sintering, Contactless, and Cold Flash Hybrid

Nuclear material capabilities (i.e. activity limits)

Radioactive materials trials undertaken at partner facilities

Related instrumentation/capabilities

- Advanced Ceramics development & pilot line facility - including forming technologies, drying, powder handling and sintering
- Analytical and testing facilities

Areas instrument used over last 12 months

Area	% Usage
Waste Management	30%
Environmental (batteries)	30%
Advanced Nuclear Fuels	30%
Other (advanced ceramics)	10%

External user access arrangements

Collaborative R&D projects with industrial and academic partners.

Other relevant information

Development and trials undertaken for advanced nuclear fuels applications in collaboration with National Nuclear Laboratory and University of Manchester, under the BEIS funded Advanced Fuels Cycle Programme.

Contact

Tim Abbott
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+44 (0) 7800 570 372

Organisation
Lucideon Ltd

Facility
Geopolymer Encapsulation

Location
Queens Road, Stoke-on-Trent, Staffordshire

Summary of capability/facility

Lucideon's proprietary technology is a flexible inorganic alumino silicate encapsulant developed to address the UK's and global problematic waste streams of low and intermediate level wastes including oils, sludges, and solids.

Geopolymer will rival the current use of Portland cement-based (OPC) encapsulation and Lucideon's research activities (including working with an engineering scale up partner) are currently focussed on developing and trialling geopolymer formulations for the encapsulation of problematic wastes.

Variations in geopolymer composition are used when the function is changed, and different material properties are desired. Nevertheless, the properties typically include high encapsulation efficiency, high compressive strength, high chemical resistance, fire resistance and a formulation controlled variable setting time.

Lucideon has many years of experience developing novel geopolymer formulations for construction and nuclear waste applications, with pilot scale demonstration capability and partnerships for larger scale demonstration and deployment.

Instrument specification

- Inorganic alumino silicate polymer material with the capacity to encapsulate problematic nuclear wastes
- A range of geopolymer formulations are utilised for varying wastes streams
- Facilities for formulation development and pilot plant technology demonstations

Nuclear material capabilities (i.e. activity limits)

- Oils, Sludges & Solid waste simulants (Non active samples with the goal of active trials through partner facilities)

Related instrumentation/capabilities

- Analytical and testing facilities
- Geopolymer formulations for various other applications (shielding/construction/heat resistance)

External user access arrangements

Collaborative R&D projects with academic and industrial partners.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	80%
Advanced Nuclear	
Environmental	20%
Other (please specify)	
Available/ unused	

Other relevant information

- Recent development of Lucideon's geopolymer for waste encapsulation has been part funded by UKRI
- Lucideon is engaged with industrial partners and NDA facilities to bring geopolymer technology to market

Contact

Tim Abbott
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+44 (0) 7800 570 372

Organisation
Moltex Energy Ltd

Facility
Moltex Laboratory

Location
Birchwood Park, Warrington, UK

Summary of capability/facility

Moltex Energy is developing a high temperature, low cost, low pressure nuclear reactor technology to help fight climate change and address energy poverty by providing economical power worldwide. This is made possible by the use of molten salts as both fuel and coolant.

Two frequent questions we are asked:
1. Aren't salts corrosive?
2. How do you deal with hazardous lithium and beryllium?

In our laboratory we are proving how the chemistry design will manage corrosion using salts that exclude lithium and beryllium.

The company's ambition is to rapidly develop its molten salt technology, and the laboratory supports this with a culture of incremental development of experiments and rapid learning cycles.

We have capabilities In-house for corrosion trials, thermophysical properties, precision inspection, and bespoke flow-loop rigs. We work with partners to corroborate results and are quickly refining our chemistry to demonstrate compatibility of our materials and thermohydraulics.

Instrument specification

Laboratory equipment includes:
- High temperature rheometer – MCR 302e Modular Compact Rheometer coupled with CDT1000 Furnace
- Gloveboxes – Mbraun Labstar
- High Temperature Ovens – SNOL 22/1100
- STA (TGA/DSC) – Hitachi NEXTA STA

Related instrumentation/capabilities

Nuclear material capabilities (i.e. activity limits)

Moltex perform experiments using natural and depleted uranium as fuel surrogates to develop fuel formulation and to test materials compatibility with other reactor materials.
There are three working areas for radioactive materials enabling safe working spaces both in air and inert gas environments.

External user access arrangements

Visitors are provided with protective eyewear when touring the laboratory and will be escorted by one of the materials and chemistry team. Visitor tours include demonstrations of the molten salt in action, high temperature materials testing oven, and corrosion trial coupons.

Contact Hilary Howarth or Chloe Fletcher for further information.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	100
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

Other relevant information

www.moltexenergy.com
Linkedin - Moltex Energy
Twitter - @MoltexEnergy

Contact

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Chemist
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Organisation
National College for Nuclear

Facility
National College for Nuclear providing skills and education for the nuclear and net zero energy sector

Location
NCfN at Lakes College Campus in Cumbria

NCfN at Bridgwater and Taunton College in Somerset

Approved providers: Please see our website for the most up to date list of approved providers.

Summary of capability/facility

The National College for Nuclear NCfN was established by Government to work with employers in the nuclear industry to create a pipeline of skilled talent to reduce skills shortages and build capability in scarce fields. The NCfN is therefore guided by the needs of nuclear employers.

The National College for Nuclear is not one particular facility. There are physical NCfN colleges in the north west located on the Lakes College campus in Cumbria, and in the south west at Bridgwater and Taunton College campus in Somerset. In addition, the NCfN delivers training, short courses, and qualifications through an approved provider network of HE/FE colleges. Our Approved Providers undertake a vigorous approval process to ensure that content and delivery methods meet our exacting standards.

Our qualifications contain up to 20% nuclear context with the other 80% being core underpinning skills and knowledge. This creates a workforce that is 'work ready' when they enter employment, as they understand the context of their qualifications, and how to apply their knowledge.

Instrument specification

Through our NCfN colleges and approved provider network, we have multiple instruments that are primarily used in skills and education provision such as VR suites, robotic arms, flow loop simulators and industrial mock-up rigs etc. Some of these can be made available for external use if available.

Related instrumentation/capabilities

Our main capabilities are focused on developing skills pipelines and generating capability for the nuclear industry through the provision primarily of STEM qualifications. That said, our portfolio expands to meet the evolving needs of industry, whether that is in the development of new curricula or through innovative training/education delivery.

Nuclear material capabilities (i.e. activity limits)

Non-active

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Op Reactors	
Other (please specify)	
Available/ unused	

External user access arrangements

External users may be able to access our facilities and instrumentation by prior arrangement and may be subject to safety, security or safeguarding rules and regulations for the specific facility or instrumentation.

Other relevant information

For all other up to date information, please go to the NCfN website at: www.ncfn.ac.uk

Contact

For more information, please visit the website National College for Nuclear or make any enquiries to: enquiries@ncfn.ac.uk

Organisation
National College for Nuclear

Facility
Online Catalogue of simulation facilites

Location
www.ncfn.ac.uk

UK based facilities

Summary of capability/facility

The National College for Nuclear (NCfN) has produced an online catalogue of simulation facilities for the nuclear sector. The aim of the catalogue is to showcase available facilities across the UK which may be of interest both to Employers and Providers. The catalogue is free to access through the NCfN website.

The catalogue is fully searchable and includes categories such as Design Engineering, Flow Loop Simulation, Aquatic testing, Reactor Ops, Virtual Reality, Remote Handling etc.

The capabilities addressed include Construction, Control systems, Electrical, Instrumentation, Lifting, Maintenance, Mechanicals and Operations. All of these are operated within the scope of nuclear operations and nuclear professional behaviours.

The website is not definitive and other facilities may become available as the catalogue grows and develops over time.

For specific needs NCfN will facilitate search and access to suitable facilities and operational capabilities.

Instrument specification

Examples include:

- Aquatic Test Facility - Deep recovery simulation and wet test focused to support ROVs;
- Flow Loop Simulators - enhanced control systems training;
- Glove Box Simulator - National Alpha Radiation facility - full post-in and post-out facilities

Related instrumentation/capabilities

The facilities cover the UK Regions - the database is searchable in this area.

Nuclear material capabilities (i.e. activity limits)

Nuclear material capabilities are based on facility local rules and environmental and regulatory licences and permits. Each facility will be able to provide full details on enquiry.

Areas instrument used over last 12 months

The percentages shown are indicative of overall activity for a range of facilities across the UK.

Area	% Usage
Waste Management	15
Advanced Nuclear	15
Environmental	5
Education	30
Training	30
Available/ unused	5

External user access arrangements

The online catalogue gives key contact and access arrangements. Access is predicated on scheduling around employer operational demands.

Other relevant information

NCfN listed facilities are primarily utilised for educational and training purposes. However, every enquiry is welcome for consideration.

Contact

enquiries@ncfn.ac.uk

Organisation
UK National Ion Beam Centre (UKNIBC)

Facility
Surrey Ion Beam Centre

Location
University of Surrey Ion Beam Centre, Guildford, Surrey, GU2 7XH

Summary of capability/facility

The University of Surrey houses the lead site of the EPSRC sponsored UK National Ion Beam Centre. It is the largest ion beam facility in the UK, housing 3 accelerators and 2 bespoke single ion implanters and 2 additional FIBs. The accelerators are used for irradiation and implantation studies as well as the analysis of materials with advanced ion beam analysis capabilities. The centre has a long track record, providing ion beam services to UK academia and industry since 1978. More than 40 University groups and over 40 companies both within the UK and internationally use the facilities at Surrey.

The Surrey Facility is the lead site for the Quality Assurance program with the EU project, RADIATE, which provide ion beam facilities across Europe via 17 ion beam labs.

Instrument specification

Surrey houses three accelerators, a 2MV HVEE tandem used for advanced ion beam analysis (RBS, ERD, PIXE, PIGE, NRA, MeV-SIMS etc.); a 2MV van de Graaff implanter and a 200keV DanFysik implanter. Irradiations can be made hot (<700C) or cold (>10K) and with energies from 2keV up to 4MeV (some heavy ions up to 10MeV). Sample size can be mm2 up to 40cmx40cm. Beam currents up to 10mA.

See more detailed descriptions of our facilities at http://www.ukNibc.co.uk/SIBC/Implant.php

Related instrumentation/capabilities

Two Focussed Ion Beam instruments can be used for sample preparation, alongside SEM, TEM, Raman etc facilities for observation. Rapid Thermal Processing equipment is also available for use.

Nuclear material capabilities (i.e. activity limits)

Non-active.

External user access arrangements

There are five mechanisms through which users can gain access:

- Commercial. The user pays for usage. Contact Luke Antwis above for a quote
- New EPSRC Application. UKNIBC facilities can be requested as part of a conventional EPSRC grant application. We provide a form to go with your Case for Support. Contact Luke Antwis above for the form
- EPSRC Students. EPSRC funded students can access the UKNIBC for access for small training projects
- Pump Priming. A proportion (10%) of UKNIBC time is earmarked for new projects that have no current EPSRC support, but where a limited amount of time is expected to generate results which can be used in new bids for funding
- For EU (non UK) users it is possible to apply for time through the RADIATE project. Details on how to do this can be obtained from https://www.ionbeamcenters.eu/

Areas instrument used over last 12 months

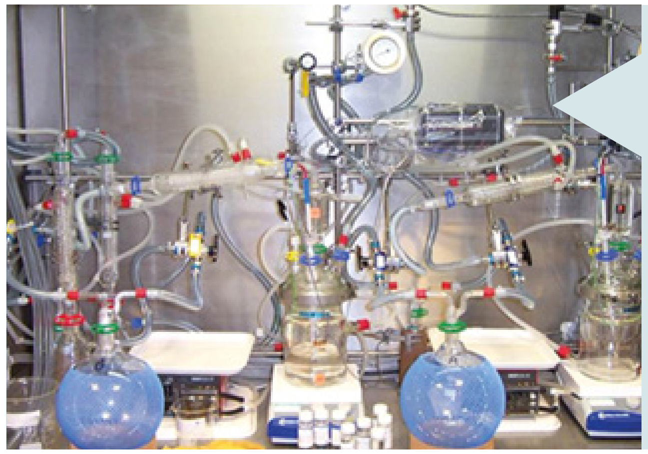
Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	Implantation 70%
Other (please specify)	Analysis 30%
Available/ unused	

Other relevant information

The UKNIBC is an EPSRC sponsored consortium of three University facilities housed at Surrey, Manchester and Huddersfield Universities.
See https://uknibc.co.uk for more information.

Contact

Email: Luke.Antwis@surrey.ac.uk
Tel: +44 (0) 1483 689 145
Mob: +44 (0) 7920 097 195



Organisation
National Nuclear Laboratory

Facility
Inactive Laboratory Simulant Preparation Facility

Location
NNL Central Laboratory Facility, Sellafield Site, Cumbria, CA20 1PG

Summary of capability/facility

The Effluents, HALES and Environmental Chemistry Team, with particular expertise in the behaviour of nitric acid based Highly Active Liquor (HAL), is primarily based in the NNL Central Laboratory on the Sellafield site. The team which consists of predominantly chemists, undertakes a full range of work from desk-based studies to hands-on practical inactive laboratory work which includes running small scale rigs that mimic Highly Active Liquor Evaporation that occurs on the Sellafield Site.

We have a core capability that can be applied to the treatment of complex liquors with varying solids content. This includes development and provision of inactive simulants representative of complex HAL and development of Post Operational Clean Out (POCO) strategies such as the POCO strategy for the Highly Active Storage Tanks (HASTs) which will involve the use of reagents to dissolve the solids within the tanks. We also have laboratory based equipment and techniques. Such as yield stress, solid settling and density in place to characterise simulants produced.

Instrument specification

Inactive laboratory facilities including:

- 4 litre simulant preparation facility
- Small scale reduced pressure experimental evaporator rig (see photo above)
- Kinexus Pro+ rheometer
- Long term storage of samples at temperatures up to 50 °C
- Metrohm Ti-Touch auto-titrator

Skills:

- Development and provision of (inactive) simulants representative of complex HAL, with the facility to provide up to 4 litre batches for experimental work
- Advise large scale simulant manufacturers on how to provide representative liquors, at the m^3 scale, for use on development rigs. This can include advice on how to simplify simulants for large scale rigs without affecting the validity of the simulant
- Analysis and interpretation of liquor/solids properties such as yield stress, particle size, solids settling, density and elemental analysis, including support to modelling work carried out by other teams via the provision of empirical data
- Consideration of the effect of radiation and active environments on the results of inactive experiments and assessments, with regular collaboration with relevant experts inside and outside of NNL to assess the impact and carry out confirmatory active experiments where required

Nuclear material capabilities (i.e. activity limits)

Inactive laboratory work

Related instrumentation/capabilities

In addition to the Kinexus rheometer mentioned above, we also have access to simpler characterisation techniques such as acidity analysis and density measurement (within the team) and Scanning Electron Microscopy SEM and ICP-OES within the facility.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Available/ unused	

External user access arrangements

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Other relevant information

Closely aligned with NNL Vitrification team and their capabilities and project activities.

Contact

Steven Thomson
steven.thomson@uknnl.com

NNL Engagement Team
engagement@uknnl.com

Organisation
National Nuclear Laboratory

Facility
Materials and Corrosion

Location
Sellafield Site & Bristol

Summary of capability/facility

NNL's Materials and Corrosion group contains a number of uniquely experienced professional radiochemists, metallurgists, physicists, materials and corrosion scientists, whose expertise spans a wide range of areas in materials, reactor/plant chemistry and corrosion, and the group supports strategic programmes for both the civil and naval fleets, as well as provide advice on strategic UK issues.

The Materials and Corrosion group have provided support on both chemistry and materials issues to the Office for Nuclear Regulation (ONR) for the Generic Design Assessment process for the approval of new reactor designs. For current reactors, both civil and naval, the team provides support to our customers in areas such as reactor chemistry (graphite and coolant), plant chemistry (storage ponds and associated plant) & the effect of irradiation on materials (including embrittlement of ferritic steels, radiolytic oxidation of graphite and oxidation of Zr alloys).

Part of the group focus is to develop and maintain knowledge databases on specific technical topics such as embrittlement of reactor pressure vessel, iodine chemistry and dry storage of spent fuel. The team has access to unique facilities and expertise both within our organisations and within NNL's wider network.

Instrument specification

A wide variety of investigative techniques are used and the team of technicians are both scientifically qualified and expert at remote handling. The work undertaken in the labs consists of routine monitoring of nuclear fuel and reactor components, extended performance trials of 'standard fuel', experiments involving non-standard fuel or non-standard operating conditions and trouble-shooting unforeseen problems, including failures.

A variety of destructive and non-destructive techniques are available: Mensuration/ metrology, X-radiography, Gamma scanning, eddy-current and ultrasonic flaw detection, leak testing, fission gas pressure, volume & sampling, internal stress, Deposit/oxide thickness & morphology, Youngs modulus, thermal expansion & diffusivity, mechanical testing - tensile, compression, 3-point bend, impact testing, fracture toughness, gas-diffusivity, open pore volume, isotope assay, gas mass spectroscopy, fluorescence spectroscopy, corrosion rate, stress rupture, density, weight loss, differential oxidation, hot-vacuum extraction, optical microscopy, electron microscopy & various associated analyses.

Nuclear material capabilities (i.e. activity limits)

The group operate in low and high active operational areas (fumehoods at central and high active caves at Windscale) to undertake a 'forensic' type investigation & analysis of a wide variety of fuel types, irradiated components and radioactive contaminated plant.

Related instrumentation/capabilities

Fuel PIE Laboratory, Post-Irradiation Examination of Civil Nuclear Fuel, and Graphite Technology and PIE.

External user access arrangements

Many of the techniques used are difficult to access for external users e.g. they were customer funded or are in almost constant use for customer work. Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Other relevant information

The Materials and Corrosion group can draw from expertise held in other areas of the business, as well as a number of external resources. Members of the group hold visiting researcher/professor status, supervise PhD's and/or have access to experimental facilities at universities in Oxford, Bristol, Manchester, London, Birmingham, Liverpool, Glasgow, Leeds, Lancashire, Southampton and Swansea, and the international facilities that NNL regularly access include the Diamond Light Source (Harwell, UK) and the European Synchrotron Radiation Facility (Grenoble, France).

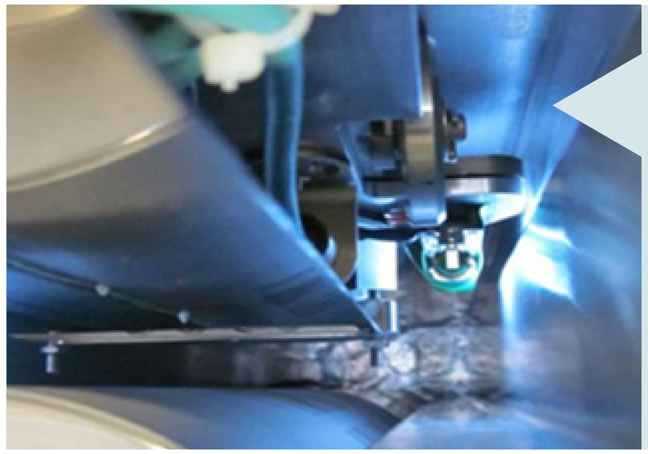
Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Available/ unused	

Contact

Sarah Harris
sarah.harris@uknnl.com

NNL Engagement Team
engagement@uknnl.com



Organisation
National Nuclear Laboratory

Facility
Measurement & Analysis: Instrumentation and In-situ Analysis

Location
NNL Central Laboratory Facility, Sellafield Site, Cumbria, CA20 1PG

Summary of capability/facility

The M&A-Instrumentation capability develops novel in-situ physical and radiometric instruments.

- On-line automatic chemical analysis is essential for near real-time process control and effluent monitoring. M&A-I has developed more than 30 process analysers for the Sellafield reprocessing plants using techniques ranging from spectro-photometry and electrochemistry to X-ray and laser-induced fluorescence
- M&A-I has developed instrumentation for physical metrology ranging from conventional techniques such as displacement, temperature, pressure, humidity and liquid level to the use of eddy currents for reading engraved barcodes inside sealed metal canisters. We also have practical experience with on-line radiometric techniques such as gamma spectroscopy
- M&A-I has used sophisticated visual image processing for a variety of unusual measurements including crystallisation temperature, meniscus tracking, leak detection and physical dimensions. We have been particularly successful with smart cameras for reading barcodes at distance and through shield windows where conventional laser readers are ineffective. We also have experience with networked surveillance cameras and digital video recording

Instrument specification

Equipment: SMART Cameras, Gamma Detector, Gas Mass spectrometer, Development PC's and Eddy Current Test Rig

The M&A-I bespoke software capability supports our instrumentation products as these typically require both control and data logging features. Our instruments are often used in safety related applications and our procedures have been assessed for compliance with BS EN 61508. We also create specialist scientific calculation and data logging software for laboratory trials. Expertise covers several languages including Pascal, C, C++, Microsoft C# and Visual Basic for the .NET framework.

Hardware Controllers

- We have a design and build capability for bench-top or rack-mounted hardware and/or software controllers aimed primarily at small to medium-scale laboratory experiments

Nuclear material capabilities (i.e. activity limits)

We are able to analyse a wide range of materials from the entire fuel cycle from high active to intermediate and low levels materials.

Related instrumentation/capabilities

Capability ties in with M&A Laboratory capability.

External user access arrangements

Hands in Pocket but looking to extend to full access in some areas for non-NNL scientists.

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Areas instrument used over last 12 months

M&A-I has the capacity to undertake further significant programme of instrument and software development programmes. Albeit this would require recruitment of new hardware and software engineers.

Other relevant information

As part of commissioning the active facilities at NNL-Central Laboratory the M&A instrumentation programme is developing a range of analytical instruments with Sellafield Ltd capable of non-destructive measurements in high active environments.

Contact

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NNL Engagement Team
engagement@uknnl.com

Organisation
National Nuclear Laboratory

Facility
Measurement & Analysis Laboratory

Location
NNL Central Laboratory Facility, Sellafield Site, Cumbria, CA20 1PG
NNL Preston Laboratory Facility, Preston, PR4 0XJ

Summary of capability/facility

The NNL Measurement and Analysis capability undertakes routine analysis of active materials as well as undertaking R&D activities concerned with new analytical techniques and instrumentation. Measurement and Analysis has two laboratories at Sellafield Site (M&A-Central Laboratory CL) and Springfield Site (M&A-Preston Laboratory PL).

- M&A -CL is R&D analysis laboratory undertakes longer term research projects to develop analytical methods and instrumentation to undertake complex measurements for UK civil and defence programmes. The Laboratory is undertaking a major refurbishment to bring into operation state of the art high active and glovebox capability.
- M&A -PL is an ISO 17025 accredited analysis and characterisation laboratory that undertakes routine analysis of a wide range of active materials. The laboratory provides UKAS accredited radiochemical, physical and chemical data to UK civil and defence customers

M&A-PL and CL also have the capability to perform immobilisation, decontamination and process chemistry studies to determine waste package performance.

- Isotopic analysis of a wide range of radionuclides

Instrument specification

Skills: Analytical Science, Active Laboratory Operations (glovebox and fumehood), Safety SQEP, Waste Management, Classified Workers, DV Clearance, Internal Project Management.

Facilities: Active Facilities (Alpha boxes, gloveboxes, shielded fumehoods, scrubbed fumehoods).

Related instrumentation/capabilities

- Radioanalytical capability - Alpha, Beta and gamma analysis
- Chemical Analysis - ICP-MS / OES, mc-ICPMS, Ion chromatography, TIC TOC, CHONS
- Physical Analysis - particle size, rheology, density and viscosity
- Transport packages for active materials

Nuclear material capabilities (i.e. activity limits)

We are able to analyse a wide range of materials from the entire fuel cycle from high active to intermediate and low levels materials.

Areas instrument used over last 12 months

At both M&A-CL and M&A-PL there is capacity to undertake further significant programme of analytical and characterisation work. Albeit this would require recruitment of new analytical scientists and operators.

External user access arrangements

Hands in Pocket but looking to extend to full access in some areas for non-NNL scientists.

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Other relevant information

Following the commissioning of the active facilities at NNL-Central Laboratory the M&A capability will take responsibility for delivering the analytical service on Sellafield Site and will become the largest radioanalytical provider in the UK.

Contact

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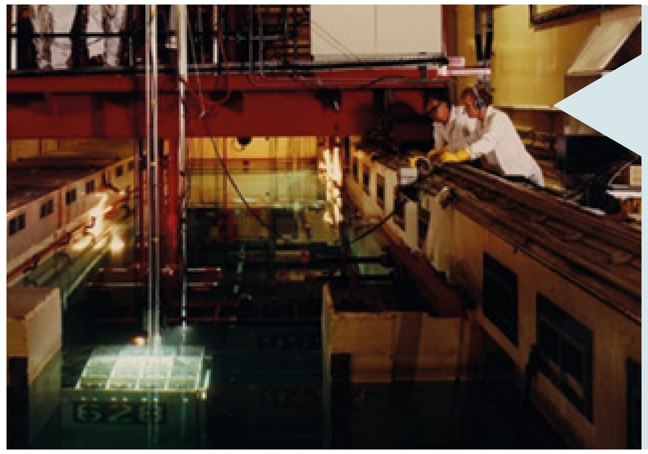
NNL Engagement Team
engagement@uknnl.com



Organisation
National Nuclear Laboratory

Facility
Underwater Post-Irradiation Examination

Location
Mobile Endoscope Capability for Monitoring Fission Reactors and Fuel in Ponds

Summary of capability/facility

Underwater PIE is primarily provided by the Endoscopy team surveying in-pond fuel for damage and deposition at the UK's Advanced Gas-cooled Reactor power stations. This provides the reactor operator with a large volume of data to assure safe operation of fuel. The data are used primarily for monitoring of carbonaceous deposition on fuel pins, although some other aspects of fuel performance are also considered. This capability is particularly important as it allows fuel to be examined soon after removal from the reactor, yielding a large quantity of information in a timely manner.

NNL are developing an underwater PIE capability, using tablet computers for in-situ digital data acquisition and machine learning to aid image assessment.

Instrument specification

A system of a remotely operated endoscope, lighting equipment and custom cameras provides visual inspection of fuel surfaces. The thickness of surface deposits can be measured to a precision of tens of microns; imagery also permits examination of deposit morphology, and other aspects of fuel condition.

Development of further PIE techniques for underwater deployment are under consideration with a view of utilising the underwater test tank managed by NNL's NNUF-HR facility in Workington.

Related instrumentation/capabilities

Active Handling Facility Fuel PIE Laboratory, Post-Irradiation Examination of Civil Nuclear Fuel, and Graphite Technology and PIE.

Nuclear material capabilities (i.e. activity limits)

Highly Active.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Available/ unused	

External user access arrangements

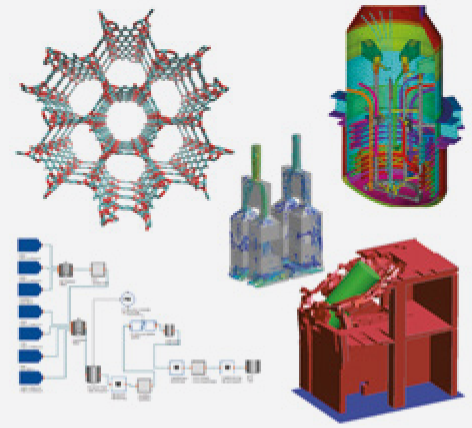
Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Other relevant information

Contact

Hayley Stoddart
Hayley.Stoddart@uknnl.com

Henry Preston
Henry.preston@uknnl.com



Organisation
National Nuclear Laboratory

Facility
Modelling and Simulation Capability
- Thermal and Structural Modelling
- Chemical and Process Modelling

Location
NNL Chadwick House Facility, Warrington, WA3 6AE
NNL Central Laboratory Facility, Sellafield Site, Cumbria, CA20 1PG

Summary of capability/facility

The capability covers the full spectrum of modelling tool sets that support all areas of the nuclear fuel cycle. Allowing for future design, accurate forecasting, optimisation, verification and validation.

The team includes the following modelling capabilities:

Structural and Thermal Modelling
- Computational Fluid dynamics Modelling - analysing different fluid flow regimes
- Finite Element Analysis - Thermal and structural analysis
- Thermal Hydraulics including reactor modelling
- Seismic analysis
- Impact analysis-Modelling package drops etc
- Fracture and Fatigue
- Software development
- Rig validations
- Provides technical support to help develop robotics strategy for decommissioning activities

Chemical and Process Modelling
- Plant process: dynamic modelling; flowsheeting; optimisation
- Thermodynamic and kinetic modelling of solutions and materials.
- Mechanistic materials modelling
- Aqueous speciation modelling
- Software development
- Model validation
- Applied statistics (model parameterisation and validation)

Instrument specification

Specialist software includes:
- ANSYS
- Fieldview
- LS-Dyna
- PATRAN
- Oasys
- MATLAB
- Mathcad
- R (Statistical Package)
- gPROMS, from Process Systems Enterprise
- Aspen Custom Modeller (ACM), from AspenTech
- Aspen Exchanger Design (EDR), from AspenTech
- Materials Studio (Quantum mechanics), from Biovia
- LAMMPS (Molecular dynamics)
- MTDATA (thermodynamics), from Hampton thermodynamics
- Mathematica, from Wolfram Research
- COSSAN (uncertainty quantification), from University of Liverpool
- PHREEQC (aqueous speciation), from US Geological Survey
- Microsoft Visual Studio (software development)
- WIEN2K (Quantum Mechanics)

Facilities:
- High Performance Computing (HPC) facility

Nuclear material capabilities (i.e. activity limits)

Inactive desk-based work

Related instrumentation/capabilities

Decision Science and Operational Research

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

External user access arrangements

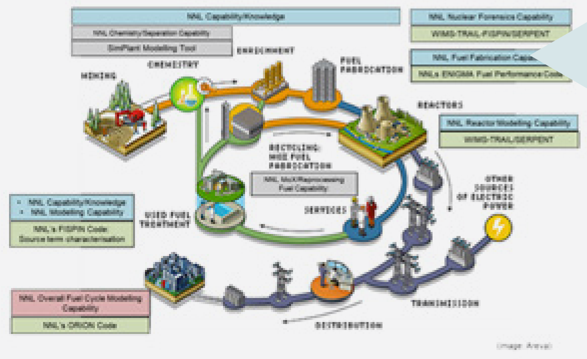
Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Other relevant information

Contact

Saad Malik
Thermal & Structural Modelling
saad.malik@uknnl.com

Jonathan Austin
Chemical & Process Modelling
jonathan.austin@uknnl.com



Organisation
National Nuclear Laboratory

Facility
Nuclear & Reactor Physics Modelling Capability

Location
NNL Chadwick House Facility, Warrington, WA3 6AE
NNL Central Laboratory Facility, Sellafield Site, Cumbria, CA20 1PGNNL
Preston Laboratory Facility, Preston, PR4 0XJ

Summary of capability/facility

The Nuclear and Reactor Physics Team provides the capability to model reactors over the entire nuclear fuel cycle. Members of the team are primarily desk-based modellers all of whom own and understand a component of the overall team capability, overlapping and supporting each other across the following primary capability areas:

- Nuclear Physics
- Reactor Physics
- Fuel Performance
- Nuclear Data.

An understanding of the underlying nuclear physics and underpinning reactor neutronics is a fundamental base upon which the other skills and kNowledge is built upon.

The team use a combination of bespoke and off-the-shelf codes to undertake their work - primarily utilising the ANSWERS code-suite for the majority of its activities.

Activities range from nuclear inventory modelling to supporting current operations, researching future fuels and reactor types for National Programmes.

Instrument specification

ANSWERS Software - including WIMS-TRAIL - Reactor Neutronics Modelling Code

ORION (Fuel Cycle Modelling Tool)

ENIGMA (Fuel Performance Modelling Software)

FISPIN (Reactor Inventory Calculation Software) -

GEANT4 (Particle Physics Framework Modelling Tool)

Nuclear material capabilities (i.e. activity limits)

Inactive desk-based work

Related instrumentation/capabilities

The Nuclear and Reactor Physics Team maintain and operate (on behalf of Lynkeos Technology Ltd) the Lynkeos Muon Imaging System (MIS) which is a fully CE accredited commercial muon-based imaging system for interrogating waste packages (e.g. 500 L drums or larger waste-forms which fit within the 1 m × 1 m × 1 m active imaging area).

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Available/ unused	

External user access arrangements

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Other relevant information

Contact

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NNL Engagement Team
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Organisation
National Nuclear Laboratory

Facility
Plant Inspection and Intervention Capability

Location
NNL Central Laboratory Facility, Sellafield Site, Cumbria, CA20 1PG

Summary of capability/facility

We provide a full range of services including the design, development, test and deployment of purpose built, remotely operable, inspection and intervention systems for use within nuclear production and power plants, and for decommissioning activities.

This capability includes the skills:

- Mechanical systems and equipment design
- Electrical, control and instrumentation design
- Engineering systems and equipment design and development for the intervention and repair of active plant and underwater operations
- Inactive rig design build and trials
- Robotics and remote handling development and consultancy
- Manipulator assessment, development and deployment
- Technical assessments, optioneering and feasibility studies
- Engineering support to active plant

Instrument specification

- Visual and NDT Plant condition monitoring and inspection
- Solid Works Professional 3D Mechanical CAD software
- AutoCAD 2D E,C&I CAD software
- AMTECH Electrical Design Software
- 3D Printers
- Mini Laser Scanner

Related instrumentation/capabilities

Hot Robotics Facility - NNL component.

Nuclear material capabilities (i.e. activity limits)

Inactive in Rig Hall - Robotics is designed for use in up to highly radioactive areas.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

External user access arrangements

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Other relevant information

Please contact David Thomson for Case Studies associated with this area.

Contact

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Organisation
National Nuclear Laboratory

Facility
Post Irradiation Examination (PIE) of Civil Nuclear Fuel

Location
NNL Windscale Laboratory, Sellafield, Cumbria, CA20 1PG

Summary of capability/facility

The Windscale Active Handling Facility (AHF) consists of thirteen heavily shielded hot cells, each with five separate lead-glass or zinc-bromide shielded workstations. The PIE facilities are supplemented by a number of fumehoods, open labs and decontamination facility.

Generally, each workstation has two manipulators. These cells are approximately 11 metres in length and contain a variety of analysis equipment for performing routine PIE, one off experiments and processing waste materials.

Many of the cells have a designated PIE purpose, ranging from dismantling of a complete AGR fuel assembly, examination of irradiated graphite, visual inspection of fuel elements, analysis of single fuel pins, small sample preparation for optical and electron microscopy.

In addtion, a dedicated metallographic hot cell, containing a full suite of Struers metallographic prepartion equipment, provides samples for optical microscopy, laser raman and micro hardness testing of high active materials. Many of these capabilities are tested at the non-active Workington lab facility.

The majority of the equipment used is heavily modified for use or custom-designed with some equipment available courtesy of HRI.

Instrument specification

Import/export of top loading flasks - over ten flasks per year are received into the facility, with a total throughput of tens of AGR elements.

Smaller packages can also be received into the plant through a secondary route (e.g. packages containing graphite samples trepanned from AGR stations).

Import/Export Cell - a dedicated import/export cell permits larger items of equipment, or small samples of material, such as irradiated steels, to be moved into and out of the cave through a gamma interlock system.

Frequent entry cave - one of the caves has been adapted to allow more: frequent man-entry for servicing of installed equipment - ideal for microscopy and thermal analysis techniques.

Many of the caves are setup for specific purposes including

- A cave dedicated to receipt and temporary storage of fuel from top loading flasks - in preparation for PIE and other activities
- Re-packaging of fuel (e.g. welding of fuel that has been cut for metallography) ready for disposal
- Element breakdown - a cave dedicated to removing graphite sleeves from AGR elements, and removal of fuel pins.
- Metallography - preparation, microscopy
- Upright optical microscope with three Raman lasers and a microhardness HV tester (Vickers)
- 532nm, 660nm and 782nm lasers
- Reflected light, polarised light capability
- Deben in-situ 5kN tensile compression and horizontal bending stage (small scale)
- Glovebox Raman 514 and 785nm lasers
- Fumehood Raman 514, 633, 785nm lasers
- Graphite PIE (see separate section)
- Fuel PIE (see separate section)
- A cave dedicated to import/export from the caveline.
- Experimental facilities for examination spent fuel - drying, corrosion, leak testing etc

Related instrumentation/capabilities

See Fuel PIE Laboratory and Graphite Technology & PIE and Electron Optics Capability.

Nuclear material capabilities (i.e. activity limits)

Highly Active.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Available/ unused	

External user access arrangements

Access to AHF/hot cells is covered under the Researcher Study Agreement for Central Lab, recently extended to include AHF. Formal arrangements for academic access are similar to those in place for NNL Central Laboratory.

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Other relevant information

NNL sits a number of external advisory panels in this area including the HOTLAB steering group (worldwide member organisation for hot cell laboratory facilities) and acts as technical consultant to IAEA within a range of PIE related areas.

Contact

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NNL Engagement Team
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Organisation

National Nuclear Laboratory

Facility

Robotics (excludes NNUF-HR)

Location

NNL Workington Laboratory, Cumbria, CA14 3YQ

NNL Preston Laboratory Facility, Preston, PR4 0XJ

NNL Chadwick House Facility, Warrington, WA3 6AE

Image: © National Nuclear Laboratory

Summary of capability/facility

NNL's facility comprises equipment and flexible floorspace to develop, test, and demonstrate robotic and artificial intelligence solutions for the nuclear industry. We also perform a significant proportion of our Robotics and Artificial Intelligence (RAI) programmes using our digital infrastructure for simulation, Virtual Reality (VR), and software development.

The research test rigs available at the NNL are on both an experimental and industrial scale. We act as a link between the small scale, low Technology Readiness Levels (TRL) (1-4) robotics research, and the full-scale demonstrator facilities to progress technology up to TRL 9.

The NNL have a National Nuclear User Facility for Robotics. This is an EPSRC-funded facility to support UK academia and industry to deliver research in robotics and artificial intelligence for application in extreme and challenging nuclear environments.

In addition, NNL also have the following RAI facilities:

- 6000m² flexible non-active rig hall
- Tailored plant representative mock-ups
- Active semi-autonomous robot / robot laser cutting facility
- Virtual Reality (VR) / Augmented Reality (AR) Suite
- Robotic Simulators
- High Performance Computing Facility
- Digital Developer Environments

Related instrumentation/capabilities

External user access arrangements

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Nuclear material capabilities (i.e. activity limits)

Non-Active.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
ADS	
Other (please specify)	
Available/ unused	

Instrument specification

NNL Workington

- 6000m² flexible non-active rig hall environment with 60 tonne SWL and 8m lift height roof crane with flexible and reconfigurable operating enclosures.
- 6m deep pit for non-active demonstration of pond and silo operations, retrievals, Post Operational Clean Out (POCO) and decommissioning.
- Tailored plant representative mock-ups for the development and testing of remotely deployed devices. All can be reconfigured for:
- Inspection
- Retrievals
- Operations
- POCO
- Decommissioning
- KUKA KR10 and mobile showcase enclosure
- KRC4 Controller
- 5kW infra-red laser
- Plant replica gloveboxes
- Various sizes available ranging from true replicas to wooden mock-ups with Perspex windows

NNL Preston

- Active semi-autonomous robot / robot laser cutting facility
- Industrial KR30 KUKA Robot
- Semi-automated system
- Point cloud data acquisition
- Active hot cell with variable ventilation to align with nuclear facilities/degraded buildings under decommissioning
- Automated tool changing
- Approved Safety Case

NNL Warrington

- VR/AR Suite - HTC Vive (2 of)
- High Performance Computing

Other relevant information

Please consult https://hotrobotics.co.uk for further information.

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Organisation

National Nuclear Laboratory

Facility

Separation Science & Special Nuclear Material Team

Location

NNL Central Laboratory Facility, Sellafield Site, Cumbria, CA20 1PG

Summary of capability/facility

The Separation Science and Special Nuclear Material (SS&SNM) capability contains some of the most fundamental technical areas that have a key role in the National Nuclear Laboratory. The team have a unique expertise and it is important to protect the key skills as they are needed to support the UK's future nuclear programmes as well as continue to support the existing plants on the Sellafield site, though this is gradually diminishing. The SS&SNM Team currently trains and deploys the majority of NNL SNM glove-box operators at NNL Central Laboratory - in addition to the many of the team are SQEP. Our fumehood operators support a wide-range of customer work programmes.

The SS&SNM capability is currently made up of Advanced Fuel Reprocessing, Separation Science and the Can Surveillance Programme. The key capability areas which the team supports are:

- Advanced Fuel Reprocessing: (Flowsheet development) Through National Programmes, EU projects and internal R&D the team is developing advanced fuel reprocessing flowsheets. This includes head end processes, chemical separation, finishing and solvent degradation and clean-up.
- Can Surveillance Programme (Plutonium storage): The team is doing a lot of work under the SPRS and Pu Science programs looking at various issues decontamination. This work has progressed with the Pu can Surveillance project, which involves a number of techniques including thermogravimetric analysis, specific surface area analysis and x-ray diffraction. Similar work is being undertaken for Nuclear Decommissioning Authority (NDA) along with Mixed Oxide (MOX) oxidation studies
- Separation Science (Isotope separations): The team are involved with actinide separations primarily the separation of Am-241 from plutonium for the Space Battery programmes

Related instrumentation/capabilities

External user access arrangements

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Other relevant information

Instrument specification

- X-ray diffraction (XRD)
- Specific Surface Area Analyser (SSA-BET)
- Thermo-balance (TGA)
- TGA- Mass Spectrometer (not yet commissioned)
- Gas Chromatograph
- Metallography / Ceramography capability
- A number of UV/vis spectrometers (glovebox and fumehood)
- Infra-red spectrometer (glovebox)
- Raman (glovebox and fumehood)
- Time Resolved Laser Induced Fluorimeter (currently not working)
- Ion chromatography (fumehood)
- Gas chromatograph (fumehood)
- Auto-titrators (glovebox and fumehood)
- Dissolution apparatus including direct and mediated electrochemical dissolution
- Centrifugal contactor banks (glovebox and fumehood)
- Mini mixer-settlers (glovebox)
- Hotplates for calcining purposes

Nuclear material capabilities (i.e. activity limits)

The team can work with Special Nuclear Material in Alpha-specified gloveboxes and medium active fumehoods.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Available/ unused	

Contact

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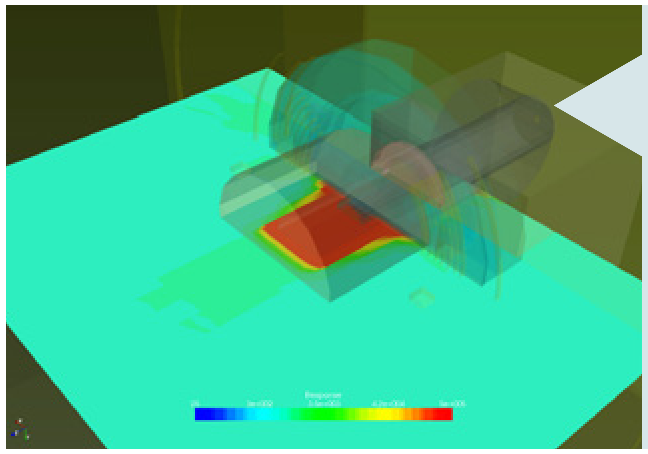

Organisation
National Nuclear Laboratory

Facility
Shielding and Criticality Modelling and Assessment Capability

Location
NNL Central Laboratory Facility, Sellafield Site, Cumbria, CA20 1PG
NNL Chadwick House Facility, Warrington, WA3 6AE

Summary of capability/facility

Criticality Expertise
NNL has extensive experience in producing criticality safety assessments for nuclear facilities and transport packages. Added to this, our team is experienced in hazard identification processes.

They have all the expertise needed to carry out nuclear criticality safety analyses using criticality data handbooks, hand methods of calculation and Monte Carlo techniques.

Shielding
NNL provides quality radiation shielding and dose rate assessments for its own facilities and for both UK and international customers. Our radiation shielding capability has a wide range of applications and covers the complete fuel cycle. This capability is enhanced with the latest nuclear codes capability, with nuclear codes such as MCBEND, MCNP® and ATTILA®, all of which can be run in parallel to aid enhanced quality of service to our customers in shorter timescales. In addition to these complex codes we can offer fit for purpose simplistic hand calculations or simple calculations using MICROSHIELD® and RANKERN for gamma radiation.

In addition, combined with other technical capabilities, such as Criticality, Reactor and Nuclear Physics within NNL, we can offer a complete integrated service. For example, fuel depletion calculations can be carried out in our FISPIN code or ORIGEN which can then feed directly into the above shielding codes.

Our Capability includes:
- Bulk shielding assessments for neutron (spontaneous fission + Alpha n), gamma and capture gamma sources
- Localised (penetration) shielding assessments for neutron (spontaneous fission + Alpha n), gamma and capture gamma sources
- Skyshine calculations
- Radiation protection plans and ALARP assessments
- Classification of areas and dose uptake assessments
- Shielding design basis
- Dose/shielding assessments for transportation of radioactive material in flasks/ships both in the UK and internationally (Japan, USA)
- CIDAS placement assessment
- Emergency planning criticality dose contours
- Source inference calculations (adjoint calculations)

Related instrumentation/capabilities

External user access arrangements

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Instrument specification

- NNL has the capability to produce Criticality Incident Detection (CID) system omission cases and CID system placement assessments. Our assessors provide specialist input into emergency planning work and guidance through out-of-hours plant support and participation in criticality emergency exercises
- Team has access to specialist computational codes, including MONK, MCBEND, RANKERN, MCNP®, ATTILA® and SCALE running on NNL's High Performance Cluster (and standalone machines)

Other relevant information

Nuclear material capabilities (i.e. activity limits)

Inactive desk-based work

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Available/ unused	

Contact

Criticality and Shielding
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Organisation
National Nuclear Laboratory

Facility
Uranium Manufacturing Laboratory

Location
NNL Preston Laboratory Facility, Preston, PR4 0XJ

Summary of capability/facility

The key skills in the Reactor Core Technology Team are fundamentally powder and fuel pellet processing and micro analysis of the associated material. The pellet processing capability involves milling fuel feedstocks of specific customer specifications and then pressing the powder into pellets prior to sintering and analysis to compare to the original customer specification.

The team also has an experimental rig to manufacture novel coated fuel particles and works with universities on national programmes looking at new accident tolerant fuels.

The Scanning Electron Microscope (SEM) capability can analyse materials at the micro-structure level and gather structural and corrosion information together with an EDX detector to determine the elemental composition of a sample.

The establishment of the Nuclear Fuel Centre of Excellence (NFCE) has been funded by the Department for Business, Energy & Industrial Strategy (BEIS) and its predecessors.

Related instrumentation/capabilities

External user access arrangements

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Other relevant information

Instrument specification

- Electric Arc Furnace (Arc Melter) for the production of metallic uranium alloys
- Uranium hexafluoride reaction rig to investigate the fabrication of advanced nuclear fuels, such as silicide and nitrides directly from UF_6
- Coated Particle Fuel Rig (the UK's only capability to make fuel kernels is currently being developed)
- Pelleting Equipment (crusher and mills, pellet presses, sintering furnaces, centreless grinder) housed in inert gloveboxes, which can be used to produce pellets from raw material, such as that produced from the arc melter/UF_6 reaction rig
- Microscope Sample Preparation Facility (mounting and subsequent grinding & polishing of both active and non-active samples from throughout the nuclear industry, including ceramics, metals, cements and grouts)
- Optical and Scanning Electron Microscopes (SEM)
- Laser flash analyser for the measurement of thermal diffusivity and calculation of thermal conductivity

Nuclear material capabilities (i.e. activity limits)

Limited to uranium active materials or Pu surrogates (e.g. Ce).

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

Contact

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Organisation
National Nuclear Laboratory

Facility
Waste Processing Services Capability

Location
NNL Central Laboratory Facility, Sellafield Site, Cumbria, CA20 1PG
NNL Preston Laboratory Facility, Preston, PR4 0XJ
NNL Workington Facility, Cumbria, CA14 3YQ

Summary of capability/facility

The NNL Waste Processing Services capability has the ability to support waste treatment from Very Low Level Waste (VLLW) through to High Level Waste (HLW). This is a combination of real waste treatment or treatment optimisation R&D on behalf of our customers within NNL facilities. The capability area deals with current and future waste arisings at the back end of the fuel cycle.

For example we operate a full scale non-active vitrification facility which supports Sellafield Ltd's active Waste Vitrification Plant, we also deal with a wide variety of uranic waste streams in the NNL Preston Laboratory.

The team has also comissioned and operated a national first active GeoMelt in container vitrification facility and treated real waste in the NNL Central Laboratory on Sellafield site. The expertise gathered from this unique project has placed NNL waste treatment techncial leads in a trusted position as technical advisors for stakeholders such as Sellafield Ltd. and the NDA.

One of the most significant projects which the team leads on at the moment is the active commissioning and operation of a Hot Isostatic Press (HIP) rig. This technology produces an extremely durable ceramic product and will be optimised for production of wasteforms allowing safe disposition of the UK plutonium oxide stockpile.

Instrument specification

Through the use of NNL's active and non-active facilities the Waste Processing Services capability area would apply this successful model to any new waste arisings which result from the fission fuel cycle. As is applied to any current and previous R&D programmes this would focus on creating waste products which minimise environmental impact and tax payer spend.

Related instrumentation/capabilities

CINDe lab at Workington
Environmental Chemistry Laboratory
Cementitious Powder Laboratory
Inactive Simulant Preparation Facility

Nuclear material capabilities (i.e. activity limits)

Inactive, and support for processing active and highly active wastes.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Available/ unused	

External user access arrangements

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Other relevant information

Contact

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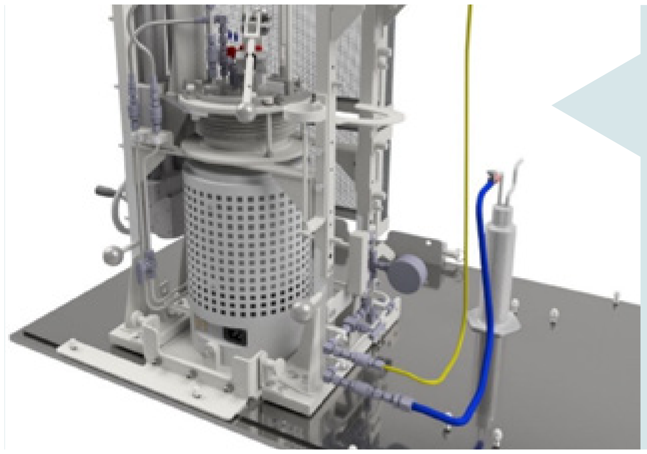

Organisation
National Nuclear Laboratory

Facility
Pyrochemical Alpha-active Processing Apparatus (PAPA)

Location
NNL Central Laboratory Facility, Sellafield Site, Cumbria, CA20 1PG

Summary of capability/facility

This unique facility enables the heating of samples up to 850°C in an inert (argon glovebox) atmosphere and the application of an electrical current through electrodes incorporated in the instrument.

PAPA was specified for experimentation on molten salts, with a particular desire to be able to carry out alpha active experiments. The reaction vessel is glass and can hold around 100g of material with alpha radiation emitting components. The sample chamber (cell) contains electrodes connected to a potentiostat enabling cyclic voltammetry measurements, and a thermocouple for temperature to be recorded.

The design incorporates learning from previous experiments. As such this bespoke design allows the electrodes to be withdrawn at temperature, without compromising the sample or atmosphere, preventing the crystallisation of cooled sample on them. The reaction vessel itself can also be withdrawn from the furnace to allow visual inspection of the cell.

Instrument specification

- Inventory of 100g
- Alpha Active
- Capable of heating up to 850°C +/- 5°C
- Stirred mixing of sample
- 5 ports into the electrochemical cell for:
  1. Working electrode
  2. Counter electrode
  3. Reference electrode
  4. Sampling
  5 thermocouple
- Connected to a potentiostat located externally to the glovebox
- High purity argon feed to electrochemical cell such that oxygen or moisture levels do not exceed 2ppm
- Off-gas scrubbing
- Glass Reaction vessel (allowing cell to be withdrawn from furnace and visual examination of contents

Nuclear material capabilities (i.e. activity limits)

The materials limits are to be within the glovebox radiation dose limits specified in the risk assessment and work requests. The sample vessel capacity is approximately 100g (including salt and alpha material). Pu limits are outlined in the risk assessment for each experiment.

Related instrumentation/capabilities

NNL possess a number of facilities for the preparation and testing of molten salts - these include dry and gloveboxes.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

External user access arrangements

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs

Other relevant information

PAPA is undergoing active commissioning in June 2022

Contact

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Organisation
National Nuclear Laboratory

Facility
Active Handling Facility (AHF)

Location
NNL Windscale Facility, Sellafield Site, Cumbria, CA20 1PG

Summary of capability/facility

AHF is a high activity facility operated by the National Nuclear Laboratory.

The major component of AHF is the hot cells, which are described in the context of Post Irradiation Examination (PIE) of Civil Nuclear Fuel.

In addition to PIE activities, AHF is used as a flexible facility for processing of non-standard items, including fuel pins.

The flexible nature of operations within AHF (rather than a fixed process route) allows, for example, dismantling of damaged fuel; processing of compromised waste forms and re-packaging of material. Materials may vary in size, from large bottles or components to small microscopy samples; and also form, allowing handling of highly active liquors, solids and powders.

The combination of heavily shielded cells, a work-force highly skilled in remote operations, a range of import/export routes, and a relatively large high-active cave space permit a wide range of activities to support both the Sellafield site, and wider UK nuclear requirements.

Example activities include sealed source processing, waste re-packaging and analysis of high-active materials. This is in addition to the fuel and graphite PIE programmes described separately.

Instrument specification

- Repackaging of Highly Active waste (HA), sampling of waste for analysis
- Size reduction of Intermediate Level Waste (ILW)
- Import via top-loading and horizontal flasks
- Inspection of items/high active waste
- Welding of fuel into container

Nuclear material capabilities (i.e. activity limits)

Highly Active.

Related instrumentation/capabilities

Post Irradiation Examination of Civil Nuclear Fuel.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

External user access arrangements

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Other relevant information

Through the Nuclear AMRC's Fit For Nuclear (F4N) programme, which focuses on business systems, we actively engage with the both the nuclear and high-value manufacturing supply-chain network on a regular basis in the form of education and audits to achieve this F4N status.

Contact

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NNL Engagement Team
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Organisation
National Nuclear Laboratory

Facility
Cementitious Powder Laboratories & Full Scale Mixers (Subtractive Manufacturing)

Location
NNL Workington Facility, Cumbria, CA14 3YQ

Image: NNL's newly refurbished wet lab at Workington where lab scale mixes are performed, along with cementitious powder testing

Summary of capability/facility

NNL has extensive knowledge of immobilisation science & technology with some team members having decades of experience in this area. The team offers technical support to the operation and development of encapsulation plants.

Practical work by the team is carried out at Workington in our rig hall and laboratory areas.

Our two laboratories enable us to analyse samples using a wide range of experimental techniques related to cementitious powder testing and the testing of products made from encapsulation trials.

Our full scale mixers are the same as those installed at the Intermediate Level Waste (ILW) plants at Sellafield Ltd Magnox Encapsulation Plant, Wastes Encapsulation Plant, Waste Packaging and Encapsulation Plant and Waste Treatment Complex (MEP, WEP, WPEP and WTC) enabling experimental trials to be undertaken to support this customer. This full scale mixing capability also enables use to support customers such as Radioactive Waste Management (RWM) to assess the properties of potential backfill materials.

We also have the ability to store large amounts of the cementitious powders in dedicated powder storage silos within Workington rig hall.

Our desk based work includes literature reviews, research and report writing.

Instrument specification

- Rheometers
- Compressive strength
- Thermogravimetric analysis
- X-Ray diffraction
- TAM Air Isothermal calorimeter
- Particle size distribution
- Dimensional stability
- Colflow
- Furnace
- Thermal conductivity meter
- Humidity room
- Varying mixer size capability (lab to full scale)
- Cement powder handling
- Powder silos

Nuclear material capabilities (i.e. activity limits)

None, all our work at Workington is non-active.

Related instrumentation/capabilities

CINDe lab at Workington

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

External user access arrangements

The team has hosted external secondees from university and industry within the team.

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Other relevant information

Contact

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NNL Engagement Team
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Organisation
National Nuclear Laboratory

Facility
Cosmic Ray Muon Imaging

Location
NNL Central Laboratory, Sellafield

Summary of capability/facility

Muons, produced in collisions between cosmic rays and the upper atmosphere, are a naturally occurring form of background radiation. Thanks to their mass, charge and high energies, muons can travel through heavily shielded objects and convey information about the object's internal structure.

The Muon Imaging Facility tracks the paths of muons as they pass through an object under inspection. From the trajectory displacement and scattering angle of individual muons a sophisticated analysis technique reconstructs a 3D image of the density distribution of materials contained within the object, with a spatial resolution on the order of a few mm.

Muon imaging provides a new method of non-destructive testing and can produce tomograms of packages which may be too dense or too thick for traditional non-destructive techniques NDT to penetrate. No additional radiation source is required.

The system is available for feasibility trials, extended imaging campaigns, or individual one-off imaging requirements.

Instrument specification

- Four muon tracking modules to measure the trajectories and scattering angles of muons passing through the object under inspection.
- Imaging volume can accommodate packages of sizes up to 1mx1mx1.5m and with a mass of up to 1t.
- Spatial resolution of internal object locations is typically on the order of a few mm.

Nuclear material capabilities (i.e. activity limits)

The system is housed in a R2/C2 controlled area. Please contact us to discuss individual requirements.

Related instrumentation/capabilities

- Feasibility studies using Monte Carlo simulation.
- Bespoke imaging system development, construction and deployment for specific application requirements.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

External user access arrangements

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Other relevant information

Contact

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01946 556684

David Mahon
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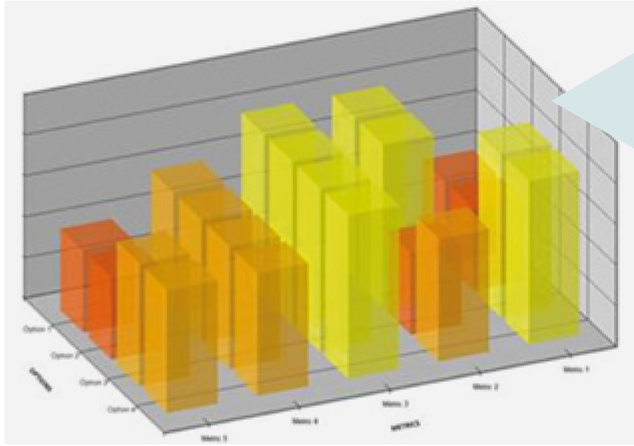
07747 045 700

Engagement
engagement@uknnl.com



Organisation
National Nuclear Laboratory

Facility
Decision Science and Statistics Capability

Location
NNL Central Laboratory Facility, Sellafield Site, Cumbria, CA20 1PG

Summary of capability/facility

The Decision Science team comprises of Statisticians, Operational Research analysts and Software Developers.

The Statisticians support scientists in the design of their experiments; customers with data analysis, modelling and prediction; and decision makers understand the uncertainty in their datasets, or underpin assumptions using probabilistic methods.

The Operational Research analysts undertake facility throughput modelling through digital twin simulation development. They support strategy and roadmap production, problem structuring methodologies, and undertake monte carlo based risk modelling analysis.

The Software Developers provide inventory management solutions, which include software design, development, installation, commissioning, procedure development and documentation. The team also provided a wide range of applications which combine their knowledge of the nuclear industry, offering best practice IT solutions.

The Software Developers are also an integral part of the robotics capability developing Software for robot simulation and robotic control.

Instrument specification

- Proficiency with a number of different statistical packages and software codes, including: R, C++. C#, ROS, SQL, HTML, UNITY and Javascript
- Witness Discrete Event Simulation and Risk Management Software
- KUKA Robotics Simulator Software

Nuclear material capabilities (i.e. activity limits)

Inactive desk-based work

Related instrumentation/capabilities

M+A In-situ Measurement and Analysis Team, NNL Robotics (Software Development), Modelling and Simulation Capability.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

External user access arrangements

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Other relevant information

Contact

Paul Jennings - paul.jennings@uknnl.com
NNL Engagement Team - engagement@uknnl.com

Organisation
National Nuclear Laboratory

Facility
Electron Optics Capability(FEG-SEM, TEM, Ga/Plasma FIB, EDX, WDX, EBSD, EELS, X-Ray Tomography)

Location
Our microscopes are located in radiologically controlled areas on Sellafield Site allowing the preparation and analysis of active materials

Summary of capability/facility

The team offers world class active electron microscopy facilities. A combination of high specification instruments enables detailed correlative microscopy to be performed from bulk scale down to the atomic level.

Using our focused ion beam (FIB) instrument, targeted samples can be produced for transmission electron microscopy or atom probe tomography. With the recent installation of a plasma FIB (PFIB), this capability has been greatly expanded enabling the production of larger sample cross-sections.

A combination of scanning electron microscopes (SEM) with energy & wavelength dispersive X-ray (EDX/WDX) and electron backscatter diffraction detectors (EBSD) enables elemental and orientation mapping. The PFIB also adds secondary ion mass spectroscopy (SIMS) and transmission imaging capabilities.

Our scanning transmission electron microscopy (STEM) offers detailed investigations into lattice expansion, crystallography and grain boundary analysis. Energy electron loss spectroscopy (EELS) enables further elemental quantification, free of anomalies associated with radioactivity. An aberration corrected cold FEG-STEM, planned for installation May 2022, will allow spectroscopic studies on individual atomic columns within a crystal. In addition, a bench top (low active) macro and microhardness test capability is available.

NNL acknowledges the Henry Royce Institute (HRI), and National Nuclear User Facility (NNUF) support for this capability.

Instrument specification

- FEI Helios Nanolab 600i: High specification DualBeam FEG-SEM/FIB. Capable of producing TEM lamella and tips for atom probe tomography. Ion imaging, SE, BSE, EDX and EBSD detectors (NNUF)
- JEOL 2100 LaB6 200 kV (S)TEM: 80 - 200 kV operation. 0.19 nm lattice resolution in TEM mode, ~ 2 nm STEM resolution. Electron diffraction, EDX, EELS, spectrum imaging and EFTEM capability. HAADF, ADF and BF detectors for STEM
- Bruker 1172 SkyScan CT Scanner: Automated 3D X-ray tomography. Sample diameter up to 27 mm (single scan) or 50 nm (offset scan). Details down to 0.65 µm (NNUF)
- Tescan MIRA FEG-SEM: with SE, BSE, EDX, WDX and EBSD detectors (HRI)
- Tescan XEIA3 Plasma FIB-SEM: with EDX, EBSD, STEM detectors and TOF-SIMS (HRI)
- JEOL ARM200CF FEG-STEM Cold FEG probe aberration corrector allowing. 68 pm resolution STEM mode, 0.19 nm TEM mode. Electron diffraction, EDX, EELS, spectrum imaging and EFTEM capability. HAADF, ADF, ABF and BF detectors for STEM (NNUF)
- Low Active Struers Macro and Micro Hardness tester

Nuclear material capabilities (i.e. activity limits)

Samples of irradiated fuel or structural materials up to 50mSv/h Beta/Gamma at 10cm can be accepted. Please contact us to discuss individual requirements.

Related instrumentation/capabilities

These facilities complement the sample preparation capability at NNL Active Handling Facility and materials can be receipted direct from AHF.

External user access arrangements

Our active Electron Optics capability is accessible to external researchers through a variety of modes with the researcher either not present and receiving the results (remote access) or present (i) watching the experiment as it is run by NNL operators (hands in pockets access) or (ii) running the experiment (hands on access) following the required training. Please email phil.ivison@uknnl.com and access.liaison@uknnl.com to discuss access needs.

Areas instrument used over last 12 months

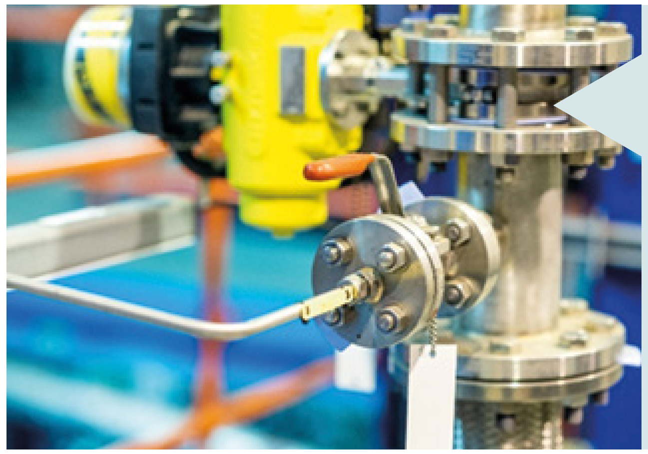
Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

Other relevant information

Contact

Phil Ivison
phil.ivison@uknnl.com

NNL Engagement Team
engagement@uknnl.com



Organisation
National Nuclear Laboratory

Facility
Effluents & Environmental Chemistry Labs and Rigs

Location
The EEC team is based over four sites at Risley, Preston, Sellafield and Workington. The laboratory facilities that the team use are in the Central Laboratory (both active and non-active labs exist) on the Sellafield Site. We also have access to the Rig Hall facilities at NNL's Workington Laboratory, and a newly established active decontamination laboratory on the Springfields Site in Preston.

Summary of capability/facility

The EEC team provides support to several areas of work:
- Innovative Decontamination Techniques
- Pond and Silo Chemistry
- Guidance and training on effluent abatement processes
- Design and operation of Effluent Rigs
- Experimental and modelling assessments on the impact of microbial processes on the long term storage of nuclear waste
- Environmental Radiochemistry Research
- Geochemical, reactive transport and hydrogeological modelling
- HALES Chemistry

In the non-active labs at Central Laboratory we carry out small scale chemistry work alongside the specialist work carried out in our active laboratories. We can use this facility to trial experimental techniques prior to carrying our active experiments, and have a specialist inert box in place for this purpose, inert boxes being a common feature of our active side work.
We also have electrochemical rig testing facilities, for use in decontamination experiments supported in recent years by NNL Innovation programmes but now attracting significant customer interest and support.
Our rig hall at NNL Workington boasts a number of rigs built to mimic particular general aspects of plant (e.g. pipe runs and lute lines) or specific unit operations within effluents plants, such as the Enhanced Actinide Removal Plant (EARP) rig and Sand Bed Filter Rig (Site Ion Exchange Effluent Plant replication).
The Workington facility also boasts medium-large scale chemical operations equipment associated with these rigs, and this capability is currently increasing further.

Instrument specification

Central Lab:
- Inert atmosphere boxes (active and non-active),
- Radiometric equipment (LSC, alpha spec, gamma spec, scaler)
- ICP-MS
- ICP-OES
- ESEM
- Zeta-master
- Ion chromatography
- ELENDES equipment
- TIC/TOC analyser

Workington:
- Rheometers
- Laser light scattering particle sizer
- Cameras and associated software
- GIS, hand-held monitors, LIBS, RAMAN, LIDAR, EnVi

Risley:
- Geochemical and hydrogeological modelling.
- Modelling of microbial processes.

Key Function within this Capability:
- The capability to design, commission and operate bespoke large-scale test rigs in a non-active facility.
- Development of bespoke equipment for testing and demonstration utilising knowledge of plant and novel technologies, including decontamination technologies.
- The ability to complete active and inactive experiments to investigate:
    - Analysis and characterisation of samples (particle science).
    - Radionuclide-surface interactions, including: binding to bulk and colloidal surfaces; determination of solid/solution partition; modelling from Kd valuesand isotherms to surface complexation modelling.
    - Testing of effluent treatment media: precipitates/flocs; filtration materials; ion exchangers.
    - Development of novel effluent treatment and decontamination techniques

Related instrumentation/capabilities

Many of the analytical instruments mention above are shared with other teams, such as Measurement & Analysis (M&A).

External user access arrangements

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Other relevant information

A new decontamination facility/lab is in the early stages of commissioning at NNLs Preston laboratory. This contains a second ELENDES rig to provide operational flexibility alongside the rig at Central Laboratory.
University of Manchester previously had access labs with our team members (hands in pockets) to complete DNA extraction work in support of Sellafield Ltd ponds and silos operations.

Nuclear material capabilities (i.e. activity limits)

There are activity limits for our active labs, please get in touch to discuss your requirements.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

Contact

Steve Thomson
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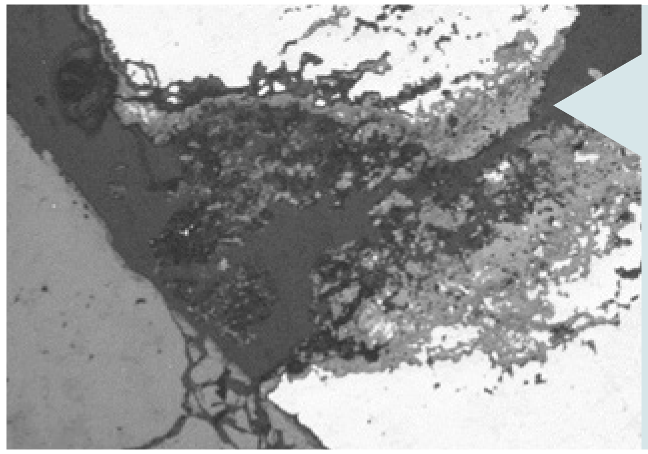
NNL Engagement Team
engagement@uknnl.com



Organisation

National Nuclear Laboratory

Facility

Fuel Post Irradiation Examination (PIE) Laboratory

Location

Sellafield Site, Cumbria, CA20 1PG

Summary of capability/facility

The fuel post irradiation evaluation team has been involved in a vast range of activities from working on Windscale's Advanced Gas-cooled Reactor (WAGR) to receiving both Magnox and AGR fuel from power stations. Much of the development work for the UK fuel requirements was carried out by the team in the UK's only high active PIE laboratory, which NNL operates. Since 2006, over 500 AGR fuel elements have entered the facility with the team examining over a 1000 fuel pins.

The team uses a variety of techniques to assess fuel behaviour, which includes monitoring surface conditions, identifying surface defects of fuel pins and examination of other nuclear items.

In addition to recently discharged fuel, the team has a strong focus on processes associated with spent fuel storage. A dedicated team undertake experimental work associated with understanding the effects of storage conditions on spent fuel and assessing disposability. This is an area of UK expertise.

Post irradiation examination techniques lead to a better understanding of material behaviour helping to support the lifespan of commercial reactor fleets and assure safe storage of spent fuel.

Related instrumentation/capabilities

Electron Optics Capability.

External user access arrangements

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Nuclear material capabilities (i.e. activity limits)

Highly Active.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

Instrument specification

- Surface deposit assessment- a non-destructive technique for measuring the thickness of surface deposit on fuel pins - used for assessing carbonaceous deposit on the surface of AGR fuel pins. The data are compared with results obtained by endoscopy in station ponds (see endoscopy section)
- Gamma spectroscopy- gamma spectroscopy provides non-destructive analysis of fuel pins and may be used for estimating fission gas release, burnup and assessing fuel stack irregularities. The technique is also used to assist in defining locations for metallographic examination
- Leak testing (NOLT) - A soak technique using nitrous oxide, to determine the integrity of fuel pins leaking fuel pins, and the approximate location of the leak site can be determined
- Pin puncture/ fission gas release - pin puncturing is a destructive technique which measures fission gas release from irradiated fuel pins, detailing the composition and quantity of gases released. A mass spectrometer is used to determine the composition of sampled gas
- Visual inspection- visual inspection takes place on nuclear items such as graphite sleeves and nuclear fuel pins. Inspection involves monitoring surface conditions and identifying surface defects of the materials that have occurred during its lifetime in the reactor. Visual inspection also identifies deposit type and can indicate deposit thickNess, acting as a validation technique for the results obtained by other rigs such as air abrasion
- Metallography - an extensive metallography capability is available
- SEM of fuel, clad and surface deposits including a range of analytical techniques
- Use of other NNL facilities - samples from fuel are exported for examination at other NNL facilities (e.g. FIB, TEM)
- Chemical burnup - Dissolution of fuel, and analysis of isotopic content to determine burnup
- Leaching - leach testing of fuel, with analysis of the leachant provided by NNL central laboratory
- Failed fuel detection - several independent techniques to determine integrity of fuel including NOLT (see above); Kr-85 sniffing; puncture;
- Fuel drying - development scale equipment for drying fuel

Other relevant information

Contact

Matthew Barker
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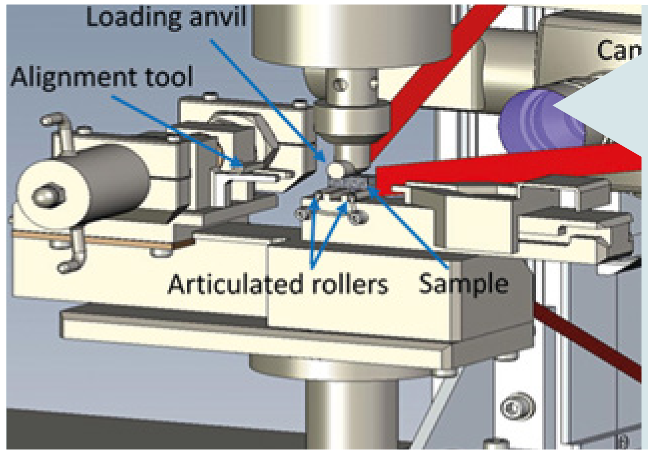
NNL Engagement Team
engagement@uknnl.com



Organisation

National Nuclear Laboratory

Facility

Graphite Technology and Post Irradiation Examination (PIE)

Location

NNL Windscale Laboratory, Sellafield, Cumbria, CA20 1PG

NNL Central Laboratory Facility, Sellafield, Cumbria, CA20 1PG

Image: Three-point loading configuration, including in situ imaging using a Dantec Dynamics Q300 ESPI system, and an alignment tool for reliable sample positioning with remote operation. The red stripes indicate the approximate laser paths used to uniformly illuminate the sample face with coherent light.

Summary of capability/facility

NNL is the sole provider for Graphite PIE in the UK, with more than 50 years' experience analysing over 19,000 samples of AGR and Magnox graphite.

Testing and characterisation of trepanned graphite cores is carried out in the unique world-class Windscale and Central Lab facilities based at Sellafield.

A variety of PIE techniques are used to measure material properties including density, Young's modulus, gas diffusivity, electrical resistivity, thermal expansion, and fracture strength. These techniques can be used for the qualification of new graphites or for understanding the behaviour of graphite in Very High Temperature gas Reactors (V)HTRs.

Related instrumentation/capabilities

See Active Handling Facility, Post Irradiation Examination (PIE) of Civil Nuclear Fuel, and Fuel PIE Laboratory.

External user access arrangements

More than 15 PhD students have been in Central Lab for part of their work as Desk-based, Hands-in-Pockets or Full Access.

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Other relevant information

- NNL works closely with the universities of: Manchester, Liverpool, Loughborough, Oxford and Bristol
- NNL is in collaboration with EDF Energy and The University of Manchester on Innovate UK projects and New Techniques research
- New techniques are constantly being developed, these include electronic speckle pattern interferometry (ESPI), work of fracture, and optical, polarised and fluorescent microscopy
- NNL chairs the ASTM committee D02.F on Manufactured Carbons and Graphite
- NNL participates in the ASME Working Group on Non-metallic Design and Materials for the Boiler and Pressure Vessel Code

Nuclear material capabilities (i.e. activity limits)

No limit in the AHF at Windscale
2 mSV/h gamma in Central Lab

Instrument specification

- Remotely operated materials characterisation rigs in Windscale AHF:
  - Machining rig
  - Photography
  - Density by contact mensuration
  - Laser mensuration
  - Helium pyncometry (Open and closed pore volume)
  - Gas diffusivity/Gas permeability
  - Thermal conductivity (diffusivity)
  - Electrical resistivity
  - Dilatometry (Coefficient of thermal expansion)
  - Compressive strength/Ultimate tensile strength/3-point and 4-point bend strength/Work of fracture
  - Ultrasonic Time-of-Flight (Dynamic Young's modulus)
  - Electron Speckle Pattern Interferometry (ESPI) for static Young's modulus and Poisson's ratio
  - Electron Speckle Pattern Interferometry (ESPI) for coefficient of thermal expansion
- Materials characterisation rigs in Central lab fumehoods:
  - Versatile machining enclosure
  - Density by contact mensuration
  - Density by immersion (Archimedes method)
  - Helium pycnometry (Open pore volume)
  - Gas diffusivity
  - Gas permeability
  - Differential Scanning Calorimetry (Rate of release of Wigner energy, total Wigner energy)
  - Thermogravimetric analyser (Graphite-air reactivity and activation energy, Deposit concentration and reactivity)
  - Optical microscopy (including sample preparation)
  - Ultrasonic Time-of-Flight (Dynamic Young's modulus)
  - Annealing furnace (200^{o}C)
  - SEM/EDX/TEM/XCT (Electron Optics team)
  - XRD and Laser Raman (Separation Science Team)

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Support to UK reactors	
Other (please specify)	
Available/ unused	

Contact

Nassia Tzelepi
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NNL Engagement Team
engagement@uknnl.com

Organisation
National Nuclear Laboratory

Facility
Hot Robotics Facility - NNL component

Location
NNL Workington Facility, Cumbria, CA14 3YQ

Image: © National Nuclear Laboratory

Summary of capability/facility

The National Nuclear User Facility for Hot Robotics (NNUF-HR) is an EPSRC-funded facility to support UK academia and industry to deliver ground-breaking, impactful research in robotics and artificial intelligence for application in extreme and challenging nuclear environments.

The facility is arranged across three regional nodes with four research partners: NNL, University of Manchester, University of Bristol and UKAEA's Remote Applications in Challenging Environments (RACE).

NNL's facility comprises equipment and flexible floorspace to develop, test, and demonstrate robotic solutions for the nuclear industry.

The research test rigs available at the NNL Workington Laboratory are on an industrial scale, acting as a link between the small-scale, low TRL (1-4) robotics research, and the full-scale demonstrator facilities being set up by NNL to progress technology up to TRL 9.

Facilities include:
- Robot laser cutting facility
- Robot sort and segregation capability
- Dive tank for ROVs with side viewing window
- Flexible and reconfigurable operating enclosures and tailored plant representative mock-ups for the development and testing of remotely deployed devices
- Access to operators and engineers with decades of nuclear fission expertise

Instrument specification

Collaborative Robotics
- 2 x Kinova 7DOF Gen3 arms and 2 x Robotiq two-finger grippers
- Mounting frame for 0, 45° and 90° deployment and height adjustment
- Full size replica gloveboxes

Robotic Sort and Segregation Capability
- 2 x KR180 KUKA industrial robots
- Replica plant joystick controllers
- Semi-autonomous control
- Several gripper and tool options from manufacturers including Zimmer and Schunk
- Tool changer

Robot Laser Cutting Facility
- KUKA KR120
- 5KW laser with 30m fibre
- Fume management and detection equipment
- Thermal imaging cameras
- Schunk gripper

NNUF-HR Dive Tank
- (3.2m wide x 5.2m long x 3.58m high)

Flexible and Reconfigurable Operating Enclosures
Please consult https://hotrobotics.co.uk for more information.

Nuclear material capabilities (i.e. activity limits)

Non-Active

Related instrumentation/capabilities

NNUF-HR also has hubs at UKAEA's RACE; University of Bristol; and University of Manchester.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

External user access arrangements

- Users from UK-based Higher education institutions (HEIs) and other organisations that are eligible to apply for UKRI funding can apply for funded access through NNUF, until March 2023 (please see www.nnuf.ac.uk/how-gain-access)
- Users from industry - Please contact us to discuss your opportunities: nnuf-hr@uknnl.com

Other relevant information

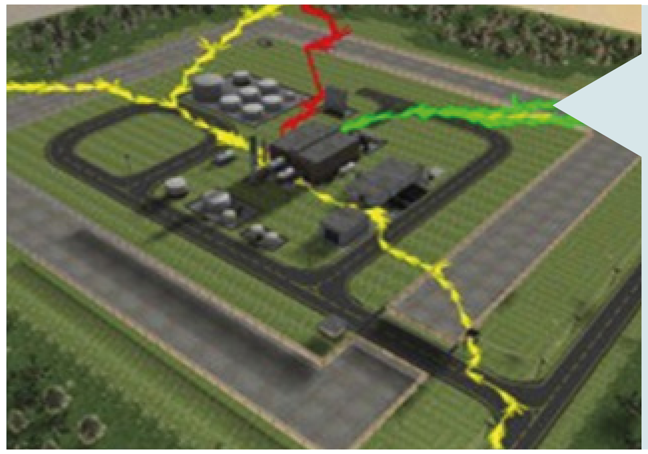
Please consult https://hotrobotics.co.uk for further information.

NNL's NNUF-HR facility in Workington Cumbria opens Spring/Summer 2021.

Contact

nnuf-hr@uknnl.com

engagement@uknnl.com



Organisation
National Nuclear Laboratory

Facility
Human Factors and Security Vulnerability Assessment Capability

Location
NNL Preston Laboratory Facility, Preston, PR4 0XJ
NNL Central Laboratory Facility, Sellafield Site, Cumbria, CA20 1PG
NNL Culham Facility, Oxford, OX14 3DB

Image: AVERT Simulation-© ARES.

Summary of capability/facility

The Human Factors and Security Team at NNL is comprised of two discrete disciplines.

The Human Factors team are highly skilled Human Factors professionals with a range of expertise. They support the delivery of Nuclear Safety and Nuclear Security outcomes for NNL and external customers. Team members work at a national and international level developing techniques and methods and have unique skill sets in novel technologies such as robotics. The Technical Lead is the UK representative on the Halden HTO project steering committee.

The Security Team are a team with highly skilled and experienced Security Professionals with a range of Nuclear Industry, Government, Critical National Infrastructure, Policing, Military and Regulatory experience. They support the delivery of security assessments that support the delivery of Nuclear Site Security Plans, 'Secure by Design' facilities, and effective Physical Protection System. The Team contribute to International Atomic Energy Agency Consultancy and Technical meetings and participate in Co-ordinated Research Programmes. A Principal Security Consultant is the World Nuclear Association Security Working Group Chair.

Instrument specification

The team use a security software package called 'AVERT' to assess the physical security system effectiveness. AVERT is a unique product that is used to visualise and quantify the performance of a physical security system. AVERT's holistic and integrated approach, delivers accurate, measurable, and repeatable assessments of physical security design and operations.

Through performing many Monte-Carlo simulations of the potential adversarial pathways, and response force interactions, AVERT provides decision makers with a detailed and quantified understanding of the effectiveness of the physical security system. This increases confidence in the security design and enables the evaluation of the cost-benefit of any proposed security system modifications.

AVERT provides information that can be used to evaluate the effectiveness or vulnerabilities of a site's different security configurations against an attack by adversaries (including insiders).

AVERT provides a user-friendly and intuitive Graphical User Interface (GUI) allowing users to model a site and run simulations of hypothetical attacks on the modelled site. The 3-Dimensional (3D) model of a site can include the interior and exterior features of structures, access points and entrances, natural features, and the placement of both active and passive barriers and detection tools.

Nuclear material capabilities (i.e. activity limits)

Inactive desk-based work

Related instrumentation/capabilities

Modelling and Simulation Capability.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
ADS	
Other (please specify)	
Available/ unused	

External user access arrangements

Please email the Key Contact or access.liaison@uknnl.com to discuss your access needs.

Other relevant information

Contact

David Thoburn
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NNL Engagement Team
engagement@uknnl.com

Organisation
National Physical Laboratory

Facility
Traceable Standards of Radioactivity

Location
Nuclear Metrology Group, National Physical Laboratory, Hampton Road, Teddington, TW11 0LW

Summary of capability/facility

The NPL Nuclear Metrology Group produces a range of single and mixed radionuclide standards for end users in multiple sectors including decommissioning, environmental monitoring, healthcare, academia, and other metrology institutes. The standards also support research and method development within the Nuclear Metrology Group.

Approximately seventy stock solutions are available at a range of activity concentrations, some of which are unique to NPL. Custom radionuclides can be produced on request, and spiked solid sources such as filters can also be provided. The service is UKAS accredited, fulfilling approximately 150 orders annually.

The radionuclides provided are standardised using a combination of primary and secondary counting techniques. There is constant research and development to provide new and improved radionuclide standards in response to customer requests and market requirements.

www.npl.co.uk/products-services/radioactivity/radionuclide-solutions
www.npl.co.uk/products-services/radioactivity/custom-radionuclides

Instrument specification

Related instrumentation/capabilities

Primary standards of radioactivity using coincidence counting and liquid scintillation counting, alpha spectrometry, gamma spectrometry, mass spectrometry, NPL proficiency/performance test exercises.

Nuclear material capabilities (i.e. activity limits)

Stock products range from 1 Bq/g up to 100 kBq/g, custom activities both inside and outside of this range can be produced upon request.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	40
Advanced Nuclear	
Environmental	50
Other (Healthcare)	10
Other (please specify)	
Available/ unused	

External user access arrangements

Access is arranged via the contacts on this page. Customers, particularly those with devices that are complex to operate, often come to NPL to participate in data acquisition during calibrations.

Other relevant information

https://www.npl.co.uk/products-services/radioactivity/radionuclide-solutions

Contact

Heather Thompkins
heather.thompkins@npl.co.uk
020 8943 8599

Organisation
National Physical Laboratory

Facility
Calibration facility for radionuclide neutron sources

Location
Nuclear Metrology Group, National Physical Laboratory, Hampton Road, Teddington, TW11 0LW

Summary of capability/facility

Absolute emission rate measurements are performed using the manganese bath technique. The neutron source is placed at the centre of a spherical bath, 1 m in diameter, containing an aqueous solution of manganese sulphate. The amount of radioactive manganese produced is measured by pumping the solution past two scintillation detectors, the γ-counting efficiencies of which are determined by absolute counting techniques. The neutron emission rate is calculated from the γ-count rate at saturation, applying appropriate correction factors.

A moderating assembly incorporating BF_3 proportional counters is used to make comparative emission rate measurements. The source emission rate is obtained by comparison with a source of the same type which has been measured in the manganese bath.

Anisotropy measurements are made in a low-scatter area using a long counter to measure the output in steps of 10°.

A shielded cell with manipulators is available for operations involving sealed sources.

Instrument specification

The calibration limits are determined by the emission rate of a source. Lower and upper limits are outlined in the following table:

	Manganese bath	Moderating assembly	Anisotropy
Lower limit	2.0×10^5 s^{-1}	10^2 s^{-1}	10^5 s^{-1}
Upper limit	2.4×10^9 s^{-1}	2.4×10^6 s^{-1}	10^8 s^{-1}

Calibrations are UKAS accredited within our schedule of accreditation.

Related instrumentation/capabilities

Uncertainties depend on source emission rate and type. Typical values are summarised in the following table (at k=2):

	Emission rate		
	Manganese bath	Moderating assembly	Anisotropy factor (90° to axis of source)
Lower limit	1.0%	1.4%	0.7%
Upper limit	1.8%	2.0%	1.8%

Nuclear material capabilities (i.e. activity limits)

The source cell can be used for ^{252}Cf sources with activities up to 20 GBq

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Measurement services	50
Other (please specify)	
Available/ unused	50

External user access arrangements

Access is arranged through contacts on this page.

Other relevant information

Recalibration frequency:
It is recommended in ISO8529 that ^{252}Cf and ^{241}Am-based sources are recalibrated at least every 5 years.

Contact

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020 8943 6869

Nicola Horwood
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Organisation
National Physical Laboratory

Facility
Radioactive Gas Metrology Laboratory. Standardisation of Radioactive Gases and Calibration of Radioactive Gas Monitors

Location
Nuclear Metrology Group, National Physical Laboratory, Hampton Road, Lucideon, TW11 0LW

Summary of capability/facility

NPL Radioactive Gas Metrology Laboratory maintains primary standards for radioactive gases such as ^{3}H, ^{14}C, ^{85}Kr and ^{133}Xe, through absolute internal-gas proportional counting (AIGPC). The system comprises four proportional counters of identical diameters but varying lengths allowing 'length compensation', hence removing non-uniform end effects. Correcting for pulses lost below the low-energy threshold, this technique is considered an absolute counting method, and thus a primary standard.

The range of gases has recently been expanded to include short-lived radionuclides such as ^{11}C, ^{41}Ar, ^{87}Kr, ^{88}Kr and ^{135}Xe. These are produced at NPL and monitor calibration is performed simultaneously with the gas standardisation.

The laboratory also operates a radioactive gas monitor calibration facility used to calibrate handheld, area and stack monitors typically used for radiation protection and regulatory compliance.
The facility supports routine/bespoke customer work and collaborative R&D with partners such as the University of Surrey and AWE.

Instrument specification

Radioactive gas standards of ^{3}H, ^{14}C (CO_2 or CH_4), ^{85}Kr and ^{133}Xe contained in pressurised cylinders are available for sale. The cylinders are certified for their activity concentration in the range 1 MBq m^{-3} to 30 GBq m^{-3} (depending on the gas) with an uncertainty in the order of 1 to 5% (k=2).
Reference atmospheres of ^{3}H, ^{11}C (CO_2), ^{14}C (CO_2 or CH_4), ^{41}Ar, ^{85}Kr and ^{133}Xe can be produced at NPL for calibration of gas monitors. High activity gases can be diluted as low was 40 kBq m^{-3} with an uncertainty as low as 4% (k=2).
A mixed atmosphere of fission product gases (^{85}mKr, ^{87}Kr, ^{88}Kr, ^{135}mXe and ^{135}Xe) can be produced for R&D applications.
Bespoke gas standards can be produced on request.

Related instrumentation/capabilities

Inline gamma-ray spectrometry and beta/gamma coincidence measurements are available for R&D applications.

Nuclear material capabilities (i.e. activity limits)

NPL is not a nuclear licensed site, but the Nuclear Metrology Group has a section devoted to radioactivity measurements with capabilities of handling significant amounts of radioactive material.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	15
Environmental	15
Customer irradiations of devices	
Radiation protection	45
Available/ unused	25

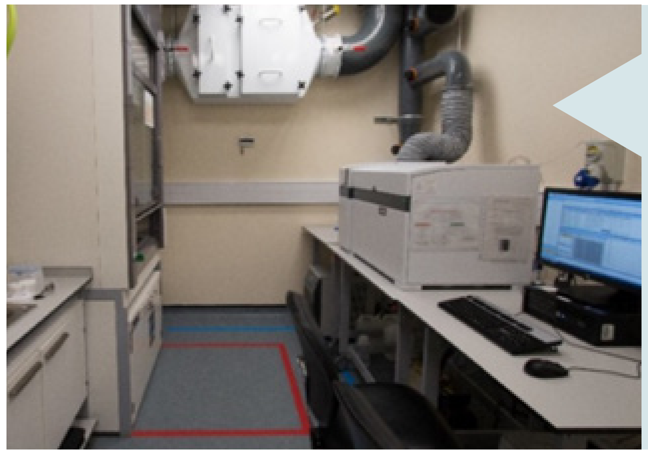
External user access arrangements

Access is arranged via the contacts on this page. Customers, particularly those with devices that are complex to operate, often come to NPL to participate in data acquisition during calibrations.

Other relevant information

Contact

Steven Bell - steven.bell@npl.co.uk
Marc Abilama - marc.abilama@npl.co.uk
Commercial enquiries - radioactivity@npl.co.uk



Organisation
National Physical Laboratory

Facility
Tandem plasma mass spectrometry

Location
Nuclear Metrology Group, National Physical Laboratory, Hampton Road, Teddington, TW11 0LW

Summary of capability/facility

The NPL Nuclear Metrology Group inductively coupled plasma tandem mass spectrometer (ICP-MS/MS) was installed in 2015 to expand measurement capabilities for medium and long-lived radionuclides (half-life of approximately 20 years and longer) compared to decay counting capabilities.

The tandem setup offers improved interference separation that can otherwise prevent accurate radionuclide detection, reducing the need for relatively time-consuming offline separation and reducing the total procedural time. Several hundred samples can be run each day, with procedures in place for >20 radionuclides and stable elements, contributing to cost-effective decommissioning as a result of higher sample throughput.

The laboratory leads and supports projects in nuclear decommissioning, environmental monitoring, nuclear forensics through isotopic ratio measurements, and combining ICP-MS/MS with primary counting techniques to provide precise half-life measurements.

The lab also provides mass spectrometry-relevant standards for end users, both as single radionuclide standards and as part of mixtures for the annual NPL Environmental Proficiency Test Exercise.

Instrument specification

Agilent 8800 Inductively Coupled Plasma Mass Spectrometer (ICP-MS/MS).
X-lens, Nickel or platinum-tipped interface cones.
Four dedicated gas lines for collision-reaction cell mass spectrometry-hydrogen, helium, non-corrosive gas (currently oxygen), corrosive gas (currently 10% ammonia balanced in 90% helium).
Single Particle Mass Spectrometry capability, including 1.0 mm internal diameter torch.
Agilent SPS 4 Autosampler.
ESI Apex Q desolvating sample introduction.
HEPA filtered lab under positive pressure to reduce background contamination.
Fume cupboard for sample preparation.

Related instrumentation/capabilities

Alpha spectrometry, liquid scintillation counting, gamma spectrometry, radiochemistry, measurement services, Proficiency Test Exercises.

Nuclear material capabilities (i.e. activity limits)

This is a low-level facility specialising in the measurement of medium and long-lived radionuclides (half-life approximately 20 years and longer). There is a maximum activity in the order of 100 Bq/g per sample.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	10
Advanced Nuclear	5
Environmental	20
Other (please specify)	Nuclear Medicine (20)
Other (please specify)	Development of standards (25)
Available/ unused	20

External user access arrangements

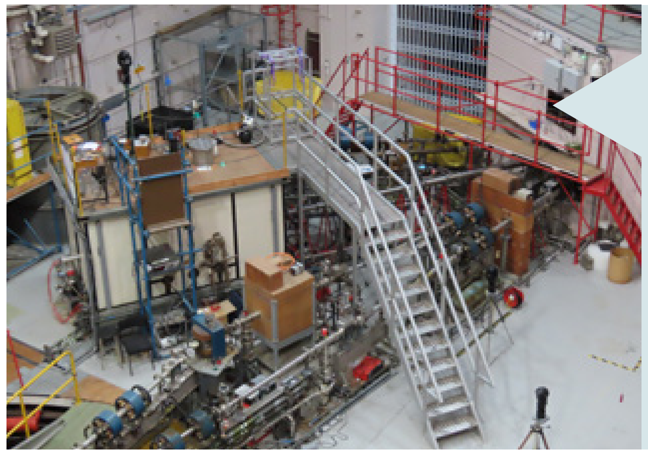
Collaborative R&D projects with industry and academic partners, other Metrology Institutes, instrument manufacturers.
Training of end users and testing of methods and materials from academic or nuclear industry backgrounds can be undertaken.
To enquire about instrument time, contact Ben Russell.

Other relevant information

https://www.npl.co.uk/projects/decommissioning-radionuclides

Contact

Ben Russell - ben.russell@npl.co.uk
0208 943 7181
Commercial enquiries: radioactivity@npl.co.uk



Organisation
National Physical Laboratory

Facility
NPL Proficiency Test Exercise (PTE)

Location
Nuclear Metrology Group, National Physical Laboratory, Hampton Road, Teddington, TW11 0LW

Summary of capability/facility

NPL organise regular UKAS accredited Environmental Radioactivity Proficiency Test Exercise (PTE) as well as other performance and intercomparison exercises to assess laboratories performance and assist in method development. The Environmental Radioactivity PTE circulates aqueous radionuclide solutions for participating laboratories to measure. The Nuclear Industry Intercomparison Exercise distributes a 200 L simulated waste drum to be measured by non-destructive assay methods.

These exercises help participating laboratories to test methods and to demonstrate their commitment to quality. The ongoing evolution of the exercises ensure they remain fit for purpose with end users, measuring relevant radionuclides and activity concentrations, as well as looking into new exercises, including those dedicated to naturally occurring radionuclides and production of a 1m^3 bag.

NPL co-ordinate these exercises; organising the production and despatch of comparison items, as well as compilation of the results as a report and a workshop, with participants from various industries including construction, nuclear, radiation protection, research and academia.

Instrument specification

Related instrumentation/capabilities

Primary standards of radioactivity, alpha spectrometry, liquid scintillation counting, gamma spectrometry, mass spectrometry, measurement services.

Nuclear material capabilities (i.e. activity limits)

The activity ranges from 1 Bq/kg to 20 kBq/kg. For the Environmental PTE, alpha, beta and gamma emitting radionuclides are included. The Nuclear Industry Drum PTE focuses on gamma emitting radionuclides.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	30
Advanced Nuclear	
Environmental	70
Other (please specify)	
Other (please specify)	
Available/ unused	

External user access arrangements

Proficiency training enquiries can be sent to the contacts listed on this page

Other relevant information

https://www.npl.co.uk/products-services/radioactivity/environmental-pte
https://www.npl.co.uk/products-services/radioactivity/nuclear-industry-pte

Contact

Elsje van Es
elsje.van.es@npl.co.uk
Commercial enquiries: radioactivity@npl.co.uk

Organisation
National Physical Laboratory

Facility
Radiochemistry suite

Location
Nuclear Metrology Group, National Physical Laboratory, Hampton Road,Teddington, TW11 0LW

Summary of capability/facility

The NPL Nuclear Metrology Group radiochemistry suite contains five radiochemistry laboratories, each dedicated to specific applications: low level sample preparation; source preparation including reference filters; handling of volatile radionuclides; preparation of solid materials including reference materials; high activity irradiated target processing.

The radiochemistry suite is used for preparing homogenised solid and aqueous reference materials as part of the NPL Proficiency Test Exercise scheme, as well as custom material development. The facility is also used to prepare high purity radionuclides prior to characterisation using primary and secondary counting techniques in the NPL Nuclear Metrology Group.

Radiochemical preparation includes dissolution of solid materials using leaching or fusion-based techniques, bulk chemical separation and development of methods for radionuclide-specific separation using ion exchange or extraction chromatography.

Instrument specification

Sample moisture content- drying ovens, moisture content analyser.
Solid sample leaching and dissolution- Microwave oven leaching, automated borate fusion.

Pyrolyser for volatile radionuclide handling

Grinding and mixing of solid samples- drum mixer, gyro mill, jaw crusher, hydraulic press.

Chemical separation of radionuclides- fume cupboards with vacuum-box based ion exchange and extraction chromatography separation.
Source preparation facility with balance precisions ranging from two to six figure, able to precisely measure samples from microgram to kilogram range.

Related instrumentation/capabilities

Primary standards of radioactivity, Alpha spectrometry, liquid scintillation counting, gamma spectrometry, mass spectrometry, measurement services, Proficiency Test Exercises.

Nuclear material capabilities (i.e. activity limits)

Activity levels handled range from milli Becquerels for environmental applications to mega Becquerel levels for nuclear medicine applications.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	15
Advanced Nuclear	5
Environmental	20
Other (please specify)	Nuclear Medicine (25)
Other (please specify)	Development of standards (20)
Available/ unused	15

External user access arrangements

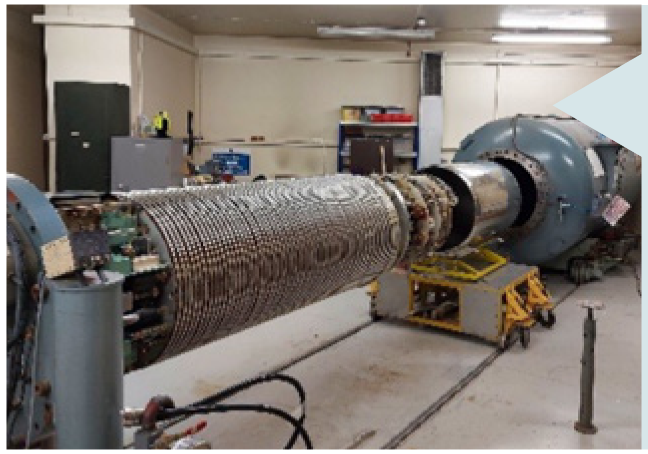
Collaborative R&D projects with industry and academic partners, other Metrology Institutes, instrument manufacturers.
Training of end users and testing of methods and materials from academic or nuclear industry backgrounds can be undertaken.
To enquire about instrument time, see contact listed on this page.

Other relevant information

https://www.npl.co.uk/nuclear-metrology/radiochemistry

Contact

Hibaaq Mohamud
hibaaq.mohamud@npl.co.uk
Commercial enquiries: radiaoctivity@npl.co.uk



Organisation
National Physical Laboratory

Facility
Facility for the production of monoenergetic and radionuclide-based neutron fields

Location
National Physical Laboratory, Hampton Road, Teddington, TW11 0LW

Summary of capability/facility

Since the 1960's the National Physical Laboratory has been providing fluence and dose standard monoenergetic neutron fields for industry and research. This standard is realised via a 3.5 MV single-ended Van de Graaff that accelerates ions of protons or deuterons onto various neutron producing targets. Monoenergetic neutron fields between 8 keV and 19 MeV can be produced. The neutrons are produced in a large low-scatter laboratory reducing the contribution of down-scattered neutrons in the neutron field.

Fluence and dose standards are also realised using radionuclide sources within the low scatter laboratory. In use are common sources ^{252}Cf and AmBe, and rarer ones AmB, AmF, AmLi and SbBe.

These neutron fields are typically used in the characterisation of neutron sensitive devices such as area survey instruments, personnel dosemeters, scintillators, novel devices, etc. Research includes improvements in neutron metrology, detector development and nuclear data.

Instrument specification

3.5 MV Van de Graaff accelerator
Ions: protons and deuterons
Beam Energy: 0.9-3.5 MeV
Beam current: up to 80 µA
Neutron energies: between 8 keV and 19 MeV
Standardised neutron energies:

Neutron Energy	Reaction	Max. Fluence @ 1m ($cm^{-2}.s^{-1}$)	Max. Dose equiv. @ 1m ($\mu Sv.h^{-1}$)
27 keV	$^{45}Sc(p,n)^{45}Ti$	8	0.6
144 keV	$^{7}Li(p,n)^{7}Be$	1000	450
250 keV	$^{7}Li(p,n)^{7}Be$	600	440
565 keV	$^{7}Li(p,n)^{7}Be$	1600	2000
1.2 MeV	$T(p,n)^{3}He$	850	1300
2.5 MeV	$T(p,n)^{3}He$	1500	2000
5.0 MeV	$D(d,n)^{3}He$	600	870
16.5 MeV	$T(d,n)^{4}He$	500	1000

Radionuclide sources with max. emission rate (s^{-1}): ^{252}Cf-10^7, $^{252}Cf(D_2O)$-10^7, $^{241}AmBe$-10^7, ^{241}AmB-10^5, ^{241}AmF-10^5, $^{241}AmLi$-10^5

Related instrumentation/capabilities

Large low-scatter laboratory: 26 x 17 x 18 m (W x L x H)
Neutron instruments: Long counters, moderating detectors, recoil counters, scintillators
Monte Carlo modelling capabilities

Nuclear material capabilities (i.e. activity limits)

NPL is not a nuclear licensed site, but the Nuclear Metrology Group has a section devoted to radioactivity measurements with capabilities of handling significant amounts of radioactive material.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Measurement Services	40
Research - various	20
Other facilities*	20
Available/ unused	20

*The low-scatter laboratory is shared with other capabilities which utilises some facility time

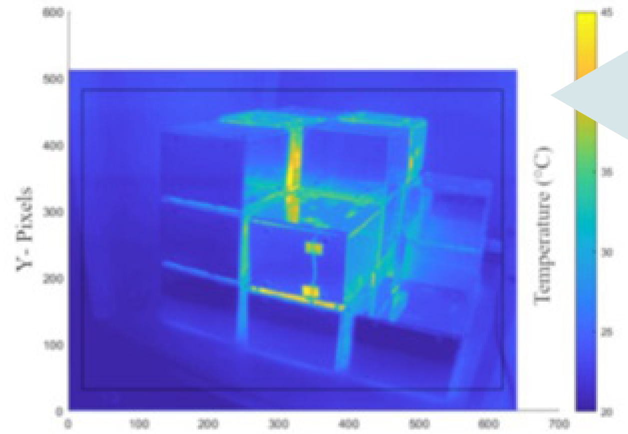
External user access arrangements

Access is arranged through contacts on this page

Other relevant information

Contact

Commercial enquiries - radioactivity@npl.co.uk



Organisation
National Physical Laboratory

Facility
Metrology Centre for Nuclear Decommissioning

Location
Nuclear Metrology Group, National Physical Laboratory, Hampton Road, Teddington, TW11 0LW

Thermal image of 1:10 scale 3 m^3 boxes (for intermediate level waste) with target boxes identified with an elevated temperature

Summary of capability/facility

NPL is the UK's national measurement institute with globally leading state-of-the-art metrology capability. This capability has been, over a wide range of measurement disciplines, used to facilitate the most effective approach to decommissioning. Specific examples have included:

- Assessing the radioactivity level and elemental composition of complex sample matrices
- Understanding corrosion processes in the environments found in waste stores, waste containers and spent fuel
- Thermal measurement approaches including reliable surface thermometry, fibre-optic based thermometry, quantitative thermal imaging, low uncertainty contact thermometry and humidity and moisture evaluation
- Establishment of complex thermal models of, for example, nuclear waste stores
- Sensor-to-decision measurement uncertainty evaluation for example for safety case underpinning
- Digital image correlation to determine displacement, physical changes (e.g., caused by corrosion) and strain in stores and containers
- Provision of wide-ranging metrology advice to help with sensor and method selection for particular metrology requirements

Instrument specification

NPL's measurement capability is world leading and globally recognised. Many of our routine measurement services are ISO17025 accredited with the lowest uncertainties achievable in the UK (details can be found on the UKAS website).

Related instrumentation/capabilities

Inline gamma-ray spectrometry and beta/gamma coincidence measurements are available for R&D applications.

Nuclear material capabilities (i.e. activity limits)

NPL is not a nuclear licensed site, but the Nuclear Metrology Group has a section devoted to radioactivity measurements with capabilities of handling significant amounts of radioactive material.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	100
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

External user access arrangements

Access is arranged via the contacts on this page. Customers, particularly those with devices that are complex to operate, often come to NPL to participate in data acquisition during calibrations.

Other relevant information

Most of our work for decommissioning has been through developing and extending our standard measurement capability and modifying it to provide reliable traceable measurements in the particularly challenging environments encountered in decommissioning. Recent examples include digital image correlation and reliable non-contact surface thermometry by phosphor thermometry.

Contact

Professor Graham Machin FREng, DSc, DPhil
NPL Senior Fellow, Science Lead for Nuclear Decommissioning,
Head of Temperature Standards
Email: graham.machin@npl.co.uk Phone: 07718 193725
Commercial enquiries: andy.duncan@npl.co.uk Phone: 07827 991469

Organisation
National Physical Laboratory

Facility
Production of standardised thermal neutron fields and measurement of thermal neutron fields using gold foil activation

Location
Nuclear Metrology Group, National Physical Laboratory, Hampton Road, Teddington, TW11 0LW

NPL thermal pile

Summary of capability/facility

The NPL thermal pile facility is unique in the UK, and probably in the world. Neutrons are produced within a graphite block by a deuteron beam from a 3.5 MV Van de Graaff accelerator striking two off-set beryllium targets. The fast neutrons produced in this reaction are moderated by the graphite to thermal energies, and there are two irradiation test locations. One is down a 120 mm diameter access hole where fluence rates in excess of 10^7 cm^{-2} s^{-1} are available. The other is a 300 mm diameter beam extracted from within the pile with fluence rates up to about 4 x 10^4 cm^{-2} s^{-1}.

This capability can be applied to testing nuclear reactor neutron monitors, to characterising neutron radiation protection devices, specifically personal dosemeters and survey instruments, and to measuring the responses of other neutron detecting devices such as neutron spectrometers.

We provide traceability to international standards, providing ultimate confidence in neutron measurements, thus enabling the safe operation of nuclear facilities and the radiation protection of workers.

Instrument specification

The thermal pile is shown in the figure with the beam from the Van de Graaff accelerator entering the graphite block from the bottom left hand side. The cylindrical thermal column can be seen on top of the pile on the central axis nearest the end where the deuteron beam enters the block. The column provides a vertical beam of thermal neutrons. The central access hole, down which higher fluences are available, is at the centre of the pile just behind the thermal column.

- Test location 1. Down a 120 mm diameter and 1 m deep hole. Fluences up to 1 x 10^7 cm^{-2} s^{-1}
- Test location 2. In a 300 mm diameter vertical beam. Fluences up to 4 x 10^4 cm^{-2} s^{-1}

The fluence rates are varied by changing the deuteron beam current. A feedback system, monitoring fluence production from the targets, controls the neutron fluence rate with a stability of better than 1%.

Related instrumentation/capabilities

Thermal fluences produced at NPL are measured using the activation of gold foils. A set of low-background β and 4πβ-γ counters are available for determining the induced activity, and these measurements result in an accuracy of about 1% for the fluence. Ambient and personal dose equivalent rates can be derived by using spectrum averaged fluence to dose equivalent conversion coefficients. The measurement of thermal fluence with the gold foils is available as an external service.

Nuclear material capabilities (i.e. activity limits)

NPL is not a nuclear licensed site, but the Nuclear Metrology Group has a section devoted to radioactivity measurements with capabilities of handling significant amounts of radioactive material.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Customer irradiations of devices	20*
Other (please specify)	
Available/ unused	80

* The thermal pile is located in a lab with other facilities which explains the low % usage figure as they cannot all be used at the same time.

External user access arrangements

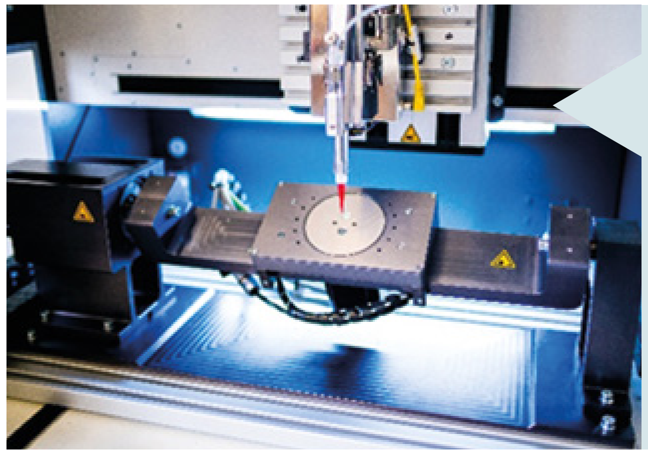
Access is arranged via the contacts on this page. Customers, particularly those with devices that are complex to operate, often come to NPL to participate in data acquisition during irradiations. Simple devices, e.g. neutron personal dosemeters, can be sent to NPL with information on the fluence or dose required.

Other relevant information

The NPL thermal pile was built to perform activation cross section measurements. These made use of the radioactivity measurement capability available within the Nuclear Metrology Group. The thermal pile facility and associated activity measuring capabilities are available for this type of work.

Contact

Kim Ward - Kim.Ward@npl.co.uk
David Thomas - David.Thomas@npl.co.uk
Neil Roberts - Neil.Roberts@npl.co.uk
Commercial enquiries - radioactivity@npl.co.uk



Organisation
Nuclear Advanced Manufacturing Research Centre (Nuclear AMRC)

Facility
Anchor Technology - Controls & Instrumentation

Location
Nuclear AMRC (Midlands) University of Sheffield, iHub, Infinity Park, Infinity Park Way, Derbyshire, DE24 9FU

Summary of capability/facility

Based in Derby, Nuclear AMRC's digital controls and instrumentation group focus on developing and applying controls, instrumentation and digital technologies to nuclear and many regulated industry sectors.

Our engineers have extensive expertise in advanced sensing and monitoring technologies which bridge the physical world and virtual environment, most advanced industrial control techniques, supporting through-life engineering services, etc. We develop smart sensors and other AI-based apparatus for unmanned ground and aerial vehicles. We also offer a range of additive manufacturing capabilities for R&D, rapid prototyping and product development, including advanced capabilities in 3D printed electronics.

The group works with customers across the UK to assess and develop their digital manufacturing capabilities to improve performance and reduce waste through digitalised design, analysis, training, validation and production scheduling.

Our core C&I research areas encompass:
- Sensing technology
- Industrial control systems
- Digital manufacturing
- Robotics and teleoperation
- Wireless topology
- Industrial Internet of Things (IoT)

Instrument specification

Rohde & Schwarz RTM3004 - Digital oscilloscope
Keysight digital bench power supply
Vector network analyser (ZNLE6)
R&S FPL1003-P4 Spectrum Analyser
Keithely 6517B/E Bench digital multimeter
Tektronix AFG31252 function generator and counter
BotFactory SV2 Desktop PCB printer
Electrodynamic shaker
- Vibration and shock test for small component (<40kg)
- Compliance testing to international standards

3D Electronic printing machines (PJ 15X)
- Best-in-class 5 axis motion for 3D Printed Electronics - effective processing of even the most complex parts
- It is modular R&D and product development system with the widest range of processing tools

Relay tester
- A relay's performance and compliance testing

Unmanned Ground Vehicle
- Payload <50kg
- With 3D LiDAR, GPS and HD camera, etc.

Single-axis seismic shake table (Due in February 2022)
- Equipment qualification testing for electric device and small mechanical component up to 100 kg
- Test meeting requirements from RCC-E and IEEE standards

Unmanned Aerial Vehicle (Due in July 2022)
- max. 6 kg payload
- 30 mins max. flying time at one charge
- With 3D LiDAR, GPS and HD camera

HALT/HASS environmental chamber (Due in December 2022)

Related instrumentation/capabilities

Anchor Technology - Additive manufacturing & near-net shaped forming
Anchor Technology - Automation and Digitalisation
Anchor Technology - Codes and Standards
Anchor Technology - Material, surface, corrosive and thermal engineering
Anchor Technology - Product and Process Verification and Validation

Nuclear material capabilities (i.e. activity limits)

The Nuclear AMRC's facilities do not have radioactive handling licenses and do not handle active materials.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Available/ unused	

External user access arrangements

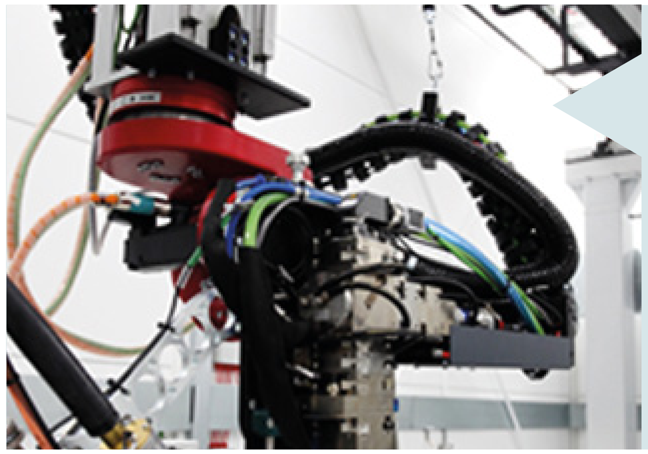
The Nuclear AMRC's mission is to help UK businesses to win work in the nuclear and ancillary HVM safety critical sectors and therefore we encourage SMEs, OEMs, universities and other RTOs to utilise our hardware and SQEP to help the Nuclear AMRC achieve its mission.

Other relevant information

Through the Nuclear AMRC's Fit For Nuclear (F4N) programme, which focuses on business systems, we actively engage with the both the nuclear and high-value manufacturing supply-chain network on a regular basis in the form of education and audits to achieve this F4N status.

Contact

Dr. Li Li - Head of Group
li.li@namrc.co.uk



Organisation
Nuclear Advanced Manufacturing Research Centre (Nuclear AMRC)

Facility
Anchor Technology - Additive Manufacturing and Near-Net Shape Forming

Location
Brunel Way, Rotherham S60 5WG

Summary of capability/facility

Additive manufacturing and near-net shape forming R&D at the Nuclear AMRC focuses on high-integrity manufacturing and customisation of large metal components through the use of arc, power beam and solid-state methods applied to structural and corrosion resistant steels, nickel-based alloys and other exotic alloys.

Our team is in collaboration with international organisations to develop codes and standards for additive manufacturing and near-net shape forming. Delivery of these processes also encompasses the qualification of material and components through the use of integrity inspection methods as a critical research area to accelerate the use of advanced manufacturing for nuclear applications.

Our core research areas include:
- Power beam technologies (Electron Beam and Laser)
- Powder metallurgy - Hot Isostatic Pressing (HIP)
- In-process inspection and monitoring
- Structural integrity X-Ray Diffraction (XRD) and Computerised Tomography (CT)
- Environmentally sustainable manufacturing

Instrument specification

Pro-Beam K2000 - Electron Beam Welding
- 208 cubic metres vacuum chamber
- Internal mobile 40kW 80kV gun including wire feeds

Disk Laser Cell - 16kW Trumpf fibre-coupled disk laser
- Laser-hybrid welding
- Autogenous or wire-fed laser welding

Quintus Hot Isostatic Pressing Facility
- Hot zone of 450mm diameter by 1300mm length, workload up to 1 tonne
- Temperature up to 1450°C, pressure up to 207MPa (30,000psi)

Related instrumentation/capabilities

Anchor Technology - Joining Technologies
Anchor Technology - Additive Manufacturing & Near-Net Shaped Forming
Anchor Technology - Digital Environment
Anchor Technology - Simulation and Verification
Anchor Technology - Modularisation

Nuclear material capabilities (i.e. activity limits)

The Nuclear AMRC's facilities do not have radioactive handling licenses and do not handle active materials.

External user access arrangements

The Nuclear AMRC's mission is to help UK businesses to win work in the nuclear and ancillary HVM safety critical sectors and therefore we encourage SME's OEMs and other RTOs to utilise our hardware and SQEP to help the Nuclear AMRC achieve its mission.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

Other relevant information

Through the Nuclear AMRC's Fit For Nuclear (F4N) programme, which focuses on business systems, we actively engage with the both the nuclear and high-value manufacturing supply-chain network on a regular basis in the form of education and audits to achieve this F4N status.

Contact

Dr Will Kyffin - Head of Welding and Materials
will.kyffin@namrc.co.uk

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Organisation
Nuclear Advanced Manufacturing Research Centre (Nuclear AMRC)

Facility
Anchor Technology - Simulation & Verification

Location
Brunel Way, Rotherham, S60 5WG

Summary of capability/facility

The Nuclear AMRC's simulation and verification engineers help manufacturers improve productivity and quality. We offer multi-disciplinary support to model, measure, analyse and optimise your production, from overall factory layout to individual manufacturing processes.

Our simulation capabilities include factory modelling, where we use industry-standard tools, to plan and optimise the layout of manufacturing facilities. We can identify potential bottlenecks within the proposed layouts, and make recommendations to maximise your productivity.

We can also model and simulate specific manufacturing processes, using finite element analysis. By understanding the evolution of residual stresses induced during machining and welding, we can predict and mitigate the risk of distortion. Our weld modelling capabilities cover our full range of welding technologies.

Our core research areas encompass:
- Digital manufacturing
- Factory simulation
- Manufacturing process verification
- In-process inspection
- Surface integrity
- Measurement system analysis
- Design for inspection

Instrument specification

- Hexagon - Large CMM (6 x 3 x 2 metres)
- Laser Tracker - Leica AT901 and T-Probe
- Discrete Event Simulation
- Weld NDE Capability
- Surface Residual stress capability
- 3D Optical Microscopy

Nuclear material capabilities (i.e. activity limits)

The Nuclear AMRC's facilities do not have radioactive handling licenses and do not handle active materials.

Related instrumentation/capabilities

Anchor Technology - Additive manufacturing & near-net shaped forming
Anchor Technology - Controls & Instrumentation
Anchor Technology - Digital Environment
Anchor Technology - Modularisation
Anchor Technology - Machining Technologies
Anchor Technology - Joining Technologies

External user access arrangements

The Nuclear AMRC's mission is to help UK businesses to win work in the nuclear and ancillary HVM safety critical sectors and therefore we encourage SME's OEMs and other RTOs to utilise our hardware and SQEP to help the Nuclear AMRC achieve its mission.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Available/ unused	

Other relevant information

Through the Nuclear AMRC's Fit For Nuclear (F4N) programme, which focuses on business systems, we actively engage with the both the nuclear and high-value manufacturing supply-chain network on a regular basis in the form of education and audits to achieve this F4N status.

Contact

Dave Stoddart - Head of Simulation & Verification
dave.stoddart@namrc.co.uk

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Organisation

Nuclear Advanced Manufacturing Research Centre (Nuclear AMRC)

Facility

Anchor Technology - Digital Environment

Location

Brunel Way, Rotherham S60 5WG

Summary of capability/facility

As part of the fourth industrial revolution, industries are developing complete digital models of infrastructure and assemblies that mirror the physical world - a full digital twin, which covers the entire product life-cycle. Machines and sensors that talk to each other through an industrial internet of things, creating integrated cyber-physical systems will help improve productivity and performance.

The Nuclear AMRC's digital environment group works with manufacturers of all sizes to demystify the digital world and increase their readiness for digital transformation across activities including design, analysis, training, validation, production scheduling, condition monitoring and asset tracking.

We can help you evolve your digital manufacturing capabilities, improve digital communication, and effectively use digital technologies that can help you improve performance and reduce waste.

We also use the full range of industrial digital technologies to deliver projects across the UK manufacturing and energy sectors.

Our core research areas encompass:
- Digital SME engagement
- Data pathways
- Cyber security

Instrument specification

Tracked mixed reality cell
- OptiTrack motion tracker
- Valve Index VR & Vive Pro head-mounted displays.
- Microsoft Hololens 2s and various Android devices for augmented reality

Industrial digital technologies testbed
- Internet of things connectivity and development kits, including Arduino Gateway and LoRa-WAN.
- Data acquisition hardware, including NI cRIO systems

Digital support
- Digital architecture for connected systems to improve business and operations efficiency
- Data acquisition for verification and validation of live systems.
- Support on research topics from data-driven systems to quantum encryption systems

Related instrumentation/capabilities

Anchor Technology - Additive manufacturing & near-net shaped forming
Anchor Technology - Controls & Instrumentation
Anchor Technology - Simulation and Verification
Anchor Technology - Modularisation
Anchor Technology - Machining Technologies
Anchor Technology - Joining Technologies

Nuclear material capabilities (i.e. activity limits)

The Nuclear AMRC's facilities do not have radioactive handling licenses and do not handle active materials.

External user access arrangements

The Nuclear AMRC's mission is to help UK businesses to win work in the nuclear and ancillary HVM safety critical sectors and therefore we encourage SME's OEMs and other RTOs to utilise our hardware and SQEP to help the Nuclear AMRC achieve its mission.

Areas instrument used over last 12 months

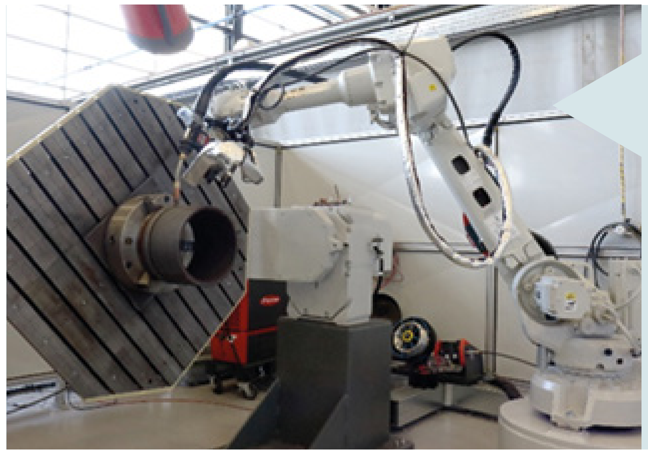
Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

Other relevant information

Through the Nuclear AMRC's Fit For Nuclear (F4N) programme, which focuses on business systems, we actively engage with both the nuclear and high-value manufacturing supply-chain network on a regular basis in the form of education and audits to achieve this F4N status.

Contact

Carl Hitchens - Head of Machining
carl.hitchens@namrc.co.uk



Organisation

Nuclear Advanced Manufacturing Research Centre (Nuclear AMRC)

Facility

Anchor Technology - Joining Technologies

Location

Brunel Way, Rotherham S60 5WG

Summary of capability/facility

Welding R&D at the Nuclear AMRC focuses on developing advanced and innovative joining and surfacing techniques tailored to the needs of the nuclear industry.

Many key components in a nuclear power plant must be manufactured by joining very large sub-components in a way that resists corrosion and achieves and maintains structural integrity under extreme in-service conditions.

Welding on this scale can be a complex task - a single joint between thick-walled nuclear components might require over 100 weld passes using standard arc welding techniques. The repeated heating and cooling can have significant effects on the material properties around the joint, potentially harming the long-term performance of the component.

Our welding team has the resources and experience to help companies develop new and optimised welding processes methods for the most demanding applications.

Our core research areas encompass:
- Power beam technologies
- In-process inspection and monitoring
- Robotic welding and cladding platforms
- Environmentally sustainable manufacturing

Related instrumentation/capabilities

Anchor Technology - Additive manufacturing & near-net shaped forming
Anchor Technology - Digital Environment
Anchor Technology - Simulation and Verification
Anchor Technology - Modularisation

External user access arrangements

The Nuclear AMRC's mission is to help UK businesses to win work in the nuclear and ancillary HVM safety critical sectors and therefore we encourage SME's OEMs and other RTOs to utilise our hardware and SQEP to help the Nuclear AMRC achieve its mission.

Other relevant information

Through the Nuclear AMRC's Fit For Nuclear (F4N) programme, which focuses on business systems, we actively engage with the both the nuclear and high-value manufacturing supply-chain network on a regular basis in the form of education and audits to achieve this F4N status.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

Instrument specification

Pro-Beam K2000 - Electron Beam Welding
- 208 cubic metres vacuum chamber
- Internal mobile 40kW 80kV gun including wire feeds

Pro-Beam K25 - Electron Beam Welding
- 2.5 cubic meters vacuum chamber
- Static 40kW 80kV gun

Diode Laser Cell - 15kW Laserline fibre-coupled diode laser
- Cladding large components up to 3 metres diameter and small-bore cladding down to 70mm and 400mm stroke
- Welding of stainless steels, nickel alloys and wear-resistant alloys

Disk Laser Cell - 16kW Trumpf fibre-coupled disk laser
- Laser-hybrid welding
- Autogenous or wire-fed laser welding

ITW Miller - Submerged Arc Welding Cell
- 15 tonne manipulator with 5 x 5 metres column and boom
- Flexible welding cell for conventional narrow-groove, circumferential and longitudinal welding

Polysoude GTAW Cell
- 7.5 tonne manipulator with 6 x 4 metres column and boom
- Heads include dual hot and cold wire; narrow gap; extremely narrow gap; and keyhole welding

ABB/Fronius Robotic Welding Cell
- Fronius TPS 400i MIG/MAG welding system, with cold metal transfer function for high-speed cladding
- ABB IRB2600 six-axis robot arms and two-axis workpiece positioners
- Fronius MagicWave and PlasmaModule technology with specialist plasma welding torches

K-TIG 1000 Keyhole Welding
- High-speed single-pass full-penetration GTAW system for tubes, pipes and other fabrications

ESAB Planetary SAW
- ESAB A6-MHW submerged arc welding system designed for joining nozzles and access hatches
- Can weld nozzles of 150-1,100mm diameter and 150-750mm height

AMI Tubesheet welding cell
- Specialised GTAW cell for autogenous welding of tubes and tubesheets
- AMI Model 96 and Model 6 weld heads with AMI Model 227 power source

AMI Narrow-groove welding cell
- Orbital welding cell for large and small diameter narrow groove
- AMI Model 52 narrow groove welding head with AMI Model 415 power source

Quintus Hot Isostatic Pressing Facility
- Hot zone of 450mm diameter by 1300mm length, workload up to 1 tonne
- Temperature up to 1450°C, pressure up to 207MPa (30,000psi)

Nuclear material capabilities (i.e. activity limits)

The Nuclear AMRC's facilities do not have radioactive handling licenses and do not handle active materials.

Contact

Dr Will Kyffin - Head of Welding and Materials
will.kyffin@namrc.co.uk

Organisation

Nuclear Advanced Manufacturing Research Centre (Nuclear AMRC)

Facility

Anchor Technology - Machining Technologies, (Subtractive Manufacturing)

Location

Brunel Way, Rotherham S60 5WG

Summary of capability/facility

Machining R&D at the Nuclear AMRC focuses on innovative and optimised processes for large high-value engineered components, along with providing a machining science platform for fundamental early-stage research into pioneering techniques, machinability and material removal studies and cutting tool characterisation.

Our machining research engineers optimise production across a range of technologies to significantly reduce cutting time while maintaining the highest material integrity standards. Working with the full range of stainless and structural steels, we have also performed high-performance assessment on nickel-based superalloys, titanium and refractory metals, e.g. tantalum for the nuclear and wider energy sector. We are now leading research into the machinability of next-generation metals such as high-entropy alloys, targeted as a potential solution for the AMR and STEP programme.

Our research facility in Rotherham hosts a variety of industrially-relevant machine configurations including milling, turning and deep-hole drilling. Work piece capacity can range up to 12 metres in length, five metres diameter, and mass up to 50,000kg (50 metric tonnes).

Our core research areas encompass:
- Advanced coolants
- Next generation machining
- Machining of next generation materials
- In-process inspection and monitoring
- Robotic machining platforms
- Size reduction
- Ancillary metal removal
- Environmentally sustainable manufacturing

Related instrumentation/capabilities

Anchor Technology - Digital Environment
Anchor Technology - Simulation & Verification

External user access arrangements

The Nuclear AMRC's mission is to help UK businesses to win work in the nuclear and ancillary HVM safety critical sectors and therefore we encourage SME's OEMs and other RTOs to utilise our hardware and SQEP to help the Nuclear AMRC achieve its mission.

Other relevant information

Through the Nuclear AMRC's Fit For Nuclear (F4N) programme, which focuses on business systems, we actively engage with the both the nuclear and high-value manufacturing supply-chain network on a regular basis in the form of education and audits to achieve this F4N status.

Instrument specification

Dörries Contumat VTL - Vertical Turning/Milling Lathe
- 5 metres diameter x 3 metres height
- Ultra-high pressure coolant and high speed spindle

Soraluce FX1200 - Large horizontal boring machine
- Work pieces up 12 meters length and 5 metres Diameter
- Five-sided machining

Heckert HEC1800 - Large horizontal boring machine
- Work pieces up to 2.5 meters height and 3.3 metres dia.
- Ultra-high pressure coolant

Heckert HEC800 - Heavy duty machining centre
- milling, turning, drilling and multi-diameter turn-face capabilities

Mori Seiki NT6600 - Multi-axis mill/turn
- Work pieces over 6 metres length and up to 1 metre diameter

Hartford LG-500
- Advanced coolants featuring supercritical carbon dioxide and minimum quantity lubricant systems

Mazak Integrex i-200 - High precision machining
- Advanced coolant featuring liquid carbon dioxide system

Robotic Machining

Nuclear material capabilities (i.e. activity limits)

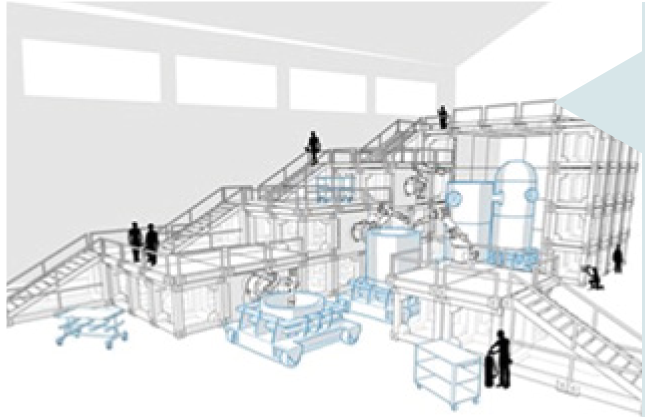
The Nuclear AMRC's facilities do not have radioactive handling licenses and do not handle active materials.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

Contact

Carl Hitchens - Head of Machining
carl.hitchens@namrc.co.uk



Organisation

Nuclear Advanced Manufacturing Research Centre (Nuclear AMRC)

Facility

Anchor Technology - Modularisation

Location

Brunel Way, Rotherham S60 5WG

Summary of capability/facility

Modular manufacturing research at the Nuclear AMRC tackles the challenges of modular production for new reactors of all sizes, as well as for decommissioning and waste management.

Modular manufacturing involves the off-site assembly of large-scale complex systems, which are then transported to site for final installation.

These techniques are already widely used in shipbuilding, aerospace and other safety-critical industries. In the nuclear sector, they can significantly reduce construction risk and help deliver new power stations to schedule and cost.

The Nuclear AMRC focuses on applying and developing modular manufacturing techniques for nuclear applications, from our dedicated facility in Birkenhead hosted by our member company Cammell Laird.

The facility includes a workshop of around 1,000m^2, hosting a range of advanced facilities to meet industry needs, including polymer-based additive manufacturing and visualisation technologies to support modular design.

Our core research areas encompass:
- Through-life modularisation - systematic approach to the modularisation of complex assemblies

Related instrumentation/capabilities

Anchor Technology - Additive manufacturing & near-net shaped forming
Anchor Technology - Joining Technologies
Anchor Technology - Digital Environment
Anchor Technology - Simulation & Verification
Anchor Technology - Modularisation

External user access arrangements

The Nuclear AMRC's mission is to help UK businesses to win work in the nuclear and ancillary HVM safety critical sectors and therefore we encourage SME's OEMs and other RTOs to utilise our hardware and SQEP to help the Nuclear AMRC achieve its mission.

Other relevant information

Through the Nuclear AMRC's Fit For Nuclear (F4N) programme, which focuses on business systems, we actively engage with the both the nuclear and high-value manufacturing supply-chain network on a regular basis in the form of education and audits to achieve this F4N status.

Contact

Miguel Garcia - Head of Modules
miguel.garcia@namrc.co.uk

Instrument specification

Virtalis ActiveWall
- 2.7 metre wide single-screen system with 3D short-throw projection and 4K resolution
- Can be viewed by up to 12 people
- Can be linked to off-site VR facilities for collaborative working.

Wearable VR/AR technology
- Hands-free technology for virtual reality and augmented reality
- Current equipment includes HTC Vive and Microsoft HoloLens
- Applications in collaborative design, training, guided assembly, repair and maintenance

Stratsys F270 3D printer
- Rapid prototyping to support the design process for modular assemblies
- 305 x 254 x 305mm build volume
- Four material spool bays - three for model (ABS-M30, PLA, ASA) and one for support (QSR)
- GrabCAD Print software

Virtual sandbox
- Virtual environment to allow people to naturally and collaboratively explore large complex designs
- Develop low-cost virtual tools and demonstrators to support modularisation
- Create a low-cost alignment and metrology demonstrator for modules, to support the development of a model-based systems engineering (MBSE) and VR tool
- Equipped using low-cost off-the-shelf technology, allowing cost-effective adoption by SMEs

Flow line assembly for modular manufacturing
- Flexible production line to develop and prove modular manufacturing techniques for nuclear applications
- Selection of specialised machining, joining and assembly equipment

Nuclear material capabilities (i.e. activity limits)

The Nuclear AMRC's facilities do not have radioactive handling licenses and do not handle active materials.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Available/ unused	

Organisation
NDA Group

Facility
Multiple

Location
www.nda.gov.uk
17 NDA sites across the UK

Summary of capability/facility

NDA's mission is to clean up the UK's earliest nuclear sites safely, securely and cost effectively. Our 17 nuclear sites are all at different stages of decommissioning and have unique challenges. They include the first fleet of nuclear power stations, research centres and Sellafield, which has the largest radioactive inventory and the most complex facilities to decommission.

Investing in Technology and Innovation Development is fundamental to our strategy, as we strive to accelerate our mission. Our challenges demand innovative and safe engineering solutions.

Across the NDA group we invest around £85 million per year in research and development. We work collaboratively with the supply chain and internationally to access experimental facilities, such as research into geological disposal. We welcome undergraduate and placement students from a variety of universities to work alongside our teams every year and are happy to co-ordinate where possible.

Instrument specification

Facilities vary across the Group.

Radiochemical (destructive and non-destructive) and chemical analysis capabilities are available at Dounreay.

Magnox is currently demonstrating new technologies and decommissioning capabilities at Harwell and Winfrith as it dismantles its research reactors, BEPO, Dragon and SGHWR. This includes BIM modelling to design optimal waste packages and cut sequences, virtual reality techniques to decommissioning operators, robotics with unique end effectors and asbestos control systems to enable rapid maintenance of equipment.

For R&D facilities on the Sellafield site e.g. Central Laboratories, please refer to the relevant NNL entries. Inactive rig hall facilities are also available off site.

Related instrumentation/capabilities

Nuclear material capabilities (i.e. activity limits)

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

External user access arrangements

NDA sites and the experimental facilities on them have restricted access. If you have any specific requirements, please email research@nda.gov.uk and we will try to assist access where possible.

Other relevant information

Contact

research@nda.gov.uk

Organisation
NSG Environmental Ltd

Facility
Waste Encapsulation

Location
Chorley, Lancashire

Summary of capability/facility

NSG has over 35 years' experience in cement solidification, encapsulation technologies and the design of LLW/ILW encapsulation plants. NSG has the understanding and capability to evaluate prospective waste forms against the Nuclear Waste Services acceptance criteria for both LLW and HAW. NSG is the UK's leading expert in the use of polymers to encapsulate radioactive waste and also has experience of working with innovative encapsulation materials such as Nochar.

This capability is supported by NSG's in-house analytical laboratory. Staffed by a team of qualified consultants and technicians, the facility provides scientific testing and formulation underpinning in a controlled environment. The laboratory is furnished with testing equipment to measure shear strength, viscosity, pH, turbidity, particle size distribution, particle density and setting.

NSG also has the capability and facilities to perform larger trials and a mobile grout plant that can be deployed for inactive trials or encapsulating active waste on site.

Instrument specification

- Particle size analysis (Malvern Mastersizer)
- Viscometry (Brookfield RS)
- Compressive strength (ELE 2000)
- Glovebox facility
- Large-scale test material manufacturing plant
- 1,500-litre KNIELE grout plant
- 250-litre grout plant
- 500-litre scale in-drum mixing rig
- 3m3 large liner mixing rig
- IONSIV cartridge filling rig
- Small-scale mixing systems
- Cement powder blending plant
- 33m3 temperature and humidity-controlled sample store
- GGBS bulk powder silo
- CEM1 bulk powder silo

Related instrumentation/capabilities

See NSG Non-Active Trials section.

Nuclear material capabilities (i.e. activity limits)

- Non-active trials facility
- Mobile modular plant for grouting of active wastes (LLW and CHILW)

Areas instrument used over last 12 months

Area	% Usage
Waste Management	100
Advanced Nuclear	
Environmental	
Customer irradiations of devices	
Other (please specify)	
Available/ unused	

External user access arrangements

Please contact James Rudd to discuss access arrangements.

Other relevant information

Please visit www.nsgltd.com for further information.

Contact

James Rudd, Business Development Manager
james.rudd@nsgltd.com
07718 974400

Organisation
NSG Environmental Ltd

Facility
Non-Active Trials

Location
Chorley, Lancashire

Summary of capability/facility

Through the use of smaller scale and full-scale test rigs, NSG has the capability and facilities to practically validate and underpin system designs in a cost-effective manner before proceeding to the detailed design phase of a project. As the project designs develop, NSG also has the in-house processes, resources and a mature supply chain to provide either full-scale system mock-ups that can replicate plant or the actual plant that will be used on site.

NSG is able to supplement this extensive capability with R&D facilities that make up 3,300m² of working area. The Low Bay is often used for proof of concept testing and trials prior to development to full-scale testing within NSG's High Bay facility. The High Bay is capable of housing test rigs up to 20 metres in height that contain a variety of heavy-duty equipment at a wide range of loads.

Instrument specification

Low Bay:
- 12.5-tonne overhead gantry crane
- Large-scale sludge manufacturing plant
- Materials testing laboratory
- 250-litre grout plant
- 500-litre scale in-drum mixing rig
- 3m3 large liner mixing rig
- IONSIV cartridge filling rig
- Small-scale mixing systems
- 33m3 temperature and humidity-controlled sample store

High Bay:
- 20-tonne overhead gantry crane
- 1,500-litre KNIELE grout plant
- GGBS bulk powder silo
- CEM1 bulk powder silo

Related instrumentation/capabilities

See NSG Waste Encapsulation section.

Nuclear material capabilities (i.e. activity limits)

Non-active facility.

Areas instrument used over last 12 months

The fraction of use of ISIS for studies relevant to this area is around 1-2% of total facility usage.

Area	% Usage
Waste Management	100
Advanced Nuclear	
Environmental	
Other (please specify)	
Available/ unused	

External user access arrangements

Please contact James Rudd to discuss access arrangements.

Other relevant information

Please visit www.nsgltd.com for further information.

Contact

James Rudd, Business Development Manager
james.rudd@nsgltd.com
07718 974400

Organisation
Rutherford Appleton Laboratory

Facility
ISIS Neutron and Muon Source. ISIS has a suite of 34 neutron and muon instruments, all bespoke-built

Location
All instruments are located at the ISIS Neutron & Muon Source, Rutherford Appleton Laboratory, Chilton, UK

Image: External view of the ISIS Neutron & Muon Source

Summary of capability/facility

The ISIS Neutron & Muon Source is the UK's national facility for neutron scattering and muon spectroscopy. It is a large science infrastructure serving a user community of 3000 researchers from academia and industry. Its suite of 34 instruments enables materials studies on length scales from atom-level through larger crystalline and molecular structures up to engineering precipitates and on to micron-scale imaging resolution and stress-strain mapping in large engineering objects. In addition, ISIS has around 100 scientific staff who are experts in their areas and who can work with researchers to bring neutron scattering or muon spectroscopy to bear on their problems. Neutron and muon techniques are often complementary to methods such as synchrotron x-rays or NMR.

Specific examples of the sorts of studies that can be undertaken include:

- Crystal structure studies of fuel-related material including studies under pressure
- Structural studies of materials for waste storage
- Engineering stress/strain or defect studies on structural reactor materials
- Imaging to reveal internal structure of components
- Studies of diffusion within reactor materials

Instrument specification

Details of individual ISIS instruments and their characteristics can be found on the ISIS website (https://www.isis.stfc.ac.uk/pages/Instruments.aspx). ISIS instrument scientists are also available to provide advice (contact the ISIS User Office: isisuo@stfc.ac.uk).

Instrument categories include:
- Neutron diffraction - for measuring crystal structures, but also including stress-strain mapping in engineering components as well as studies of disordered materials and liquids
- Neutron spectroscopy - for examining dynamics, including ionic diffusion, phonons, magnetism, molecular vibrational spectroscopy
- Neutron Reflectometry - for studying thin films, surfaces and interfaces including liquid interfaces
- Small angle neutron scattering - for studying larger structures such as precipitates up to 1 micron in size
- Muon spectroscopy - complementary information to neutrons in areas such as magnetism, diffusion studies
- Microelectronics irradiation - for assessing the effects on microelectronics components of neutron irradiation

Instruments have a range of sample environment enabling studies under conditions of variable temperature, pressure and magnetic field, as well as in-situ or in-operando capabilities.

Related instrumentation/capabilities

ISIS has a variety of sample preparation laboratories in addition to a range of on-site lab-based characterisation methods which can be used in conjunction with neutron or muon time at the facility.

Nuclear material capabilities (i.e. activity limits)

ISIS is able to accommodate active samples for study on our beamlines up to individual sample and overall facility limits. Please contact the facility to discuss your requirements in this area.

Areas instrument used over last 12 months

The fraction of use of ISIS for studies relevant to this area is around 1-2% of total facility usage.

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Available/ unused	

External user access arrangements

ISIS has a well-developed external user access programme, including two calls for proposals each year, mechanisms for rapid studies and bespoke routes for industry. Details can be found on the ISIS website (www.isis.stfc.ac.uk) or by contacting the ISIS User Office (isisuo@stfc.ac.uk).

Other relevant information

ISIS welcomes use by researchers unfamiliar with neutron or muon techniques, and our instrument scientists are available to discuss possible projects and the suitability of neutrons or muons.

Contact

Sean Langridge - sean.langridge@stfc.ac.uk 01235 445269
Philip King - philip.king@stfc.ac..uk 01235 446117
ISIS User Office: isisuo@stfc.ac.uk 01235 445592

Organisation
Sheffield Forgemasters

Facility
Casting and Forging solutions for the world's most complex engineering challenges

Location
Brightside Lane, Sheffield UK

Summary of capability/facility

Sheffield Forgemasters specialises in the design and manufacture of high integrity forgings and castings offering a 'one-stop shop' for steel component production from a single site in the UK and seeks out contracts that carry a premium value through their manufacturing complexity and safety critical requirements.

The company also offers design, project management, steel melting, forging, casting, machining, testing and delivery. In addition a number of specialist services are available onsite and through an extensive supplier network.

Some of the largest bespoke engineered steel products in the world are produced at the Brightside Lane facility with capacity for castings of up to 350 tonnes and forgings of up to 200 tonnes finished weight.

The company's history traces back to the 1750's and through many famous Sheffield steel industry names including Vickers, Cammel Laird, English Steel, Firth Brown and British Steel.

Instrument specification

Sheffield Forgemasters' melt shop is equipped with industry leading technology to allow us to produce ultra-clean steel which can then be supplied to our forge and foundry. The forge currently includes two open die forging presses, 4,500 tonne and 10,000 tonne which are capable of handling ingots up to 300 tonnes. The foundry is one of the most agile in the world and can produce finish machined steel components from 1 tonne up to 350 tonnes, with the capability to handle liquid steel volumes of over 600 tonnes at a single time. To complement the forge and foundry our facilities include a vast array of milling, turning, boring and finishing machinery including the UK's largest Vertical Turning Lathe and Horizontal Floor Borer. This allows both cast steel and forged steel components to be supplied rough or finish precision machined to high tolerances.

For more detail on each area please follow the links below:
Design Capabilities
Melt Shop
Forge
Foundry
Heat Treatment
Machining
NDT
Testing

Related instrumentation/capabilities

Sheffield Forgemasters - Research, Design and Technology Capabilities
For Further Information: Sheffield Forgemasters RD&T

Nuclear material capabilities (i.e. activity limits)

Sheffield Forgemasters does not process radioactive nuclear materials, but does manufacture many steel grades & components to all relevant nuclear codes.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Available/ unused	

External user access arrangements

Sheffield Forgemasters provide cast and forged solutions for our customers complex engineering challenges. The company also supports collaborative R&D projects, subcontract materials analysis and testing and design and manufacturing process modelling.

Other relevant information

To learn more about Sheffield Forgemasters please visit:
Home - Sheffield Forgemasters

Contact

Barry Rice - Head of Sales
Sheffield Forgemasters
T: +44 (0)114 244 9071 | M: +44 (0)7714 684770
E: brice@sfel.com

Organisation
Sheffield Forgemasters

Facility
Research, Design and Technology Capabilities

Location
Brightside Lane, Sheffield UK

Summary of capability/facility

Sheffield Forgemasters believes that continual development and improvement is the key to securing its future against global competition.

Consistent with the policy to advance and sustain heavy forging and casting development, Sheffield Forgemasters has complemented its infrastructure with strong links to universities, strategic client partnerships, other manufacturers and centres of technical development in this field. The company has successfully managed and participated in large government funded projects which have had an immediate impact on both productivity and development of new manufacturing processes.

We have conducted R&D projects with customers to improve component quality and reduce production costs and regularly support projects in the manufacture of various steel grades for almost all heavy forging and casting applications. The breadth of kNowledge held by our personnel also means R&D can be supported in a vast array of other alloys and engineering applications.

For Further Information: Sheffield Forgemasters RD&T

Instrument specification

Our dedicated and experienced R&D team at Sheffield Forgemasters use preliminary design software and hardware tools for steel melting, casting and forging prediction and analysis. Preliminary design services can reduce the risks and costs involved in various steps of a steel making process, converting heavily stressed and safety critical fabricated components into an optimal cast or forged steel solution. The department has a variety of analysis equipment, both laboratory based and portable to facilitate process prediction and in-situ verification. Some of our key offerings can be seen below:

- Design for manufacture
- Residual stress prediction
- Forging & shaping simulation
- Solidification (casting) simulation
- Segregation prediction modelling
- Fabrication & welding simulation
- Structural stress modelling
- Heat treatment & cooling simulation
- Mechanical properties prediction
- 3D CAD modelling
- 3D Printing
- Ingot mould design
- Differential scanning calorimetry
- Scanning electron microscopy
- 2D drafting
- 3D solid modelling
- Full finite element analysis
- Hand calculations, loading analysis and fatigue assessments
- Portable large volume & high precision metrology
- Digital image correlation
- Infrared thermography

Related instrumentation/capabilities

Sheffield Forgemasters - Casting and Forging solutions for the World's most complex engineering challenges.For more detail on each area please follow the links below:
Design Capabilities
Melt Shop
Forge
Foundry
Heat Treatment
Machining
NDT
Testing

External user access arrangements

Sheffield Forgemasters has a dedicated and highly qualified Research & Development team. The R&D team provides expert analysis, prediction, modelling and design services to various areas of the Sheffield Forgemasters business. Many consultancy services are also available to our customers and external contracts.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Available/ unused	

Other relevant information

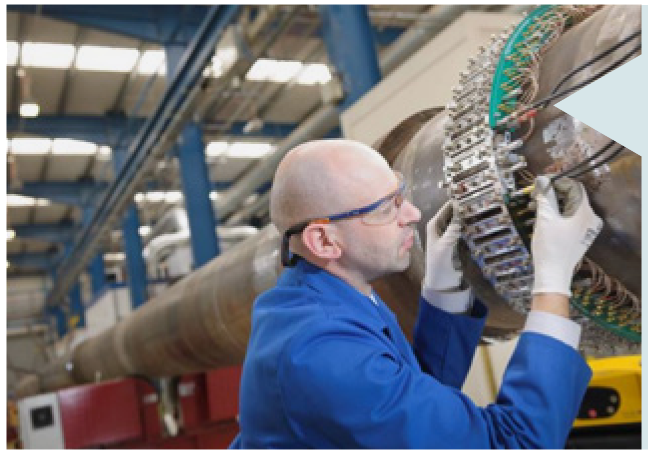
Sheffield Forgemasters continues to explore advanced methods for manufacturing and has developed innovative techniques over the years including simulation, modelling and hollow ingot forging. We have recently demonstrated the effectiveness of Electron Beam welding, up to 200mm depth, of nuclear grade low alloy steels in a single pass. This shows great potential for nuclear applications.

Nuclear material capabilities (i.e. activity limits)

Sheffield Forgemasters does not process radioactive nuclear materials, but does manufacture many steel grades & components to all relevant nuclear codes.

Contact

Marcus Crabbe - Senior Project Manager
Research Design and Technology
T: +44 (0)114 251 9047 | M: +44 (0)7703 608750
E: mcrabbe@sfel.com



Organisation
TWI Ltd

Facility
Advanced Non-Destructive Evaluation (NDE)

Location
Port Talbot, UK, Cambridge, UK, Middlesbrough, UK

Summary of capability/facility

TWI provides world leading NDE consultancy and technology from three UK sites, offering a wide range of products and services:

- TECHNICAL EXPERTISE – World leading capability in development of advanced inspection solutions (automated UT, PAUT, FMC, eddy current array, radiography)
- VALIDATION AND QUALIFICATION - Validation and qualification of inspection procedures, equipment and personnel, compliant with nuclear regulatory bodies and standards
- AUDIT/INDEPENDENT QUALIFICATION - Independent Qualification Body, third party audit services and Level III NDE review of inspection procedures and technical justifications
- REGULATORY COMPLIANCE - Guidance on code compliance and support to working groups for the integration of new technologies for future deployment on nuclear plant
- BESPOKE SOLUTIONS - Capability to develop bespoke solutions for complex geometries, exotic materials and high temperatures. This includes bespoke software modules and libraries able to utilise a wide range of NDE hardware
- TRAINING AND CERTIFICATION – NDE training school and provision of bespoke nuclear specific NDE training

Instrument specification

Extensive range of state-of-the-art laboratory and site deployment NDE equipment operated by experienced staff qualified to ISO 9712 Level II and Level III in a wide range of NDE methods. Some of which includes:
PAUT/FMC:
Zetec Dynaray; Zetec Topaz; Eddyfi Gekko; Olympus Omniscan; PeakNDT MicroPulse 5PA; PeakNDT LTPA.

Eddy current:
Eddyfi Ectane 2 (eddy current array); Olympus Nortec 600; RITEC RAM 5000 (high energy signal generator); Eddyfi Amigo 2 (ACFM).

Radiography:
NSI 240kV XCT; Nikon 225kV XCT; Nikon 450kV XCT; X-Tek 450kV XCT; Portable GemX 160kV x-ray source with Dereo Up portable detector.

Automation and Integration:
Our inspection equipment is underpinned by a systems integration team enabling automated inspection using off the shelf and bespoke scanner manipulators and robotic systems.

Related instrumentation/capabilities

TWI is one of the world's foremost independent research and technology organisations, with expertise in materials, joining and engineering processes. TWI provides engineering consultancy to its Members and stakeholders with authoritative and impartial expert advice, knowhow and safety assurance related to engineering technologies.

Nuclear material capabilities (i.e. activity limits)

None-radioactive materials, only.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

External user access arrangements

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Academic and public-funded collaborative access by arrangement.

Other relevant information

Contact

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Organisation
TWI Ltd

Facility
Polymer and Composite Technologies

Location
Cambridge, UK

Summary of capability/facility

The Polymer & Composite Technologies group capabilities include:

- Materials sourcing, evaluation and failure investigation
- Plastic Welding/Inspection
  - Training and Inspector courses (CSWIP)
  - Weld procedure development
  - Welding assessment for plastic pipes
  - Qualification of welding personnel
- Composites
  - Process design, fabrication, welding
  - Dissimilar materials
  - Thermally-assisted piercing and laser riveting
- Coatings
  - Selection and validation
  - Standardised evaluations. E.g. Environmental, corrosion, CoF, Chemical resistance, reflectivity; Surface energy, Chrome-free primers, Corrosion protective coatings, High performance barrier coatings, Intumescent coatings, Diffusion coatings, Dry film lubrication, Anti-fouling coatings,
- Adhesive bonding
  - Adhesive bonding (joint design, pre-treatment, adhesive selection, dry and wet application)
  - Bond testing (tensile, lap shear, peel, fatigue, etc.)

Instrument specification

- Environmental performance e.g BS EN ISO 1520
- Cyclic corrosion e.g. ASTM B117
- Coefficient of friction e.g. ASTM D1894
- Chemical resistance e.g BS 3900 Part G5
- IR reflectivity assessment e.g ASTM E903 – 12
- Surface energy determination e.g ISO 19403 – 5

Related instrumentation/capabilities

- Metallographic laboratory; Optical microscopes; Scanning electron microscopy (SEM)
- Mechanical testing facilities (tensile, flexural, bend, shear, Peel, Fatigue, Charpy, hardness, Tribometry, etc.)
- Whole pipe creep rupture test
- DSC; FTIR; DMTA; TGA; GC; Surface profilometry; Contact Angle Analyser; GC; Thermal Conductivity; Electrical conductivity.
- Co-ordinate measuring machine (CMM) and a GOM system; In-house machining and fabrication facilities; NDT facilities (radiography, ultrasonic, shearography, X-ray CT etc.)
- Environmental chamber; Autoclaves; Permeation test rig.

Nuclear material capabilities (i.e. activity limits)

Inactive materials only.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	10%
Advanced Nuclear	5%
Environmental	10%
Other (please specify)	Transport 10%, Power 15%, Construction 15%, O&G 25%,
Other (please specify)	
Available/ unused	

External user access arrangements

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Academic and public-funded collaborative access by arrangement.

Other relevant information

Contact

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Organisation
TWI Ltd

Facility
Brazing, diffusion bonding, heat treatment and near-net shape powder metallurgy

Location
TWI Ltd - Granta Park, Cambridge CB21 6AL

Summary of capability/facility

TWI offers a host of services in brazing, diffusion bonding, heat treatment and Near Net Shape Powder Metallurgy (NNS PM). We take pride in offering a full and rounded solution and take great care to ensure that we recommend the techniques that best suit your circumstances, paying particular attention to:

- Process selection
- Power Characterisation and Handling
- Metallurgy
- Component
- HIP canister design and assembly
- Testing

Brazing types covered include torch brazing, vacuum brazing, furnace brazing and induction brazing, and our furnaces can also be used for well-controlled heat treatments, uniaxial hot pressing and powder sintering.
Diffusion bonding types include vacuum, controlled atmosphere and induction heating, as well as transient liquid phase diffusion bonding (diffusion brazing). Both brazing and diffusion bonding offer numerous benefits to a wide range of industry sectors and applications, particularly where there is a need to join dissimilar materials, or parts with complex internal geometries.

Instrument specification

- Uniaxial diffusion bonding furnace (DB7)
  - 300mm(w) x 360mm(d) x 400mm(h)
  - Max. temp 1,600°C and 35kN uniaxial load cell
  - High vacuum, or inert gas partial pressure
  - Modifiable chamber for larger components
  - For uniaxial hot pressing and powder sintering.
- Vacuum brazing furnace (VB1 & VB2)
  - Chamber sizes i)200 dia. x250mm H and ii) 300 dia x 250mm H
  - Max. temp i)1,250°C and ii) 1,350°C
  - High vacuum or Ar partial pressure
  - i) Ar gas quench facility and ii) All metal hot zone
- Industrial scale vacuum furnace (VFE)
  - 750mm(w) x 750mm(h) x 1000mm(d)
  - Max. temp 1,400°C (high vac or Ar or N_2 pp)
  - 1bar gas fan quench capability (Ar or N_2)
  - Up to 5% H_2 gas mixes
- Powder Categorisation & Handling Facilities
  - Flowability (ASTM B213-13), Apparent Density (ASTM 212-09)
  - Powder Size Distribution (ASTM B214), Powder morphology
  - Vibration table

Related instrumentation/capabilities

- Numerical Modelling and Simulation
- Advanced Testing and Analysis
- Advanced Non-Destructive Evaluation
- Materials Performance Facility

Nuclear material capabilities (i.e. activity limits)

None-radioactive materials, only.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

External user access arrangements

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Academic and public-funded collaborative access by arrangement.

Other relevant information

Contact

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Organisation
TWI Ltd

Facility
Friction Welding and Processing

Location
TWI Ltd - Granta Park, Cambridge CB21 6AL and TWI Technology Centre - Wallis Way, Catcliffe, Rotherham S60 5TZ

Summary of capability/facility

TWI is at the forefront of solid-state friction welding and processing technology. Active and innovative in welding research and development since the 1960s, we are responsive to industry needs and provide consultancy services to all industry sectors.

Support for industry includes advice on component design, process selection and quality issues, troubleshooting, feasibility and pre-production trials, application, and prototype equipment development. Also offering short batch or pre-production runs and sub-contract welding.

TWI has been responsible for many key innovations and developments in solid phase joining: friction stir welding was invented at TWI and was rapidly applied by industry; linear friction welding was developed into a mature joining process for turbine blades.
Our core areas of technical expertise include:

- Rotary friction welding (5-100T)
- Friction stir welding (<1- >100mm thickness)
- Linear friction welding (30T)
- Refill friction stir spot welding
- Friction stud/plug welding
- CoreFlow™ - a novel sub-surface channel machining technique

Instrument specification

- FSW machines (Various 3-axis gantry arrangements + head tilt +/-10°)
  - Up to 12 x 6 x 1.6m working envelopes
  - Spindle powers ranging from 60kN, 20kW to 150kN, 132kW
  - Single-sided or simultaneous double-sided welding
  - Reconfigurable worktables
- FlexiFab FSW robot
  - 2x1x2m working envelope
  - 10kN, 12kW
  - Integrated rotary table
  - Seam tracking
- Thompson KUKA E20 30T Hydraulic Linear Friction Welding machine
- Rotary Friction Welding (all 'Direct Drive')
  - 500 -1,000kN force, up to 1500rpm, part dia. Ø10-100mm
- Kawasaki ZX300S robotic arm with 'refill' friction stir spot welding head on c-frame

Related instrumentation/capabilities

- Numerical Modelling and Simulation
- Advanced Testing and Analysis
- Advanced Non-Destructive Evaluation
- Materials Performance Facility

Nuclear material capabilities (i.e. activity limits)

Non-active material only.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	10
Advanced Nuclear	20
Environmental	
Other (please specify)	Other Sectors 50-60%
Other (please specify)	Defence production/repair 10%
Available/ unused	

External user access arrangements

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Academic and public-funded collaborative access via enquiry.

Other relevant information

Contact

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Organisation
TWI Ltd

Facility
Electron Beam Processes

Location
Cambridge, UK CB21 6AL

Summary of capability/facility

TWI is active in the development of new capabilities as well as the deployment TWI is active in the development of new capabilities as well as the deployment of established electron beam (EB) processing and technology at a range of power levels, from high power to low power.
TWI has been active and innovative in EB technology research and development since the 1960s, we are responsive to industry needs and provide consultancy services to all industry sectors, including aerospace, automotive, defence, electronics packaging, medical, oil and gas, power, space and engineering and fabrication.

Support for industry includes advice on component design, process selection and quality issues, troubleshooting, feasibility and pre-production trials, application, and prototype equipment development.
TWI focuses on the following five main themes of expertise:

- In-vacuum-chamber electron beam welding
- Out-vacuum-chamber electron beam welding
- Non-additive processing
- EB additive manufacturing
- Advanced equipment and Quality Assurance solutions
- BeamAssure™ - Electron Beam Quality Assurance tool adopted by manufacturers and end-users to measure key beam parameters

Instrument specification

TWI has various EB machines with a range of accelerating voltage and power (from 60kV, 4kW up to 175kV, 100kW) and vacuum chamber sizes (up to $36m^3$). Maximum single-pass welding in excess of 200mm in steel sections.

- CVE - High power EB equipment - 150kV, 100kW (3x3x4 m chamber)
  - Thick section welding. Large components. Multiple gun positions
- CVE - Medium power EB equipment - 60kV, 4kW
  - EB welding, Direct Energy Deposition (DED) with wire, and surface modification. Multiple gun positions. Process monitoring and control
- Steigerwald - High power EB equipment – 150kV, 15kW
  - Ultra-clean processing - dry pumped, high vacuum (5x10-5 mbar). Multiple gun positions. BSE imaging. Down-bore welding gun and vision. Advance control and monitoring of machine and process data
- xBeam Coaxial wire-feeder system - 20kV, 18kW (3x3x4 m chamber)
  - Direct Energy Deposition systems. Plasma cathode and conical electron beam. In-chamber video capability.
- Freemelt EB Powder Bed Fusion equipment
- Demagnetisation kit and modelling tools
  - Diverse's Zeromag demagnetiser suitable for large components. Maximum possible magnetic field strength, H = 2200 Ampere-turns per metre of magnetic path length. Monitored demagnetisation cycle. Modelling software for magnetic flux

Related instrumentation/capabilities

- Numerical Modelling and Simulation
- Advanced Testing and Analysis
- Advanced Non-Destructive Evaluation
- Materials Performance Facility

Nuclear material capabilities (i.e. activity limits)

Non-active material only.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

External user access arrangements

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Academic and public-funded, collaborative access agreed by arrangement.

Other relevant information

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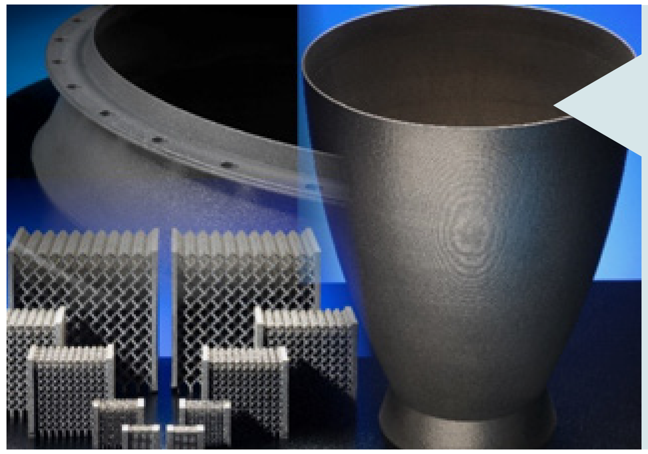

Organisation
TWI Ltd

Facility
Laser additive manufacturing

Location
Rotherham, UK S60 5TZ

Summary of capability/facility

TWI provides companies with support covering every aspect of metal additive manufacturing (AM), from simple feasibility and fabrication projects to full adoption and integration of metal AM systems, alongside supporting industry towards AM lab qualification and part certification.
As well as completing one-off manufacturing contracts, we can offer complete guidance relating to every stage of the AM adoption process for businesses considering acquiring this technology. We can also help companies already using it to maximise the effectiveness of the process and identify components suitable for AM in their product portfolio.
Our AM support covers everything from initial feasibility studies and business case proposals, numerical modelling and topology optimisation, and material and process selection, to finishing, heat treatments, testing, certification and validation, as well as relevant standards.
This laboratory, based at the TWI Yorkshire facility, is home to laser-based Powder Bed Fusion (PBF-LB) AND Directed Energy Deposition (DED) technologies. Selective Laser Melting equipment (powder bed) and Laser Metal Deposition equipment (LMD). Alongside its AM activity, the laboratory is also able to apply functional coatings and repair a variety of complex, engineering components for reintroduction into service.

Instrument specification

- TRUMPF 4x2x1.5m Gantry DED system (wire and power)
- TRUMPF 2x1x0.75m Gantry DED system (wire and power)
- Two robotic DED systems, capable of feeding powder or wire
- EOS M290 PBF system plus supporting equipment for powder sieving and preparation
- Hornet Extreme High speed laser application (EHLA) for high speed application of coatings and claddings

Related instrumentation/capabilities

- Numerical Modelling and Simulation
- Laser processing - joining, cutting and surface engineering
- Advanced Testing and Analysis
- Advanced Non-Destructive Evaluation
- Materials Performance Facility

Nuclear material capabilities (i.e. activity limits)

Non-active material only.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

External user access arrangements

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Other relevant information

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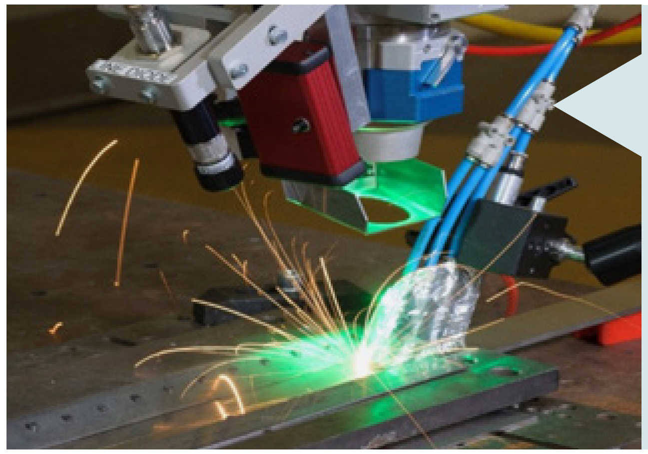

Organisation
TWI Ltd

Facility
Laser processing - joining, cutting and surface engineering

Location
Cambridge, UK CB21 6AL

Summary of capability/facility

Laser technology is currently used in a wide variety of industrial processes including cutting, welding, marking, surface engineering, repair and direct parts fabrication. The range of applications covers metals, plastics, semiconductors and ceramics, on a scale from sub-micron to several metres.
TWI has been at the forefront of using lasers for materials processing since the mid-1960s, and provides world-leading support to many industries, including the power, automotive, medical, shipbuilding and aerospace sectors.
TWI has significant experience in the development and application of laser materials processes for metals and non-metals. Our activities are supported by state-of-the-art laboratories, which include the widest range of industrial laser systems and laser sources in the UK.
Our core areas of technical expertise include:

- Laser welding
- Hybrid laser-arc welding
- Laser brazing
- Laser cutting
- Laser surface engineering
- Laser processing of polymers
- Decommissioning using lasers
- Laser Metal Deposition (LMD)
- Selective Laser Melting (SLM)
- Laser process monitoring for quality control and assurance.

Instrument specification

Various lasers sources:

- 10kW multi-mode Yb-fibre laser (2-way beam switch)
- 5kW multi-mode Yb-fibre laser (4 beam switch)
- 1.5kW and 2kW single mode Yb-fibre lasers
- 600W (CW)/6kW (pulsed) QCW Yb-fibre laser
- 5MW peak power picosecond (<15ps) laser
- >10 kW peak power nanosecond (3 -520 ns) laser
- 200W LD-Heater diode laser with real-time temperature monitoring functionality

Manipulation capability:

- 7-axis arm robots + x,y gantry tables
- Tau robot platform for laser welding large structures (3mx1mx1m)
- Novel optics scanning heads (AS-50 Raylase scanning head, 3D Arges scanning head, D30 scanning head, D50 wobble head

Process monitoring:

- LDD-700 In-Weld keyhole depth sensor
- Camera sensors for keyhole stability monitoring

Related instrumentation/capabilities

- Numerical Modelling and Simulation
- Laser additive manufacturing
- Advanced Testing and Analysis
- Advanced Non-Destructive Evaluation
- Materials Performance Facility

Nuclear material capabilities (i.e. activity limits)

Non-active material only.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

External user access arrangements

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Academic and public-funded, collaborative access agreed by arrangement.

Other relevant information

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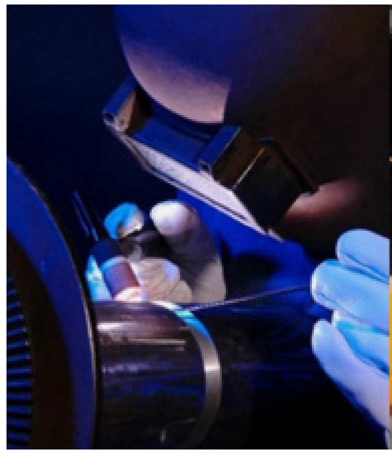

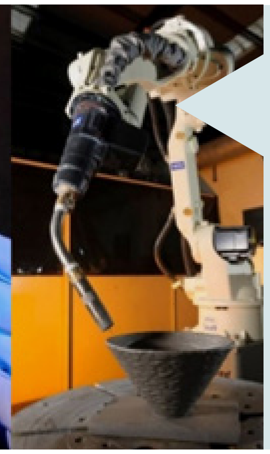

Organisation
TWI Ltd

Facility
Arc Processes and Welding Engineering

Location
Cambridge, UK CB21 6AL

Summary of capability/facility

Since its beginnings as the British Welding Research Association in 1946, TWI has been at the forefront of arc welding development.
Our achievements include developing carbon dioxide shielding for MIG/MAG welding, making the process viable for welding carbon steel, and building the first solid-state power sources, paving the way for thyristor and inverter technology.
Processes:

- Plasma arc welding
- Hybrid laser-arc welding
- Metal inert gas (MIG) welding
- Manual metal arc (MMA) welding
- Submerged arc welding
- Tungsten inert gas (TIG) welding
- Underwater welding

Supporting services:

- High-productivity welding
- Distortion control
- Arc welding automation
- Welding fume assessment
- Health, safety and environmental testing
- EMF measurement
- Facilities and equipment

Research and development:

- Cold temper bead arc welding in the context of austenitic cladding on ferritic base metal
- Additive manufacturing – generating information for arc-based additive manufacturing (AM) covering materials selection, material properties and microstructure, deposition rate and process economics and reliability
- Weld monitoring – developing a system able to predicting or determining the incidence of defects in real time

Instrument specification

- Kawasaki RA10L, 6-axis, max. payload 10kg, max. reach 1925mm, TIG/Plasma/MIG/MAG capable, current integration: Fronius TPS600i PMC MIG/MAG welding power source - 600A at 60% DC/500A at 100% DC.
- Fanuc ARC Mate 120iC, 6-axis, max. payload 20kg, max. reach 1811mm, MIG/MAG capable, current integration: Fronius CMT Advanced 4000R MIG/MAG welding power source, 2-axis positioner max. payload 500kg - 400A at 50% DC/320A at 100% DC.
- KUKA KR16-3S, 6-axis, max. payload 16kg, max. reach 1611mm, TIG/Plasma/MIG/MAG capable, current integration: SBI PMI350 AC/DC Plasma/TIG welding power source - 350A at 35% DC/290A at 100% DC.
- Daihen OTC FD-B4, 6-axis, max. payload 4kg, max. reach 1411mm, MIG/MAG capable, current integration: Daihen OTC Welbee P500L Synchro-feed MIG/MAG welding power source, 2-axis positioner max. payload 500kg.
- Polysoude PC600 (hot-wire) TIG/Plasma power source with mechanised linear Polycar torch delivery system - 600A at 60% DC/500A at 100% DC.
- AMI 227 pulsed TIG power source with Model M9500C, M91500, M95-1500 and M81 welding heads - 225A at 100% DC, OD range: 35-136mm.
- Kemmpi Mastertig 335 ACDC manual TIG/MMA welding power source with micro-spot capability - 300A at 40% DC/190A at 100% DC.
- EWM T270 Tetrix hotwire power source (80A max).
- Gullco AutoTIG 500 mechanised linear welding/cladding manipulation system with integrated wire feed and oscillation capability
- 2 x Stork Cooper Heat pre-heat and post-weld heat treatment modules
- Miller Proheat 35 induction heating system
- 2 x HDR camera systems for weld monitoring
- Range of standalone rotary manipulators with programmable speed and position.

Nuclear material capabilities (i.e. activity limits)

Non-active material only.

Related instrumentation/capabilities

- Numerical Modelling and Simulation
- Advanced Testing and Analysis
- Advanced Non-Destructive Evaluation
- Materials Performance Facility

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

External user access arrangements

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Academic and public-funded, collaborative access agreed by arrangement.

Other relevant information

Contact

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Organisation
TWI Ltd

Facility
Materials Performance Facility

Location
Cambridge, UK

Summary of capability/facility

Our facilities and systems span the full range of methods for assessing the properties and structural integrity of materials and products; both to (International/National) standards and bespoke to customer requirements.

TWI offers both non-destructive and destructive testing services for metals, composites, polymers, resins and elastomers to determine properties, performance, strength, durability and resistance to factors such as corrosion and fatigue. Our high quality material inspection services help you to ensure that your materials are compliant to standards, safe and fit for purpose. Our materials testing services include aggressive environment testing, corrosion tests, fatigue and mechanical testing, fatigue tests, hydrogen testing, residual stress measurement and welded polymer testing.

TWI's materials testing laboratories include fracture, fatigue, corrosion, environmental testing and combinations of these test methods. This is supported by a range of material analysis and characterisation equipment, as well as non-destructive testing and condition monitoring capabilities.

Instrument specification

Standard and bespoke testing
- Aggressive environment testing – fracture and fatigue testing in sour (H_2S), sweet (CO_2) and other corrosive environments; at a range of temperatures and pressures.
- Corrosion testing – covering aqueous, small scale testing
- Fracture and mechanical testing
- Fatigue testing
- High-pressure hydrogen testing facility
- Residual stress measurement
- Welded polymer testing

Full-scale testing facilities
- Full scale chain test-rig
- Pressure pit
- Resonance testing

Non-destructive testing and condition monitoring systems
- NDT testing
- Condition monitoring

Related instrumentation/capabilities

- Permeation testing facility
- 3D non-contact profilometer
- Automated light microscope and image analyser
- Enhanced high-pressure, high-temperature sour testing facility
- Environmental scanning electron microscope
- Field emission gun scanning electron microscope
- Large-scale thermal and cold spraying facility
- X-ray diffractometer

Nuclear material capabilities (i.e. activity limits)

Non-active materials only

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

External user access arrangements

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Academic and public-funded, collaborative access agreed by arrangement.

Other relevant information

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Organisation
TWI Ltd

Facility
Advanced Testing and Analysis

Location
Cambridge, UK CB21 6AL

Summary of capability/facility

TWI's fatigue specialists draw on many decades of accumulated research and expertise in fatigue analysis, design, assessment and testing, covering all industry sectors.

We provide:
- Consultancy on fatigue design and assessment
- Instrumentation and strain monitoring of structures
- Fatigue crack repair and life extension
- Residual stress measurement
- Fatigue testing of materials and components
- Fatigue testing of materials in a corrosive environment
- Resonance fatigue testing

TWI guidance, Fatigue design rules for welded steel joints, informed the progenitors of many of today's national and international fatigue design standards. We continue to participate in standards committees and play a leading role in the development of many current standards, including BS 7608:2014, BS 7910:2013, Eurocode 3 and IIW guidance documents. Our involvement with standards committees, along with other national and international committees overseeing design issues, makes us uniquely placed to provide expert guidance on fatigue design, whether you are seeking instant advice on code interpretation or a comprehensive fatigue assessment study.

Instrument specification

Our assets include the following:
- Wide range of universal fatigue testing machines, maximum load 2500kN, loading frequency 0.001-200Hz, for endurance fatigue testing in air
- Bespoke mooring chain test rig with a 6000kN load capacity
- Four large-scale rigs capable of maximum loads up to 40MN for full-scale component fatigue endurance testing in air
- Smaller-capacity machines for fatigue crack growth testing in air or seawater environments (SENB specimens as standard)
- Seven resonance fatigue test machines accommodating pipes with diameters between 6" - 36"
- Unique experience of data analysis and interpretation.

Related instrumentation/capabilities

- High- and low-cycle testing of parent materials
- Fatigue endurance testing of welded specimens
- Constant- and variable-amplitude testing
- Fatigue crack growth rate testing for parent materials, weld metal and heat-affected zone
- Bespoke full-scale tests on large structural connections.

Nuclear material capabilities (i.e. activity limits)

Non-active materials only

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

External user access arrangements

TWI provides its Industrial Members with access to state-of-the-art facilities and equipment. Being a member of TWI today means being part of an organisation that brings together a staff of hundreds of expert engineers and scientists. With 75 years of experience and expansion we have acquired tens of millions of pounds' worth of cutting-edge facilities and equipment accessible across 6000m² of workshop and lab space across our 4 main UK sites.

Academic and public-funded, collaborative access agreed by arrangement.

Other relevant information

Contact

Alec Gunner
Materials and Structural Integrity
alec.gunner@twi.co.uk

Organisation
TWI Ltd

Facility
Asset Management Facility

Location
Cambridge, UK CB21 6AL

Summary of capability/facility

Managing structural integrity is fundamental to ensure engineered structures and components remain safe and productive.

Effective inspection and risk management minimises the risk of catastrophic failure and the likelihood of having to take components out of service, maximises operational efficiency, and promotes asset life extension.
Over the last 40 years, TWI has developed world-leading capabilities in structural integrity management, including fitness-for-service, NDT and other inspection and testing services, condition and structural health monitoring, and decommissioning.

A multidisciplinary team of more than 150 consultants, engineers and technicians design and progress asset you in integrity management strategies to help you avoid engineering failure, ensure regulatory compliance and optimise operating expenditure.

Related instrumentation/capabilities

- 'Fitness for Service' assessments
- Finite Element Analysis
- Risk-based inspection/Probabilistic Engineering Critical Assessment

External user access arrangements

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Academic and public-funded, collaborative access agreed by arrangement.

Other relevant information

Instrument specification

- 2500kN servo-hydraulic fatigue test machine
- 3D laser scanning vibrometer
- 3D X-ray microscope
- 750 joule Charpy impact testing machine
- Acoustic emission measurement system
- Air-cooled vibration testing facility
- Computed radiography digital imaging system
- High-rate servo-hydraulic test machine
- Laser-ultrasonic system
- Seven-axis ultrasonic immersion tank

Nuclear material capabilities (i.e. activity limits)

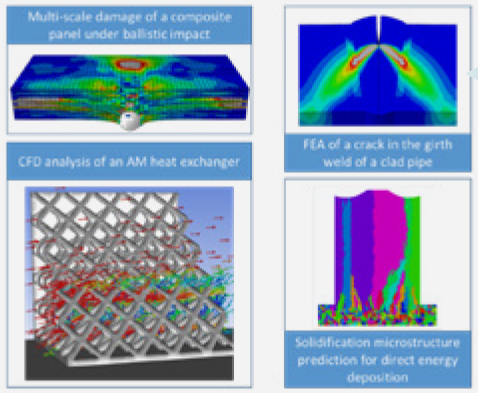
Non-active materials only

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

Contact

Alec Gunner
Materials and Structural Integrity
alec.gunner@twi.co.uk



Organisation
TWI Ltd

Facility
Numerical Modelling and Simulation

Location
TWI Technology Centre - Riverside Park Industrial Estate, Ferrous Rd, Middlesbrough TS2 1DJ

Summary of capability/facility

Computational engineering and mathematical modelling can provide significant cost and time-savings from the design stage through to the management of in-service behaviour and that of aging assets. TWI uses a range of technologies such as finite element analysis (FEA), computational fluid dynamics (CFD), and mathematical programming to understand how materials and structures behave and evolve from fabrication and manufacturing to installation and operation. Underpinning TWI's modelling capability is a focus on manufacturing process simulations: translating welding, joining and additive processes into models that can predict key performance indicators such as distortion, residual stress and microstructure evolution.

TWI's expertise lies in its breadth of experience in applying and validating welding and joining simulations covering most metal alloys (and non-metallics) and industrial applications. By identifying the most suitable modelling approach, TWI can deliver effective and reliable solutions to meet our customer requirements.
Examples of previous work on manufacturing process simulations include:

- Minimising the distortion of a complex, lightweight ship panel containing over 150 different welds by optimising weld sequence
- Simulating the electron beam welding of thick section pressure vessels to understand residual stresses and their influence on defect tolerance
- Modelling friction stir welding using techniques such as computational fluid dynamics (CFD) or so-called Eulerian techniques
- Predicting residual stresses and distortion in additively manufactured (AM) parts made out of Ti-, Al- and Ni-base alloys. TWI's expertise is AM process simulations is internationally recognised.
- Analysing the influence of global and local post-weld heat treatment to quantify stress relaxation

Related instrumentation/capabilities

- Advanced Testing and Analysis
- Advanced Non-Destructive Evaluation
- Materials performance and degradation
- Probabilistic assessment

External user access arrangements

TWI provides its Industrial Members with access to state-of-the-art facilities and equipment. Being a member of TWI today means being part of an organisation that brings together a staff of hundreds of expert engineers and scientists. With 75 years of experience and expansion we have acquired tens of millions of pounds' worth of cutting-edge facilities and equipment accessible across 6000m² of workshop and lab space across our 4 main UK sites.

Academic and public-funded, collaborative access agreed by arrangement.

Other relevant information

Instrument specification

Commercial computational engineering software such as the FEA software
- Abaqus
- COMSOL Multiphysics
- ANSYS Fluent

along with mathematical modelling tools, such as
- MATLAB
- Python
- FORTRAN
- DesignExpert.

Plus associated hardware for very high-performance computing.

Nuclear material capabilities (i.e. activity limits)

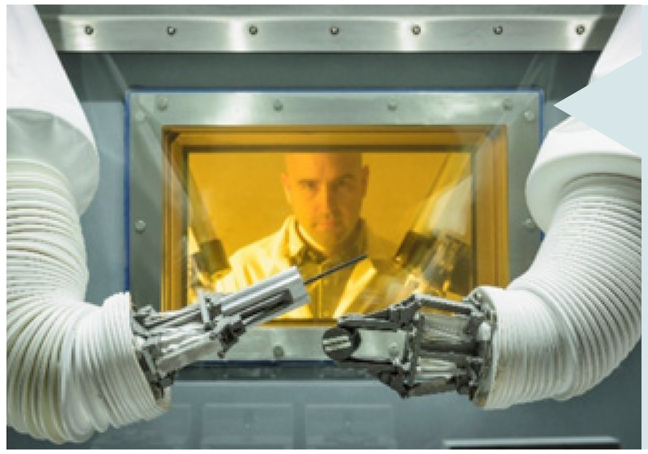
Non-radioactive materials, only

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

Contact

Vito Di Pietro
Advanced Manufacturing Technologies
vito.dipietro@twi.co.uk
+44 (0) 1223 899 321



Organisation
UK Atomic Energy Authority (UKAEA)

Facility
Materials Research Facility (MRF)

Location
Culham Science Centre, Abingdon, OX14 3EB

Summary of capability/facility

The Materials Research Facility (MRF) comprises the fixed infrastructure for handling, storage, preparation, and characterisation of active samples up to 3.75GBq*. This infrastructure comprises hot cells, transport trolleys and shielded research rooms housing the MRF's microstructural, thermophysical and mechanical test suites.
The MRF infrastructure enables the receipt of samples directly into the hot cell line (including large flasks), sample preparation, and internal transport to a shielded research room housing the instrument to be used. The MRF is thus an integrated facility for the characterisation of active samples outside of a nuclear licensed site.
Future MRF capabilities delivered as part of National Nuclear User Facility 2a will include the acquisition of a plasma Focused Ion Beam (FIB), Transmission Electron Microscopy (TEM), high vacuum Differential Scanning Calorimetry (DSC), X-Ray Diffraction (XRD) focussing optics and heating stage and in-situ piezo test stage available from January 2023. Additionally, from 2024 an active sample fabrication facility along with a 20kN load frame will be available, housed within the hot cell line.

* ^{60}Co equivalent activity.

Instrument specification

Please refer to entries for the specific instrument suites for detailed information.

Related instrumentation/capabilities

MRF Microstructural Suite
MRF Thermophysical Suite
MRF Mechanical Test Suite

Nuclear material capabilities (i.e. activity limits)

β/γ 3.75 TBq* total facility inventory.
α 1MBq facility limit.
3.75GBq* individual sample activity limit
* ^{60}Co equivalent activity.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

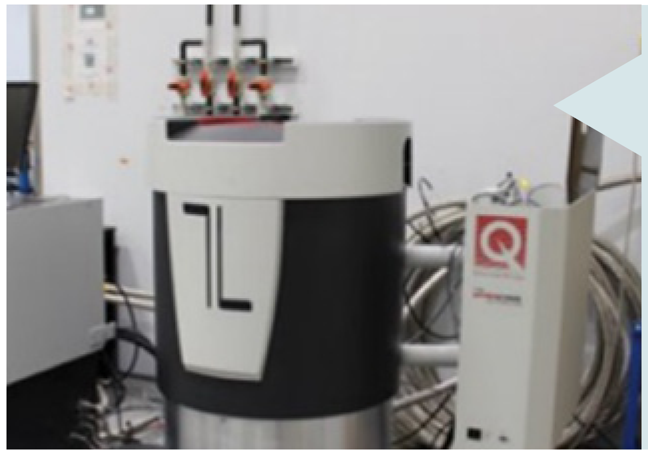
External user access arrangements

The MRF offers external access through both the Henry Royce Institute and National Nuclear User Facility access schemes. Additionally, the MRF offers direct external access to both academic and industrial users.

Other relevant information

Contact

Andy London, Active testing lead - andy.london@ukaea.uk
Ed Eardley, MRF Scientific Manager - ed.eardley@ukaea.uk
Kate Breach, MRF administrator - kate.breach@ukaea.uk



Organisation
UK Atomic Energy Authority (UKAEA)

Facility
Materials Research Facility (MRF), Thermophysical Suite

Location
Culham Science Centre, Abingdon, OX14 3EB

Summary of capability/facility

The thermophysical instrument suite within the MRF comprises a laser flash analyser, combined differential scanning calorimetry and thermogravimetric analysis, dilatometry, physical properties measurement system, thermal desorption spectrometry and ion exposure and impregnation facilities. The facilities of the MRF allows the characterisation of individual samples up to 3.75GBq*. The thermophysical suite aligns with both the microstructural and mechanical testing suites housed within the MRF to offer an integrated user facility for the preparation, testing and characterisation of active materials outside of a licensed nuclear site.

A high vacuum flash DSC system will be available from the beginning of 2023.

* ^{60}Co equivalent activity.

Instrument specification

Present facilities include laser flash analyser, combined differential scanning calorimetry and thermogravimetric analysis, dilatometry, physical properties measurement system, thermal desorption spectrometry and ion exposure and impregnation facilities.
From 2023: High Vacuum flash DSC

Related instrumentation/capabilities

UKAEA Materials Research Facility
MRF Mechanical Test Suite
MRF Microstructural Suite

Nuclear material capabilities (i.e. activity limits)

3.75GBq Co^{60} equivalent individual β/γ sample activity limit.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

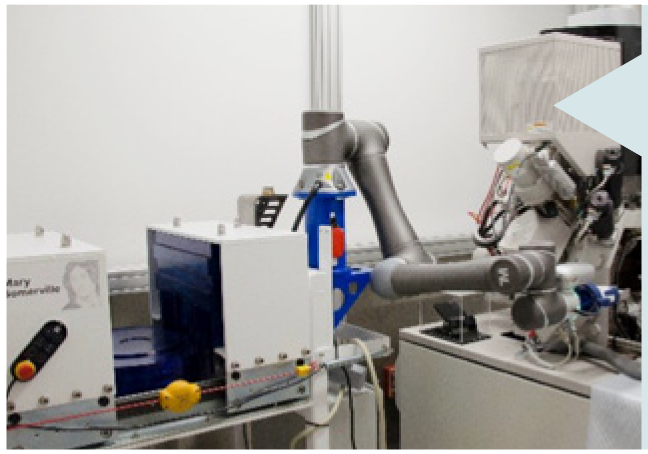
External user access arrangements

Visitors are provided with protective eyewear when touring the laboratory and will be escorted by one of the materials and chemistry team. Visitor tours include demonstrations of the molten salt in actions, high temperature materials testing oven, and corrosion trial coupons.

Other relevant information

Contact

Andy London, Active testing lead - andy.london@ukaea.uk
Ed Eardley, MRF Scientific Manager - ed.eardley@ukaea.uk
Kate Breach, MRF administrator - kate.breach@ukaea.uk



Organisation
UK Atomic Energy Authority (UKAEA)

Facility
Materials Research Facility (MRF), Microstructural Suite

Location
Culham Science Centre, Abingdon, OX14 3EB

Summary of capability/facility

The microstructural instrument suite within the MRF comprises of an analytical Scanning Electron Microscopy (SEM) with Electron Backscatter Diffraction (EBSD) and Energy-dispersive X-ray spectroscopy (EDS), a conventional Gallium Focused Ion Beam (FIB), a high source brightness Xray diffractometer, confocal laser scanning microscope and atomic force microscope. The facilities of the MRF allows the examination of individual samples up to 3.75GBq*. The microstructural suite aligns with both the thermophysical and mechanical testing suites housed within the MRF to offer an integrated user facility for the preparation, testing and characterisation of active materials outside of a licensed nuclear site.

Additional instrumentation available from the beginning of 2023 as part of NNUF2a will include a plasma FIB with EDS and EBSD, TEM, focussing optics and heating stage for the XRD, alongside EBSD and cryogenic stage for the gallium FIB. Cryogenic vacuum transfer will be also available between instruments and external institutions for small FIB-excised TEM foils and APT needles at background activity.

* ^{60}Co equivalent activity.

Instrument specification

Present facilities include SEM with EDS and EBSD, Gallium FIB, Confocal Laser Scanning Microscopy (CLSM) Raman, X-Ray Diffraction (XRD) and Atomic Force Microscopy (AFM).
From 2023: Plasma FIB and Transmission Electron Microscopy (TEM), XRD Upgrades, FIB Upgrades

Related instrumentation/capabilities

UKAEA Materials Research Facility
MRF Thermophysical Suite
MRF Mechanical Test Suite

Nuclear material capabilities (i.e. activity limits)

3.75GBq ^{60}Co equivalent individual β/γ sample activity limit

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

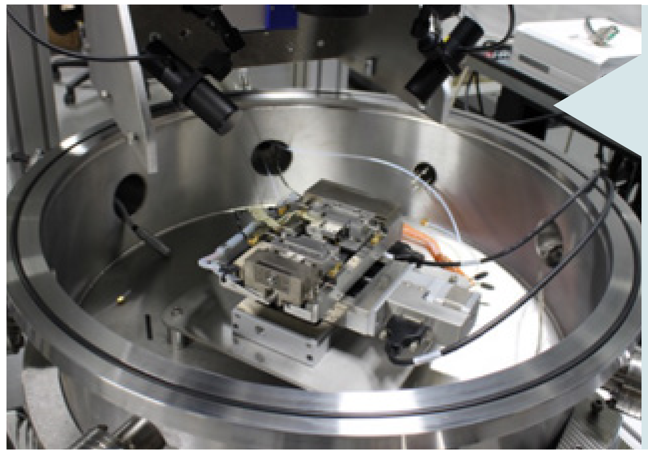
External user access arrangements

The MRF offers external access through both the Henry Royce Institute and National Nuclear User Facility access schemes. Additionally, the MRF offers direct external access to both academic and industrial users.

Other relevant information

Contact

Andy London, Active testing lead - andy.london@ukaea.uk
Ed Eardley, MRF Scientific Manager - ed.eardley@ukaea.uk
Kate Breach, MRF administrator - kate.breach@ukaea.uk



Organisation
UK Atomic Energy Authority (UKAEA)

Facility
Materials Research Facility (MRF), Mechanical Test Suite

Location
Culham Science Centre, Abingdon, OX14 3EB

Summary of capability/facility

The Mechanical Test Suite within the MRF comprises impulse excitation testing, instrumented and nano indenters, a 5kN miniature load frame with elevated temperature in vacuum and DIC, 10kN static and 15kN dynamic load frames and ultrasonic fatigue testing. The mechanical test suite aligns with both the thermophysical and microstructural suites housed within the MRF to offer an integrated user facility for the preparation, testing and characterisation of active materials outside of a licensed nuclear site.

A Piezo driven indenter for use in-situ within an SEM chamber including at elevated temperature will be available from January 2023 as part of National Nuclear User Facility 2a (NNUF2a). Additionally, sample fabrication equipment comprising milling, Electrical Discharge Machining (EDM), and laser cutting will be installed within hot cells alongside a 20kN hydraulic fatigue load frame to enable testing of highly active bulk samples - available from January 2024.

Instrument specification

Present facilities include instrumented and nano indentation, dynamic and static load frames, digital image correlation, high temperature testing.
From 2023: in situ testing within the Scanning Electron Microscopy (SEM)
From 2024: Hot Cell machining and testing capability

Related instrumentation/capabilities

UKAEA Materials Research Facility
MRF Thermophysical Suite
MRF Microstructural Suite

Nuclear material capabilities (i.e. activity limits)

3.75GBq ^{60}Co equivalent individual β/γ sample activity limit.
Mechanical testing of samples of increased activity will be possible as part of MRF Hot Cell Extension project - available from January 2024

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

External user access arrangements

The MRF offers external access through both the Henry Royce Institute and National Nuclear User Facility access schemes. Additionally, the MRF offers direct external access to both academic and industrial users.

Other relevant information

Contact

Andy London, Active testing lead - andy.london@ukaea.uk
Ed Eardley, MRF Scientific Manager - ed.eardley@ukaea.uk
Kate Breach, MRF administrator - kate.breach@ukaea.uk

Organisation
UK Atomic Energy Authority (UKAEA)

Facility
Fusion Technology - Applied Materials Laboratory

Location
Culham Science Centre, Abingdon, OX14 3EB

Summary of capability/facility

The primary aim of the Applied Materials Laboratory is to provide assurance of the mechanical performance of materials in demanding fusion environments. While the primary output of this laboratory is mechanical test data supporting materials property handbooks for fusion reactor designs, significant resource is dedicated to the development of specialist capability to establish and accelerate materials readiness. These capabilities include: development of full-field strain measurement via Digital Image Correlation (DIC) across multiple length scales, High-Resolution imaging (HR-DIC) for Scanning Electron Microscopy (SEM)-based in situ mechanical testing; Small-Scale Testing Techniques (SSTT) for eventual application on irradiated specimens; and data acquisition of the above under demanding environments (e.g., cryogenic and elevated temperature mechanical testing).

Instrument specification

Quasi-static tension/compression testing:
- Instron 5966, 10 kN load, -150°C < T < 600°C
- Instron 5965, 5 kN load, -150°C < T < 300°C

Dynamic (fatigue) testing:
- Instron Electropuls E3000 (Tension + Torsion), ± 3 kN load, T = RT

Quasi-static small-punch testing:
- Odin (Phoenix), 7.5 kN load, RT < T < 1000°C
- Thor (Phoenix), 5.0 kN load, RT < T < 700°C

Hardness testing (ambient):
- Leco AMH43, 10 gf-1 kgf load
- Innovatest Falcon 500, 10 gf-2 kgf load
- Frontics AIS3000HD, up to 120 kgf, instrumented

Microscopy
- SEM: Zeiss EVO 10 LaB6, Oxford Instruments CMOS, Symmetry EBSD and Ultim Max EDX
- In situ loading rig: Newtec MT1000, -150°C <T < 150°C or RT < T < 900°C, 5 kN load, tension, compression, bending

Complex environment testing:
- (2022 delivery) Small-scale cryogenic testing rig, 50 kN load, -190°C < T < RT
- (2022 delivery) Pheonix tension-torsion rig, 50 kN load, RT < T < 1200°C
- (2023 delivery) Cryogenic testing rig, 100 kN load, 4 K < T < RT

Related instrumentation/capabilities

UKAEA Materials Research Facility
MRF Thermophysical Suite
MRF Microstructural Suite

Nuclear material capabilities (i.e. activity limits)

Some equipment offers full-field (DIC) strain measurement capability. Small-scale testing capabilities include micro-C(T), mini-tensile, small punch, shear punch, and instrumented indentation.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	75
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	25

External user access arrangements

Enquire via key contacts listed. External access may be granted based on equipment availability outside internal project

Other relevant information

The FT Applied Materials Laboratory will be moving into a new, purpose-built facility in Q3 2022. While this will offer a significantly improved user experience, some equipment downtime is expected during this time.

Contact

Cory Hamelin
cory.hamelin@ukaea.uk
01235 467254

Paul Kilgallon
paul.kilgallon@ukaea.uk
01235 466750

Organisation
UK Atomic Energy Authority (UKAEA)

Facility
Radiological Assay and Detection Lab (RADLab)

Location
Culham Science Centre, Abingdon, OX14 3EB

Image: Compton Suppression System surrounding the BEGe detector copyright Kimberley Lennon

Summary of capability/facility

The RADLab is a facility with multiple radiometric systems, including HPGe, diamond detectors, liquid scintillators, Thermoluminescent Dosimeter (TLD) reading capabilities, and a passive neutron spectrometer (which is currently under development as R&D).
The RADLab houses Advanced Digital Radiometric Instrumentation for Applied Nuclear Activities (ADRIANA) which is a suite of digital radiometric instrumentation which forms part of National Nuclear User Facility (NNUF) and comprises three separate facilities at the UKAEA, Lancaster University, and the University of Liverpool. UKAEA ADRIANA contains a BEGe™ detector, a high RE detector, and a portable HPGe Trans-SPEC detector.
The equipment can be used to support power stations (environmental and waste measurements), nuclear security applications, decommissioning operations, university projects and research, and other research applications. The lab can also provide training to students and Early Career researchers.

Related instrumentation/capabilities

As well as the instruments at Culham, the ADRIANA suite also incorporates
- a digital neutron assay system (Prof. Malcolm Joyce, Lancaster University)
- a digital position-sensitive CZT/germanium detector array with mechanical cooler (Dr Laura Harkness-Brennan, University of Liverpool)

External user access arrangements

External users can access the equipment either in person or UKAEA scientists can deliver experiments on their behalf. There are options for the equipment to be loaned to external users for use off-site, however there is a preference for larger equipment to be used at the UKAEA site where possible. Please let the UKAEA team know as early as possible if instruments are required for loan off-site.
Users from UK-based Higher education institutions (HEIs) and other organisations that are eligible to apply for UKRI funding can apply for funded access through NNUF, until March 2023 (http://www.nnuf.ac.uk/how-to-gain-access). If this does not apply to you please contact the UKAEA team to discuss additional options.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	20
Internal Research	30
Environmental	10
External Research	10
Maintenance	10
Available/ unused	20

Contact

Chantal Nobs
chantal.nobs@ukaea.uk
01235 466804

Kimberley Lennon
kimberley.lennon@ukaea.uk
01235 466959

Instrument specification

Diamond detectors (B7HT and B6HT):
- High temperature fast and thermal neutron detectors with electronics
- Optimised for hot environments and confined spaces
- Maximum operating temperature 200°C
- H7-HT radiation hardness 1MGy

3500 TLD Reader and TLD-3 Annealing Oven:
- Multiple programmable linear heating cycles
- 30 second cycle time per detector, typically
- Heating temperature capability up to 400°C
- Measurement range: 10 µGy to 1 Gy

BEGe:
- Full LabSOCS characterisation
- Energy range from 3 keV to 3 MeV
- Detection efficiencies and energy resolution optimised in the 3 keV to 662 keV energy region
- Cooled with LN_2 using a cryo-cycler
- Samples must be less than the cavity diameter of 9 cm

Model	Typical Rel. Eff. (%)	FWHM At 5.9 keV	FWHM At 122 keV	FWHM At 1332 keV	End cap diameter (mm)
BE3825	26	0.45	0.75	1.90	89

High RE HPGe:
- PROFILE MX-Series GEM P-type detector
- Characterised MCNP model and Ortec ISOTOPIC modelling capability
- Listmode readout data format

Model	Nominal Rel. Eff. (%) (mm)	FWHM At 122 keV	FWHM At 1332 keV	End cap diameter (mm)
GEM-MX94100	175	1.30	2.30	108

Portable HPGe:
- Characterised MCNP model and Ortec ISOTOPIC modelling capability
- Portable: equipped with shoulder strap, internal battery and line power, easy for one person to carry, lead collar lifting/carrying equipment included, and a trolley for easy maneuvering.
- Electrically cooled using a Stirling-cycle cooler.
- Large items can be measured (e.g. waste drums, pipes, etc.)

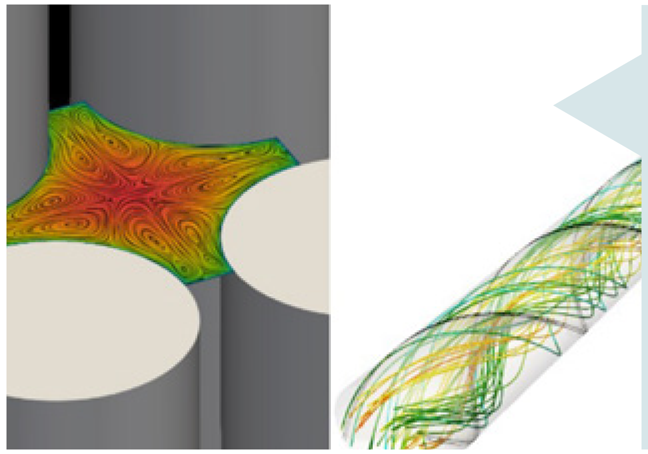
Model Trans-SPEC-DX-100T
Typical Rel. Eff. (%) 40
FWHM At 122 keV 1.60
FWHM At 1332 keV 2.30
End cap diameter (mm) 108
Further specifications can be provided on request.

Nuclear material capabilities (i.e. activity limits)

The RADLab can accommodate samples up to an activity limit of 150 kBq, maximum contact dose rate of 50 µSv/hr and dose rate on external surfaces (container/pot) <5 µSv/hr. All samples/sources must be sealed and without external contamination.
If samples/sources exceed the activity limit stated here please reach out to the UKAEA team to discuss options as it might be possible for equipment to be moved to research rooms on the UKAEA site which can accommodate much higher activity limits.

Other relevant information

For further information about the RADLab please contact the UKAEA staff using the contact details below.
For further detail on the ADRIANA suite please visit www.nnuf.ac.uk/adriana



Organisation
UK Atomic Energy Authority (UKAEA)

Facility
ANNA Thermal Hydraulics Test Facility

Location
Fusion Technology Facility, Unit 2a Lanchester Way, Advanced Manufacturing Park, Catcliffe, Rotherham, S60 5FX

Summary of capability/facility

The ANNA facility will provide a large-scale experimental set-up for research and training in nuclear thermal hydraulics with open access, funded through EPSRC's NNUF Phase 2a initiative. The facility is due to begin operations in early 2024.

The facility will feature a flow loop providing component-relevant water flows in conditions typical of light water reactors to an interchangeable test piece. It will simulate a range of multi-scale, multi-physics problems including:

1) two-phase flow,
2) conjugate heat transfer,
3) flow-induced vibration,
4) natural convection.

With high-resolution diagnostics, ANNA will be able to generate unique experimental data on steady-state and transient thermal hydraulic phenomena. Applications will include development of mechanistic understanding of behaviour to validate the performance of both fission and fusion reactors.

The facility is intended to hold a unique position in the UK-wide suite of thermal hydraulic facilities, sitting between university-scale experiments and the potential National Nuclear Thermal Hydraulics Facility.

Instrument specification

The loop will provide water flows to an interchangeable heated test piece with the following parameters:

Power Input	Up to 250 kW
Pressure	Up to 15.5 MPa
Temperature	Up to 328 °C
Flow Rate	Up to 3.5 kg/s

High-resolution diagnostics will include particle image velocimetry, shadow bubble sizing, light attenuation, and laser vibrometry.
Standard diagnostics will include pressure transducers, thermocouples, and flow meters.

Related instrumentation/capabilities

UKAEA Materials Research Facility
MRF Thermophysical Suite
MRF Microstructural Suite

Nuclear material capabilities (i.e. activity limits)

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

External user access arrangements

The ANNA facility will be open to external users from academia or industry either in person or by UKAEA scientists delivering experiments on behalf of externals. Users will be charged an appropriate amount to cover the costs of running the facility. The NNUF user access scheme is currently due to end in March 2023; however, users interested in using the ANNA facility can build in funding for this access as part of a responsive mode or programmatic application to EPSRC, or in applications to other funding bodies - please use the contacts above to discuss this further.

Other relevant information

The ANNA facility is being developed as a joint partnership between UKAEA and the University of Manchester. The equipment will be hosted at UKAEA's Fusion Technology Facility in South Yorkshire, co-located with the CHIMERA facility (for major combined-load testing of fusion components) as well as other test rigs for advanced nuclear technology.

Contact

Chris Harrington - UKAEA
Chris.Harrington@ukaea.uk
01235 465350

Andrea Cioncolini
University of Manchester
andrea.cioncolini@manchester.ac.uk

Organisation
UK Atomic Energy Authority (UKAEA)

Facility
Tritium Analysis Laboratory (TAL)

Location
Culham Science Centre, Abingdon, OX14 3EB

Summary of capability/facility

The Tritium Analysis Laboratory (TAL) provides essential support in the characterisation of waste for tritium content. Tritium is among the radioactive waste released in both fission and fusion research and plant operations. Our team of skilled laboratory technicians use effective techniques and laboratory equipment to conduct their analyses of waste products. Waste suitable for analysis within the laboratory includes, but is not limited to: paper, plastic, cardboard, metals, wood, and paint.

The lab hosts a pyrolyser, a high temperature oven, which processes both "hard" and "soft" waste. Hard waste mostly refers to metals and anything which is not combustible, whereas soft waste is combustible, such as cardboard or plastic.

Working together with the UKAEA's Health Physics Laboratory on site at Culham, we can also analyse water for its tritium content using a process approved by the UK Accreditation Service.

Instrument specification

Able to thermally treat materials to release tritium up to 1000°C under flowing air or oxygen. Tritium and other volatiles can be oxidised in a platinum-based catalyst followed by radionuclide capture and analysis by Liquid Scintillation Counting or Mass Spectrometry.
Max cross section per sample 1cm^3 (samples can be split/cut if required)
Max throughput 36 samples per day

Related instrumentation/capabilities

UKAEA Tritium Permeation rate measurement
UKAEA Materials Detritiation Facility

Nuclear material capabilities (i.e. activity limits)

Standard 160MBq Tritium, potentially up to 40GBq. UKAEA Culham EA permit requirements to be adhered to.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
R&D	
Other (please specify)	
Available/ unused	

External user access arrangements

UKAEA is not a Nuclear Licensed Site and access for external users is straightforward and easily arranged.

Operation within the facility is by UKAEA suitably qualified and experienced staff. Client access can be accommodated during test and manufacturing programs, collaborative research and development projects.

Other relevant information

Contact

glyn.stanton@ukaea.uk
info@h3at.ukaea.uk

Organisation
UK Atomic Energy Authority (UKAEA)

Facility
Materials Detritiation Facility (MDF)

Location
Culham Science Centre, Abingdon, OX14 3EB

Summary of capability/facility

The Materials Detritiation Facility (MDF) has been operational since 2017 and processes between 10-15 tonnes of tritiated solid waste every year. The thermal treatment process used within the facility liberates and captures tritium from intermediate-level waste components.

The facility has proved to be a major success, reducing intermediate-level waste to low- and even very-low-level waste. This has resulted in major economic savings and freed valuable space within national waste storage facilities.

The MDF process is based upon heating waste material in a furnace allowing the bulk tritium to be liberated from the material. A vacuum pump system draws air into the furnace which pulls the tritiated exhaust gasses through a catalyst before it meets water bubblers. The oxidised tritium is then dissolved in water.

Instrument specification

Furnace
Vacuum pump system
Catalyst
Water bubblers
Water Detritiation System (WDS)

Related instrumentation/capabilities

The MDF inventory to date includes the following material types:

- Inconel
- Ferrous (Mild steel, Stainless Steel)
- Copper
- Aluminium
- Carbon Fibre Composite (CFC), Graphite.

The tritiated water can be transported to the Water Detritiation System (WDS), located in an adjacent facility. The tritiated water is then purified and isotopically separated, allowing elemental tritium to be reused

Nuclear material capabilities (i.e. activity limits)

Tritium Inventory - 10TBq per drum
Off-gas rate - <960MBq/day per drum
Item contact radiation gamma dose rate - 100 µSv/hr

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

External user access arrangements

UKAEA is not a Nuclear Licensed Site and access for external users is straightforward and easily arranged.

Operation within the facility is by UKAEA suitably qualified and experienced staff. Client access can be accommodated during test and manufacturing programs, collaborative research and development projects.

Other relevant information

Contact

Glyn Stanton
glyn.stanton@ukaea.uk
Enquiries to info@h3at.ukaea.uk

Organisation
UK Atomic Energy Authority (UKAEA)

Facility
Beryllium Handling Facility (BeHF)

Location
Culham Science Centre, Abingdon, OX14 3EB

Summary of capability/facility

Beryllium has been in use since 1988 in Joint European Torus (JET), as tiles and evaporators, with >3000 kg in the torus at one time. Tile degradation and the evaporated deposit produce dust particles that can mobilise to create potentially harmful exposures. Considerable operational experience has been gained from working in beryllium contaminated atmospheres and handling contaminated materials. Everything that goes in to and comes out of the JET facility is processed in the BeHF. The adequate control of beryllium requires dedicated facilities for preparation, handling, decontamination, storage and processing of beryllium contaminated material.

Components removed from the experiment by the remote handling facility are placed straight into sealed containers – for example modified shipping containers – which can then be carried by crane to the beryllium handling facility. In the case of the shipping containers, they have modified doors which attach straight onto the facility's sealed area.

Instrument specification

The BeHF comprises three interconnecting areas which can be operated as standalone ar or alternatively in the following combinations BeHF 1&2, 1&3, or 1, 2,& 3. This modular design allows huge flexibility and has evolved through-out the JET project life -time, having gone through various adaptations and upgrades to meet the changing needs of JET. Based on these historical changes and the flexibility BeHF provides, it is well placed to provide service and support to other projects.

Serving as the main interface with the JET Vessel BeHF 3 is equipped with a Chesim Door ISO dock allowing direct access to and from JET Vessel. In addition to this a further standard ISO Dock and airlock arrangement at 1 & 2 allowing access to and from the Facility. Both BeHF 3 and 2 have the provision to remove the roof to allow the import and export of large pieces of equipment with BeHF 2 having the added benefit of extended headroom this dating back to initial design specification allowing for import of the central support column.

Related instrumentation/capabilities

Typical tasks that can be undertaken within the facility include;

- Waste preparation
- Decontamination of components (where possible to clearance levels)
- Analysis on components from off gas measurements to core sampling of tiles.
- Maintenance of in vessel components such as probes and diagnostics
- Maintenance of in vessel vacuum cleaners.

All of the above work uses different aspects of the facility such as:

- Decontamination and sonic baths
- Glove and slit boxes
- Air fed pressurised suits

Nuclear material capabilities (i.e. activity limits)

Tritium: 1200 TBq total inventory (~3.3g)
Total Off-gas rate: 30 GBq/day
Maximum dose rate @ 30cm- 500µSv/hr
Health Physics must be consulted prior to all work in the BeHF where there is potential for operator exposure to significant levels of tritium or high dose-rate items. Radiological risk assessment is required for doses >25 µSv per person or >1 DAC (0.3 MBq/m3 for tritium).

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

External user access arrangements

UKAEA is not a Nuclear Licensed Site and access for external users is straightforward and easily arranged.
Operation within the facility is by UKAEA suitably qualified and experienced staff. Client access can be accommodated during test and manufacturing programs, collaborative research and development projects. Access to the facility is restricted by means of ALNOR turnstile barriers. All personnel must attend a general familiarisation induction with the Area Supervisor, prior to ALNOR access being granted.

Other relevant information

Contact

Glyn Stanton
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Enquiries to info@h3at.ukaea.uk

Organisation
UK Atomic Energy Authority (UKAEA)

Facility
Plastics Fabrication Workshop

Location
Culham Science Centre, Abingdon, OX14 3EB

Summary of capability/facility

UKAEA's Plastics Fabrication Workshop manufactures bespoke, flexible containment solutions that are ideal for:

- Active and non-active contamination control
- Weather proofing
- Protection from asbestos or chemicals
- Maintaining cleanliness

We produce made-to-measure items using a variety of materials in different weights and thicknesses that we join using radio-frequency welding. Our products are primarily made with hard-wearing PVC. However, for specialist work we can use Plutonium (PU) which, when stretched, returns to its original size and shape.

Our products range from small bags to large structures weighing hundreds of kilograms and include:

- robot arm gators
- bund trays
- glove boxes with sleeves
- isolators, tents, isolators, weatherproof covers and bags of all shapes and sizes

We also produce rigid plastic items and aluminum frames. Bespoke products have also been developed and produced for commercial customers within the fusion, defence, nuclear and international decommissioning sectors.

Instrument specification

Dedicated workshop
RF welding
Cutting equipment including guillotines

Related instrumentation/capabilities

Nuclear material capabilities (i.e. activity limits)

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

External user access arrangements

UKAEA is not a Nuclear Licensed Site and access for external users is straightforward and easily arranged.

Operation within the facility is by UKAEA suitably qualified and experienced staff. Client access can be accommodated during test and manufacturing programs, collaborative research and development projects.

Other relevant information

Contact

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glyn.stanton@ukaea.uk
Enquiries to info@h3at.ukaea.uk

Organisation
UK Atomic Energy Authority (UKAEA)

Facility
Remote Applications in Challenging Environments (RACE)

Location
Culham Science Centre, Abingdon, OX14 3EB

Summary of capability/facility

RACE was formed in 2014 to provide complete remote handling and robotic solutions to enable remote operations and protect people in challenging environments. Challenging environments that are too hazardous or extreme for people to work exist in numerous sectors, such as fission, nuclear decommissioning, petrochemical, space exploration, construction and mining.
RACE develops complete systems for safe, reliable and cost-effective remote operations. This includes robotic solutions for inspection and maintenance on JET, ITER, STEP, DEMO and ESS, and decommissioning of nuclear sites in the UK and Japan.
This is achieved through research in:

- Autonomous handling from glove boxes to fusion reactors
- Autonomous mobility, such as quadrupeds, cranes and Connected and Autonomous Vehicles (CAVs)
- Resiliency in extreme environments and recovery from failure
- Interoperability of systems, and system of systems control

As part of the UK's Robotics and Autonomous Systems community, RACE is at the heart of ensuring that ideas and solutions are shared across sectors, collaborating with over 20 universities and 100 companies, developing regional expertise and innovation to enable UK businesses to win work internationally.
RACE has world leading capability in system of system design and remote handling in nuclear environments and is helping to build a federated network of cyber-physical capability through the Robotics and AI Nuclear (RAIN) hub and the new Robotics and AI Collaboration (RAICo1) in Whitehaven.

Related instrumentation/capabilities

RACE is the lead laboratory for the National Nuclear User Facility for Hot Robotics (NNUF -HR).
RACE also is a founding member of the RAICo programme, which recently opened the RAICo1 facility in Whitehaven, Cumbria.

External user access arrangements

RACE works with nuclear decommissioning and fusion energy end-users and the supply chain as well as researchers from institutions across the UK and SMEs from around the world.
If you would like to collaborate with us, please contactus@race.ukaea.uk
Industrial and academic institutions can access NNUF-HR equipment including training: see NNUF-HR access arrangements on page 116.

Other relevant information

For more information visit the RACE website.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	25
Decommissioning	25
Fusion energy	50

Contact

01235 468001
contactus@race.ukaea.uk

Instrument specification

RACE's primary mission is to develop remotely operated solutions to support and maintain fusion reactors and has performed over 40,000 hours of in-vessel remote operations at JET.
The team of over 300 people use their experience in Robotics and Autonomous Systems to conduct R&D and commercial activities into remote operations, autonomous robotic systems, driverless vehicles at its unique facilities:

- Continued remote operations at JET including a lead role in JET decommissioning with support from both physical and digital mock-ups and twins
- A 2,000 m^2 multifunctional work hall with integrated control rooms and reconfigurable robotic cells, which hosts:
  - The ITER Robot Test Facility (IRTF) for the mock-up of key remote handling tasks in anticipation of ITER
  - TARM, a unique articulated boom with 11m reach which is the sibling of the JET booms
  - MASCOT 6 bi-lateral haptic feedback local-remote manipulator
  - Multiple remote gloveboxes (RoBox™) used to develop shared autonomy, computer vision and machine learning
  - Walischmiller Telbot haptic twin-arm system
  - Multiple industrial robots
  - Multiple sensor systems
  - Multiple processing capabilities including welding, bolting, etc.
  - Comprehensive suits of operational software including interoperable communications protocols for networking, digital twins
  - Three reconfigurable remote handling control rooms including comprehensive the full suite of connectivity and infrastructure to enable remote operations
- RACE acts as one of four NNUF Hot Robotics facilities that provides a wide range of robotic hardware to enable academic and industrial users to develop novel robotic systems for use on nuclear sites.
- 10 km of roads, junctions, roundabouts, traffic lights and pedestrian crossings within the secure Culham site to host the development of Connected and Autonomous Vehicles (CAVs).
- RACE TEST hosts Europe's only standardised test facility for ground- and air-based robots with 12 test lanes to measure and compare performance of hardware and operators against international standards.

Nuclear material capabilities (i.e. activity limits)

Accumulation of radioactive waste

Specified waste type	Radionuclide or group of radionuclides permitted to be present in the waste	Activity limit	Volume limit	Period limit
Aqueous waste	Tritiated condensate	30PBq	135 m^3 in total	10 yrs
	Tritiated water	500GBq		6 mths
Solid waste	Tritium	400 TBq	5,000 m^3 in total	10 yrs
	Total Beta/gamma emitting radionuclides	1 PBq (in total)		10 yrs
	Total Alpha-emitting radionuclides	38 TBq		10 yrs
Organic liquid waste	Tritium	800GBq	4 m^3 in total	4 yrs
	Total Beta/gamma emitting radionuclides	1 GBq		4 yrs

Organisation
UK Atomic Energy Authority (UKAEA)

Facility
Hot Robotics Facility - RACE component

Location
Culham Science Centre, Abingdon, OX14 3EB

Image: Credit: UKAEA

Summary of capability/facility

The National Nuclear User Facility for Hot Robotics (NNUF-HR) is an EPSRC-funded facility to support UK academia and industry to deliver ground-breaking, impactful research in robotics and artificial intelligence for application in extreme and challenging nuclear environments.

The facility is arranged across three regional nodes with four research partners: National Nuclear Laboratory (NNL), University of Manchester, University of Bristol and Remote Applications in Challenging Environments (RACE).

RACE forms the primary NNUF-HR hub where a large array of static and mobile robots, mock-ups and sensors are housed. Additional functionality is provided through 'hot' test capabilities and portable solutions that allow the transport of equipment to user locations.

Collaboration with academia and industry is facilitated by RACE's proximity to Harwell, AWE and a multitude of academic institutions.

Related instrumentation/capabilities

NNUF-HR also has hubs at NNL, University of Manchester and University of Bristol.

External user access arrangements

- Users from UK-based Higher Education Institutions (HEI) and other organisations that are eligible to apply for UKRI funding can apply for funded access through NNUF,
  until March 2023 (please see www.nnuf.ac.uk/how-gain-access)
- Equipment can be used at the RACE site, or hired out to users' own sites. Availability is for industry & academia alike.
- Users can also be provided with supervision and training on the equipment.

Other relevant information

https://hotrobotics.co.uk for further information.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Decommissioning Robotics	50
Other (please specify)	
Available/ unused	50

Contact

nnuf-hr@race.ukaea.uk

Instrument specification

Manipulators
3 x Kinova 7DOF Gen3 arms with grippers & haptics
2 x KUKA iiwa LBR with grippers
2 x KUKA KR210 inc. tool changers & grippers
1 x Fanuc R2000iD 165FH inc. tool changers & grippers
Mobile Robotics
4 x Boston Dynamics Spot Quadruped
1 x Superdroids HD2 tracked Unmanned Ground Vehicles (UGVs) inc. sensory payload
Various Unmanned Aerial Vehicles (UAVs)
Industrial Mock-up Robot cells
Industrial Glovebox
Process Plant with pipe Wall
Sort and Segregate
Barrell store
Other
Mobile 4KW Laser Cutting Facility with robot
Mobile Expandable (15m x 5m) Control room
Cameras, radiation detectors, LIDARs & similar

Nuclear material capabilities (i.e. activity limits)

Accumulation of radioactive waste

Specified waste type	Radionuclide or group of radioclides permitted to be present in the waste	Activity limit	Volume limit	Period limit
Aqueous waste	Tritiated condensate	30PBq	135 m^3 in total	10 yrs
	Tritiated water	500GBq		6 mths
Solid waste	Tritium	400 TBq	5,000 m^3 in total	10 yrs
	Total Beta/gamma emitting radionuclides	1 PBq (in total)		10 yrs
	Total Alpha-emitting radionuclides	38 TBq		10 yrs
Organic liquid waste	Tritium	800GBq	4 m^3 in total	4 yrs
	Total Beta/gamma emitting radionuclides	1 GBq		4 yrs

Organisation
UKAEA / The University of Manchester / NDA / Sellafield Ltd / The National Nuclear Laboratory

Facility
RAICo1

Location
Whitehaven, Cumbria

Summary of capability/facility

RAICo – the Robotics and AI Collaboration – is a joint initiative led by UK Atomic Energy Authority, Nuclear Decommissioning Authority (NDA), Sellafield Ltd, The University of Manchester and the National Nuclear Laboratory.

As part of this end-user-led initiative, the RAICo1 facility was opened in March 2022.

The RAICo1 facility will be equipped with technologies designed to allow nuclear environments to be inspected and altered, with comprehensive digital models as part of digital twins.

This facility will be a place where end users, businesses and universities can work together to develop and demonstrate technology which can help to safely and cost-effectively decommission nuclear sites.

RAICo1 will be home to important work that will benefit the whole NDA estate and the UKAEA's fusion mission. RAICo Two is in conception.

Instrument specification

RAICo1 facility has a variety of spaces allocated for research and development of robotics and digital mock-ups. These are:

- Mobile arena – an area dedicated for testing and R&D of mobile robotics which has various floor setups that could replicate conditions at Sellafield
- Robotic gloveboxes – an area dedicated to gloveboxes that will allow R&D and testing of telemanipulators in representative environments, to realise the 'hands out of gloveboxes' ambition in the nuclear decommissioning sector
- Control room – an area for development and trial of digital mock-ups and digital twin technologies, including a variety of physical user interfaces and HMIs
- DPaCc - a C4 containment area to allow trials of robotics in highly contaminated environments
- Pond Test/Demo Facility - 4.8m length x 3.6m width x 2.4m deep with underwater (Qualisys) and ground/aerial (Vicon) positioning systems

Related instrumentation/capabilities

A selection of the equipment onsite is available for hire through the NNUF Hot Robotics scheme: https://hotrobotics.co.uk/

Nuclear material capabilities (i.e. activity limits)

External user access arrangements

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
R&D	
Other (please specify)	
Available/ unused	

Other relevant information

Contact

Louise Hetherington - Operations Manager RAICo1
louise.z.hetherington@sellafieldsites.com
Pete Gillham, UKAEA RAICo Project Manager
peter.gillham@ukaea.uk

Organisation
Ultra Energy

Facility
Advanced Nuclear Instrumentation Manufacture & Test Facility

Location
Wimborne, Dorset, UK

Summary of capability/facility

The Ultra Energy site is a privately owned facility built to support the supply of safety critical and specialist sensors & instrumentation to the nuclear industry. The site in Dorset is a development, manufacture & test facility for neutron flux measuring instrumentation, including high performance mineral insulated cables.

Test Capabilities:

- Helium leak testing
- Hydrostatic pressure testing (up to 2000psi)
- NDT
    - X-ray
    - Dye penetrant testing
    - Visual weld inspection
    - Sample analysis preparation
    - CMM dimensional inspection
    - XRF analysis
- Qualification & acceptance testing
    - Mechanical
    - Environmental
    - Radiological (thermal neutrons, gamma & X-ray)

Development & Manufacturing capabilities include:

- Chemical & acid cleaning facility (Steel, Nickel, Titanium & Ceramic)
- Metal (Steel, Nickel, Titanium) vacuum processing facility
- Clean assembly facility
- Metal joining
    - Automated & Manual TIG welding
    - Resistance spot welding
    - Vacuum induction & flame brazing
- Design, assembly, commissioning & maintenance of bespoke High Vacuum /Ultra High vacuum degassing & processing ovens
- Fissile material handling

Related instrumentation/capabilities

Electronics instruments and systems for the collection and analysis of the signals from safety critical and specialist sensors are also designed and developed by Ultra Energy.

External user access arrangements

The nature of the facility means that operation is by Ultra suitably qualified and experienced staff. Client access can be accommodated during test and manufacturing programs. Collaborative research and development projects.

Other relevant information

Instrument specification

- Thermal neutron generator
    - up to 1.0E7 nv thermal flux
    - Test cavity 110mm diameter, 890mm length
- X-ray suite
    - GE Isovolt 225 M2
    - Up to 225keV & 17.7mA
- Gamma Irradiation Cell
    - Up to 0.5 Gy/hr @ 1m
    - Am-241 & Cs-137 sources
- Numerous tubular and chamber furnaces capable of 1200°C operation
- Test ovens:
    - up to 650°C
    - 1.5 × 1.5 × 0.5m calibrated hot zone
- Neutron flux instrumentation performance envelope:
    - 550°C
    - 2000psi
    - Integrated neutron flux of 1.0E20 nvt
    - Sensitivities designed and manufactured to suit the application
- MI Cable Performance envelope:
    - Triaxial construction
    - Up to 25m long
    - <1.0E-14 A/m @ 100V & room temperature
    - <3.0E-9 A/m @ 100V & 550°C
    - <1.0E-6 A/m @ 100V & 850°C

Nuclear material capabilities (i.e. activity limits)

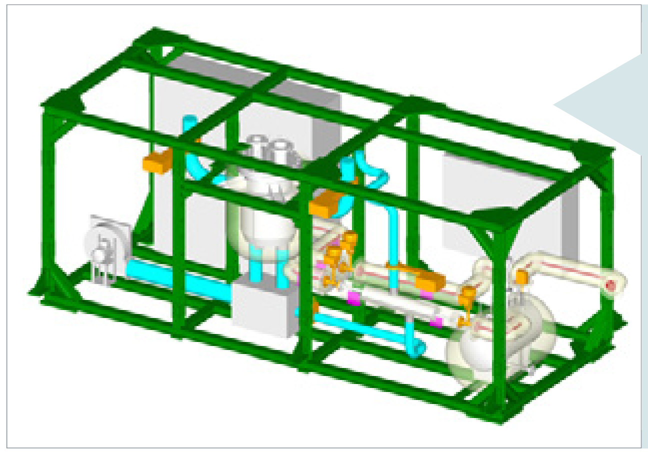
Available on request.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Nuclear	100
Other (please specify)	
Available/ unused	

Contact

Please contact sales@ultra-ncs.com to discuss any requirements you may have.



Organisation
Westinghouse Electric Company

Facility
LEad FREEZing Facility (LEFREEZ)

Location
Springfields, UK

Summary of capability/facility

A lead freezing test facility, LEFREEZ, is being installed at the Westinghouse Springfields site, UK, in support to Lead-cooled Fast Reactor (LFR) technology development as part of the Advanced Modular Reactor Program. The main objective of this facility is to experimentally assess the potential for structural damage caused by liquid lead when it freezes and remelts. Lead shrinks by approximately 3.7% in volume when it freezes and may induce tensile stresses on structures around which freezing takes place. When the frozen lead remelts, the expanding lead can damage surrounding structures if there is no room to accommodate the expansion. This facility is intended to conduct lead freezing and remelting tests both in “untrapped” and “trapped” lead configurations, depending on whether lead has room to expand. These tests will inform operational procedures for components located inside the reactor vessel and components potentially located in lead storage tanks around the plant, where lead could preferentially be stored in solid form. In addition, the facility will also be used to test certain LFR instrumentation such as Under-Lead Viewing technology.

The facility is expected to start operation in Summer 2022.

Related instrumentation/capabilities

The data acquisition and control system based on National Instruments LabVIEW processes about 140 signals from various instrumentation including:

- 2 level transmitters, 2 pressure transducers, and 2 thermocouples in the main vessel,
- 36 thermocouples and 4 strain gauges on the fuel rod bundle mock-up,
- 4 thermocouples and 6 strain gauges on the trapped lead test section,
- 1 oxygen sensor in the storage vessel

External user access arrangements

Enquiries about user access to the test facility can be made through the key contacts shown above.

Other relevant information

Instrument specification

General description

The facility consists of a storage vessel equipped with an oxygen sensor and oxygen control system, the main vessel (for “untrapped” freezing/remelting tests), and a lead line acting as test section for the “trapped” lead tests. The main vessel has two access ports on the top, one for the fuel rod bundle mock-up and one for the under-lead viewing probe. The main vessel and the trapped lead test section can be heated or cooled externally. The facility has a footprint of approximately 5.8 m x 2.3 m x 2.3 m.

Main vessel

The main vessel has a volume of 120 l and lead inventory of 100 l. The operating pressure and temperature of the main vessel are 1.1 bar and 450°C, respectively. Argon purge gas is provided to maintain the oxygen-free cover gas. Nineteen rods inside a wrapper are submerged in the lead pool. Freezing takes place by turning off heating cables and circulation of air to 1000 m^3/hr on the vessel exterior.

Trapped lead test section

The trapped lead test section is 0.5 m long with an external diameter of 0.06 m. The test section can be isolated on both ends using either frozen lead plugs or valves.

Nuclear material capabilities (i.e. activity limits)

This is a non-nuclear facility.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	Main use envisioned. Facility is anticipated to start operation in Summer 2022
Environmental	
Other (please specify)	
Available/ unused	

Contact

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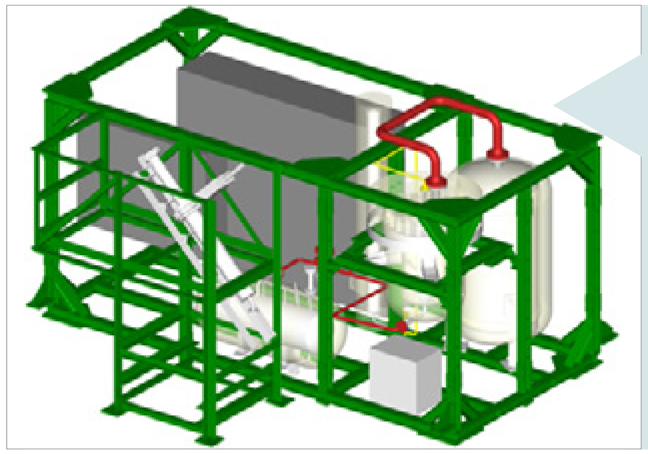

Organisation

Westinghouse Electric Company

Facility

LEad-Water INteraction Facility (LEWIN)

Location

Springfields, UK

Summary of capability/facility

A lead-water interaction facility, LEWIN, is being installed at the Westinghouse Springfields site, UK, in support of Lead-cooled Fast Reactor (LFR) technology development as part of the Advanced Modular Reactor Program. The objective of this facility is to experimentally assess some of the effects potentially resulting from the failure of a Primary Heat Exchanger (PHE) in the Westinghouse LFR. They include the water blowdown rate, liquid lead jet and two-phase H_2O jet impingement forces, and sloshing forces. The LFR employs diffusion-bonded microchannel-type heat exchangers immersed in the primary lead pool. Failure in a PHE occurs when a secondary side channel carrying high-pressure secondary fluid (subcooled or supercritical water) breaches the channel separation and enters the adjacent primary side channel carrying low-pressure liquid lead.

The facility is expected to start operation in Summer 2022.

Instrument specification

The test facility consists of the interaction vessel, storage vessel, water vessel, and dump vessel. A long capillary tube inserted from the top into the interaction vessel partially filled with liquid lead represents the primary side channel into which the secondary side fluid blowdown occurs when the PHE fails. The failure opening is simulated by a "pinhole" orifice installed at the inlet of the capillary tube. The pressure and temperature of H_2O in the water vessel, which is connected to the capillary tube, are prototypic of the secondary side of the Westinghouse LFR's PHE, 35 MPa and 340°C. The initiation of the PHE failure and forces, in the order in which they occur following a PHE failure, are simulated and/or measured. The dump vessel holds the steam and entrained lead released during the blowdown. The volumes of the interaction vessel, water vessel, and dump vessel are 114 l, 10 l, and 750 l, respectively. The design pressures of the interaction vessel, water vessel, and dump vessel are 50 bar, 380 bar, and 16 bar, respectively. The facility has a footprint of approximately 4.8 m x 2.3 m x 2.3 m

Nuclear material capabilities (i.e. activity limits)

This is a non-nuclear facility.

Related instrumentation/capabilities

The data acquisition and control system based on National Instruments LabVIEW processes about 150 signals from various instrumentation including thermocouples, level transmitters, strain gauges, and fast pressure transducers. The blowdown rate is measured indirectly by the differential pressure transducer in the water vessel. The jet impingement forces and molten lead pool sloshing forces on vessel wall are measured by fast pressure transducers.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	Main use envisioned. Facility is anticipated to start operation in Summer 2022
Environmental	
Other (please specify)	
Available/ unused	

External user access arrangements

Enquiries about user access to the test facility can be made through the key contacts shown above.

Other relevant information

Contact

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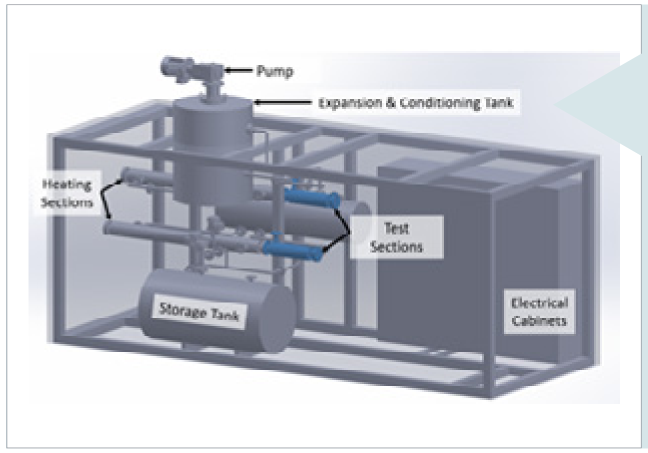

Organisation

Westinghouse Electric Company

Facility

MEtal-LEad CORrosion Facility (MELECOR)

Location

Springfields, UK

Summary of capability/facility

A corrosion test facility, MELECOR, is being installed at the Westinghouse Springfields site, UK, in support of Lead-cooled Fast Reactor (LFR) technology development as part of the Advanced Modular Reactor Program. The objective of this facility is to test reactor fuel cladding and structural materials in conditions prototypical of an LFR under normal operating and accident conditions, complete with control of the liquid lead chemistry. This objective will support down selection and qualification of LFR materials.

The facility is expected to start operation in Summer 2022.

Instrument specification

General aspects

This is a state-of-the-art flowing liquid lead corrosion test system with online dissolved oxygen level monitoring and control, and the ability to reach temperatures up to 800°C and liquid lead flow velocities of 3 m/s. The liquid lead inventory is approximately 200 litres, and the facility footprint is of approximately 7.5 m x 2.3 m x 2.3 m. The ability to independently control the temperature of the hot leg and cold leg will allow the study of mass transfer effects in addition to corrosion.

The facility is provided with two test sections, each housing test specimens. The test sections are installed between bolted flanges, and so can be replaced to accommodate a wide variety of testing.

Nuclear material capabilities (i.e. activity limits)

This is a non-nuclear facility.

Related instrumentation/capabilities

The facility is equipped with numerous thermocouples and transducers for the measurement of:

- fluids and wall temperature
- flow rate of the loop
- absolute, relative and differential pressure
- oxygen concentration in lead

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	Main use envisioned. Facility is anticipated to start operation in Summer 2022
Environmental	
Other (please specify)	
Available/ unused	

External user access arrangements

Enquiries about user access to the test facility can be made through the key contacts shown above.

Other relevant information

Contact

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(+44) 7971 161930

Mike Ickes
ickesmr@westinghouse.com
(+1)-412-256-1085

Academic Facilites

Organisation
Bangor University

Facility
High temperature horizontal tube furnace HTRH 18/70/300/E3216P1/OTC, Carbolite Gero

Location
Manufacturing lab MERLIN, Nuclear Futures Institute, Bangor University
Materials labs with capability for working with uranium compounds.
Physically split into two areas:
- Materials Manufacture,
- Materials Characterisation.

Summary of capability/facility

General info:
Furnace able to operate up to 1700°C under air, inert or hydrogen atmospheres.

Application examples:
Materials synthesis, sintering, reactions, heat treatments, powder metallurgy. Sintering of UO_2 carried out routinely.

Instrument specification

- Maximum temperature: 1800°C
- Atmosphere: air, inert gas or hydrogen
- Over-temperature protection

Related instrumentation/capabilities

Materials Characterisation:
- Scanning electron microscope: Hitachi TM4000
  - Energy-dispersive X-ray spectroscopy: Oxford Instruments Aztec One
- Raman microscopy: Bruker SENTERRA II
- Optical microscopy: Leica DM2700
- X-ray diffraction: Malvern Panalytical Aeris heated stage capability
  Sample preparation:
- Sectioning: Buehler Isomet High Speed
- Metallographic and ceramographic preparation:
  - Grinding and Polishing: Buehler EcoMet 30
  - Mounting: Buehler SimpliMet 4000
- Glove box: MBraun LABStar
  - for handling pyrophoric metal powders and small quantities of uranium

Nuclear material capabilities (i.e. activity limits)

Depleted or natural uranium powders.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	20
Advanced Nuclear	55
Environmental	5
Aerospace	10
Other (please specify)	
Available/ unused	10

External user access arrangements

Available for external research and industry work. Arrangements depending on exercise. See nubu.nu for more details.

Other relevant information

Through the Nuclear AMRC's Fit For Nuclear (F4N) programme, which focuses on business systems, we actively engage with the both the nuclear and high-value manufacturing supply-chain network on a regular basis in the form of education and audits to achieve this F4N status.

Contact

Dr Simon Middleburgh - s.middleburgh@bangor.ac.uk

Organisation
Bangor University

Facility
High temperature vacuum furnace, LHTW 100-200/22, Carbolite Gero

Location
Materials labs with capability for working with uranium compounds.
Physically split into two areas:
- Materials Manufacture,
- Materials Characterisation.

Summary of capability/facility

General info
This vacuum furnace can operate at 2200°C for sustained periods. The cylindrical 2l space of the laboratory furnace is surrounded by the heating elements and insulation material. The heated chamber is integrated into the water-cooled vessel. As a result of the small volume, the LHT is ideal for small samples and requires minimal operating space.

Application examples:
Annealing, brazing, carbonisation, ceramic injection moulding (CIM), debinding, degassing, drying, hardening, metal injection moulding (MIM), pyrolysis, rapid prototyping, siliconisation, sintering, soldering, sublimation, synthesis, tempering. Synthesis of non-oxide uranium compounds without carbon impurities.

Instrument specification

- Maximum temperature: 2200°C
- Atmosphere: vacuum or inert gas
- Over-temperature protection

Related instrumentation/capabilities

Materials Characterisation:
- Scanning electron microscope: Hitachi TM4000
  - Energy-dispersive X-ray spectroscopy: Oxford Instruments Aztec One
- Raman microscopy: Bruker SENTERRA II
- Optical microscopy: Leica DM2700
- X-ray diffraction: Malvern Panalytical Aeris heated stage capability
  Sample preparation:
- Sectioning: Buehler Isomet High Speed
- Metallographic and ceramographic preparation:
  - Grinding and Polishing: Buehler EcoMet 30
  - Mounting: Buehler SimpliMet 4000
- Glove box: MBraun LABStar
  - for handling pyrophoric metal powders and small quantities of uranium

Nuclear material capabilities (i.e. activity limits)

Working with depleted uranium presently according to local rules.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	5
Advanced Nuclear	65
Environmental	
Aerospace	10
Other (please specify)	
Available/ unused	20

External user access arrangements

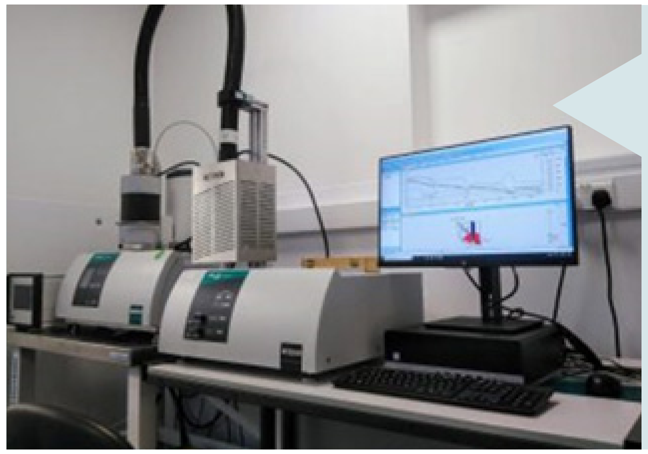
Available for external research and industry work. Arrangements depending on exercise. See nubu.nu for more details.

Other relevant information

Through the Nuclear AMRC's Fit For Nuclear (F4N) programme, which focuses on business systems, we actively engage with the both the nuclear and high-value manufacturing supply-chain network on a regular basis in the form of education and audits to achieve this F4N status.

Contact

Dr. Simon Middleburgh - s.middleburgh@bangor.ac.uk



Organisation
Bangor University

Facility
Simultaneous Thermal Analysis (STA) with Mass Spectroscopy - Netzsch

Location
Manufacturing lab MERLIN, Nuclear Futures Institute, Bangor University
Materials labs with capability for working with uranium compounds.
Physically split into two areas:
- Materials Manufacture,
- Materials Characterisation.

Summary of capability/facility

Netzsch STA 449 F-3 with Netzsch QMS 403 Aëolos Quadro. Operates under DSC, TGA & DTA modes. Fitted with SiC furnace able to reach 1600C. Can measure samples in air, inert, vacuum, hydrogen or under humid conditions.

Application examples:
Sintering studies of nuclear fuels, corrosion studies, synthesis route optimisation, corroboration of thermodynamic modelling, phase field studies.

Instrument specification

- Maximum temperature: 1600°C
- Atmosphere: ambient, vacuum, humid, hydrogen or inert gas

Related instrumentation/capabilities

Materials Characterisation:
- Scanning electron microscope: Hitachi TM4000
  - Energy-dispersive X-ray spectroscopy: Oxford Instruments Aztec One
- Raman microscopy: Bruker SENTERRA II
- Optical microscopy: Leica DM2700
- X-ray diffraction: Malvern Panalytical Aeris heated stage capability
  Sample preparation:
- Sectioning: Buehler Isomet High Speed
- Metallographic and ceramographic preparation:
  - Grinding and Polishing: Buehler EcoMet 30
  - Mounting: Buehler SimpliMet 4000
- Glove box: MBraun LABStar
  - for handling pyrophoric metal powders and small quantities of uranium

Nuclear material capabilities (i.e. activity limits)

Limited to using depleted and natural uranium at present.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	10
Advanced Nuclear	50
Environmental	
Aerospace	20
Other (please specify)	
Available/ unused	20

External user access arrangements

Available for academic and industrial researchers. See nubu.nu for more information.

Other relevant information

Contact

Dr Simon Middlelburgh - s.middleburgh@bangor.ac.uk

Organisation

Bangor University

Facility

Bangor University Fuel Fabrication Facility (BUFFF) - NNUF2a

Location

Bangor, LL57 1UT

Summary of capability/facility

BUFFF enables the investigation and research of a range of nuclear fuels and other nuclear industry relevant ceramics, progressing them from powders (provided in part by the industrial sponsors) through to blends, pressed green pellets and then sintered bodies. The sintering furnace at the centre of BUFFF being a one of a kind piece of equipment in the UK and world-leading: providing the ability to tailor the sintering atmosphere in an industrially applicable manner but on a laboratory scale, whilst also having the ability to observe the sintering process in-situ using a range of digital image correlation techniques (with further techniques to be developed using the facility) whilst monitoring the sintering atmosphere using techniques including gas-chromatography-mass-spectrometry (GC-MS). Pre-processing characterisation provisions are also included, assessing variables such as stoichiometry and powder size distribution.

Instrument specification

- Optical dilatometry with mass spectroscopy in pure H_2, CO_2, N_2, Ar with H_2O additions.
- Instrumented pellet press able to produce 100s pellets to a specific specification 50 kN reproducing rotary pellet presses used in industry.
- 4 kg UO_2 powder (AUC) from Westinghouse Electric Sweden for users of the facility.
- Inert glove boxes available to work with non-oxide materials including metals, nitrides, carbides and borides.
- Sample and powder preparation for nuclear fuels (including particle sizing, milling and blending).
- Pychnometry, hardness testing, photography.

Related instrumentation/capabilities

- MERLIN laboratory at Bangor University is a uranium active facility with vacuum furnace, x-ray diffraction, Raman spectroscopy and electron microscopy.
- Simultaneous thermal analysis (STA) with mass spectroscopy available, up to 1600 °C in inter atmosphere, with steam and H_2.
- Associated facilities with the Bangor University Lead Loop Erosion/ corrosion Testing (BULLET) facility.

External user access arrangements

Users from UK-based HEIs (and other organisations that are eligible to apply for UKRI funding) can apply for funded access through NNUF, until March 2023 (please see www.nnuf.ac.uk/how-gain-access). Researchers from outside the UK can also apply for funded access through NNUF, if a faculty member in a UK university is included on the project team or if the experiment is part of establishing/expanding a substantial collaboration between the research group and the institution hosting the facility.

Remote access options are available, please see bufff.online.

Users from industry, national laboratories and universities are welcome to work in the BUFFF.

Nuclear material capabilities (i.e. activity limits)

Depleted/natural UO_2 (open powders)

Sealed sources below exemption limits.

Areas instrument used over last 12 months

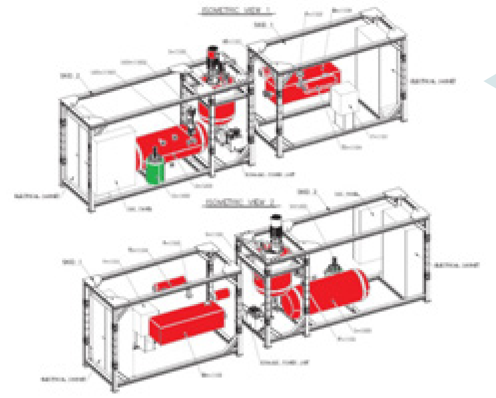
Area	% Usage
Waste Management	10
Advanced Nuclear	30
Environmental	0
Aerospace	40
Other (please specify)	0
Available/ unused	20

Other relevant information

Contact

Simon Middleburgh – s.middleburgh@bangor.ac.uk

Michael Rushton – m.rushton@bangor.ac.uk



Organisation

Bangor University

Facility

Bangor University Lead Loop Erosion/corrosion Testing (BULLET) facility

Location

M-Sparc, LL60 6AR

Summary of capability/facility

BULLET is a large rig designed with ENEA and SRS in Italy to support the Phase 2 AMR Competition funded by BEIS and the AFCP (through the NNL). Testing of structural and nuclear fuel materials in Pb is vital for the realisation of lead-fast reactor technology, and may also be useful for fusion material testing (e.g. for components for breeding). The rig allows long-term testing of materials in flowing Pb (up to 4.5 m/s) and static Pb with fine control of the oxygen content. The facility is expected to be available for external users in late 2022.

Instrument specification

- 4 m/s flowing Pb at 450 °C
- Static Pb at 600 °C
- Oxygen control (down to 10-9)
- Lead temperature monitoring within the vessels and at key points around the flowing loop.
- Lead flow rate by energy balance with known electric power supplied to lead flow and temperature measurements across the supply location.
- Lead pressure with a Venturi-based sensor.
- Gas pressure within the storage vessel and expansion tank.

Related instrumentation/capabilities

- MERLIN laboratory at Bangor University is a uranium active facility with vacuum furnace, x-ray diffraction, Raman spectroscopy and electron microscopy.
- The NNUF2a Bangor University Fuel Fabrication Facility.
- Simultaneous thermal analysis (STA) with mass spectroscopy available up to 1600 °C in inter atmosphere, with steam and H_2. Tested materials in Pb.
- Associated facilities with the Bangor University Lead Loop Erosion/ corrosion Testing (BULLET) facility.

External user access arrangements

BULLET is being used for the BEIS AMR Phase 2 project until the end of 2022. During this time there are opportunities for both flowing and static Pb testing of materials. Please contact s.middleburgh@bangor.ac.uk for more information about use and the conditions in which you want to test materials. Potential for testing in Pb-Li and other chemistries.

Nuclear material capabilities (i.e. activity limits)

Depleted/natural UO_2 (open powders)

Sealed sources below exemption limits.

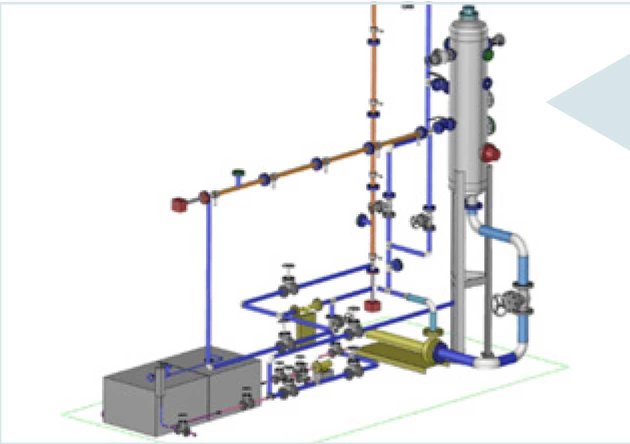
Areas instrument used over last 12 months

Area	% Usage
Waste Management	0
Advanced Nuclear	90
Environmental	0
Aerospace	0
Other (please specify)	0
Available/ unused	10

Other relevant information

Contact

Simon Middleburgh - s.middleburgh@bangor.ac.uk



Organisation
Bangor University

Facility
Thermal-Hydraulic Open-access Research (THOR) facility

Location
M-SParc Menai Science Park, Gaerwen LL60 6AG

Summary of capability/facility

THOR is a user-oriented and flexible facility in the spirit of an open invitation to the UK and beyond heat transfer communities. Established through the research equipment grant by the Welsh Government and designed by Vessco Engineering and the Nuclear Futures Institute. THOR is designed as separate effect studies facility, targeting phenomena like subcooled boiling, critical heat flux and void fraction. Unique features provided by THOR include reconfigurable horizontal and vertical test sections driven by steam and heated water supply from a main pressurisation and condensation vessel. In addition the loop is designed to operate with forced, natural and transitional flow regimes.

Instrument specification

- System pressure up to 16 bar
- Working temperature up to 200ºC
- Flow rate up to 8 kg/sec
- 20 kW 1 m immersion heaters in two test sections
- 8 kW heater in the main vessel
- ~4 m test sections (horizontal and vertical)
- 2" piping through out the loop (horizontal test section 4")
- Expected maximal void fraction at system limits -
    - Horizontal - ~7%
    - Vertical - ~20%

Related instrumentation/capabilities

- Rheonik RHM20 Flow Sensor
- Rosemount 2088 Gage and Absolute Transmitter and Rosemount R306 in-line manifold
- Rosemount coplanar transmitter 3051CD2A02A1 and Rosemount R305 Integral Manifold
- High-speed AMETEK Camera
- Z CAMTM E2 camera
- HZDR Wire-mesh sensors

Nuclear material capabilities (i.e. activity limits)

Depleted/natural UO_2 (open powders)
Sealed sources below exemption limits.

External user access arrangements

The THOR facility within its name gives indication that the facility is open to any external user. Please contact m.margulis@bangor.ac.uk for further information.

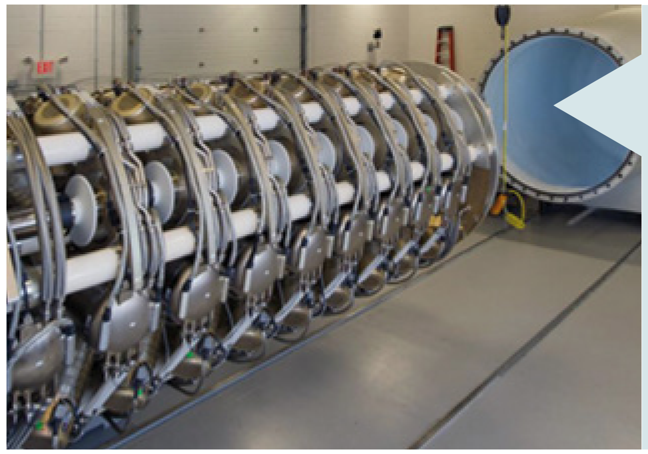
Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Other (please specify)	
Available/ unused	

Other relevant information

Contact

Marat Margulis - m.margulis@bangor.ac.uk



Organisation
University of Birmingham

Facility
High Flux Accelerator-Driven Neutron Facility

Location
Campus of the University of Birmingham, Edgbaston, Birmingham, B15 2TT

Image: The Neutron Therapeutics proton accelerator will be used for the generation of the neutrons. © 2020 University of Birmingham All Rights Reserved.

Summary of capability/facility

From summer 2022, a new UK neutron irradiation facility will be operational.

This is the first UK neutron facility capable of providing fluxes for the characterisation of degradation of materials in the reactor periphery. The high flux proton/deuteron beam will create neutrons through the interaction with a high power target. It will also be the first UK facility to possess a dual beam ion facility capable of providing the necessary fluxes to easily simulate the damage incurred by highly irradiated components such as cladding in current generation plant or structural materials in Gen IV or fusion reactors.

The new irradiation capability of this facility will combine with the existing high-energy light-ion accelerator to create a single UK user irradiation facility. This will form the most intense accelerator-driven neutron source worldwide. There are also opportunities to develop a wider community which draws in those interested in fundamental nuclear physics, cancer therapy (e.g. Boron Neutron Capture Therapy (BNCT), development of high power targets and radiobiology.

Instrument specification

The heart of the facility is a 2.6 MeV, 30-50 mA proton accelerator developed by the Boston, US, based company Neutron Therapeutics. The proton beam is incident on a water cooled, rotating, lithium target which converts the protons to neutrons through the 7Li(p,n)7Be reaction. The facility is designed to initially produce

- Fast neutron fluence rate of $1.8x10^{11}n/cm^2/s$
- Thermal fluence rate of $6x10^9$ $n/cm^2/s$

With an upgrade after initial operation to >$3x10^{12}$ $n/cm^2/s$

Related instrumentation/capabilities

A variety of user end stations are being developed which include the ability to perform *in situ* studies of materials properties and radiation assisted corrosion.

Nuclear material capabilities (i.e. activity limits)

Open source activity limits for non specified isotopes,
Beta/gamma-emitting radionuclides: 100 GBq
Alpha-emitting radionuclides: 1GBq

External user access arrangements

Users from UK-based HEIs (and other organisations that are eligible to apply for UKRI funding) can apply for funded access through NNUF, until March 2023 (please see www.nnuf.ac.uk/how-gain-access). Researchers from outside the UK can also apply for funded access through NNUF, if a faculty member in a UK university is included on the project team or if the experiment is part of establishing/expanding a substantial collaboration between the research group and the institution hosting the facility.

The facility is also open to industrial users.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (various)	
Other (please specify)	
Available/ unused	

Other relevant information

For further information please see the following links:
https://www.nnuf.ac.uk/high-flux-accelerator-driven-neutron-facility
https://www.birmingham.ac.uk/research/activity/nuclear/about-us/facilities/mc40-cyclotron-facility.aspx
https://www.birmingham.ac.uk/Documents/college-eps/energy/cyclotron_facility_brochure.pdf

Contact

Professor Martin Freer - M.Freer@bham.ac.uk (0121 414 4682)
Dr Ben Phoenix - B.Phoenix@bham.ac.uk

Organisation University of Birmingham

Facility

High-temperature corrosion testing of metals and alloys in molten salts

Location

Birmingham Centre for Energy Storage (BCES), Campus of the University of Birmingham, Edgbaston, Birmingham, B15 2TT

Summary of capability/facility

The BCES (facilities already available) has ~1000 m[2] of research labs and offices well-equipped for both fundamental and applied energy storage research, as well as a 600m[2]-pilot-plant for cryogenic (liquid air-based) energy storage integrated with heat and cold storage units (350kW/2.5MWh).

The expertise of the team ranges from nanoscale through to full-scale component testing, design and systems integration, transferring the knowledge in different areas of the nuclear sector.

Main BCES research areas are:

- Thermal (heat and cold) energy storage covering -196 °C ~ + 1500 °C;
- Manufacturing technologies and pilot-scale production lines for composite phase change materials (~1 ton/day scale) and composite thermochemical materials (~ 100kg scale);
- Cryogenic air energy storage and their integration;
- Direct wind-to-heat conversion & storage;
- Thermochemical storage (sorption based low to medium temperature storage, reversible reaction-based medium to high-temperature storage, and integrated thermal-chemical and electrochemical conversion);
- Heat transfer intensification;
- Molten salt science: thermal properties and corrosion behaviour

Related instrumentation/capabilities

Users of the BCES can also access to a wide range of thermal characterisation techniques, manufacturing equipment and test rigs.
Other equipment available in our facilities are:

- Particle size analysers (nm-to-cm range);
- Mechanical properties (~700 °C);
- Differential scanning calorimeters (DSC, -170 to +1800 °C);
- Thermal conductivity meters (-170 to +1800 °C);
- Rheometer (-150 to +700°C);
- Contact angle equipment (~1000 °C);
- FT-IR; IR Microscope;
- 2 TGA (-150 to +1700 °C);
- Dilatometer (-150 to 1000 °C)

External user access arrangements

The group is always willing to consider opportunities for collaborative R&D or consultancy projects from industrial institutions. We can provide services to external users either in person or by offering technical support.

Other relevant information

Please visit us on:
https://www.birmingham.ac.uk/research/energy/research/centre-energy-storage/index.aspx

Instrument specification

Two horizontal tube furnaces for corrosion experiments of metals and alloys in molten salts with possibility to test molten chlorides and molten nitrates. Other types of salts may be investigated upon request.

Maximum operating temperature: 800 °C

Possibility to work with a wide range of controlled atmospheres including air, nitrogen and argon. Gas cylinders with more complex atmospheres can be fitted. Furnaces are equipped with gas flow meters and scrubbing solutions for neutralisation of gases generated during the corrosion process.

Materials characterisation:

- X-Ray Diffractometer (XRD): Bruker D8 Advance
- X-Ray Tomography (nano-CT): Bruker SkyScan 2211
- Scanning Electron Microscope (SEM) equipped with EDS detector: Hitachi TM3030;
- Raman microscope: Renishaw Qontor InVia equipped with Nd:YAG laser (532.0 nm) and near-infrared diode laser (785.0 nm);
- Metallographic preparation of samples for microscopy observations.

Nuclear material capabilities (i.e. activity limits)

Non-active; the facility cannot process or test radioactive materials.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	30%
Advanced Nuclear	
Environmental	
Other (please specify)	
Thermal Energy Storage	70%
Available/ unused	

Contact

Professor Yulong Ding - Y.Ding@bham.ac.uk

Organisation University of Birmingham

Facility The University of Birmingham Centre for Energy Storage (BCES) & Energy Innovation Centre (BEIC) are cross-campus initiatives with thermal energy storage research hub at the School of Chemical Engineering. Birmingham Centre for Energy Storage (BCES) - Our on-campus laboratories and pilot facilities in The University of Birmingham Edgbaston Campus (operational since 2014). The Centre's integrated approach across disciplines and sectors allow BCES to provide novel solutions to energy storage challenges.

Location

Campus of the University of Birmingham, Edgbaston, Birmingham, B15 2TT

- 52°26'56.8"N 1°56'10.4"W
- 52°27'13.1"N 1°55'47.6"W

Summary of capability/facility

The BCES (facilities already available) has ~1000 m[2] of research labs and offices well-equipped for both fundamental and applied energy storage research, as well as a 600m[2]-pilot-plant for cryogenic (liquid air-based) energy storage integrated with heat and cold storage units (350kW/2.5MWh).

The expertise of the team ranges from nanoscale through to full-scale component testing, design and systems integration, transferring the knowledge in different areas of the nuclear sector.

Main BCES research areas are:

- Thermal (heat and cold) energy storage covering -196 °C ~ + 1500 °C;
- Manufacturing technologies and pilot-scale production lines for composite phase change materials (~1 ton/day scale) and composite thermochemical materials (~ 100kg scale);
- Cryogenic air energy storage and their integration;
- Direct wind-to-heat conversion & storage;
- Thermochemical storage (sorption based low to medium temperature storage, reversible reaction-based medium to high-temperature storage, and integrated thermal-chemical and electrochemical conversion);
- Heat transfer intensification;
- Molten salt science: thermal properties and corrosion behaviour

Related instrumentation/capabilities

Users of the BCES can also access to a wide range of thermal characterisation techniques, manufacturing equipment and test rigs.
Other equipment available in our facilities are:
Materials characterisation

- particle size analysers (nm-to-cm range);
- mechanical properties (~700 ° C);
- X-Ray Diffractometer (XRD);
- X-Ray Tomography (nano-CT);
- Scanning Electron Microscope (SEM) with EDS detector

External user access arrangements

The group is always willing to consider opportunities for collaborative R&D or consultancy projects from industrial institutions. We can provide services to external users either in person or by offering technical support.

Other relevant information

Please visit us on:
https://www.birmingham.ac.uk/research/energy/research/centre-energy-storage/index.aspx

Instrument specification

Materials characterisation equipment :

- Differential scanning calorimeters (DSC, -170 to +1800 ° C);
- Thermal conductivity meters (-170 to +1800 ° C);
- Rheometer (-150 to +700°);
- Contact angle equipment (~1000 ° C);
- Raman microscope;
- FT-IR; IR Microscope;
- 2 TGA (-150 ° C to +1700 ° C);
- Dilatometer (-150 to 1000 ° C)

Nuclear material capabilities (i.e. activity limits)

Non-active; the facility cannot process or test radioactive materials.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	30%
Advanced Nuclear	
Environmental	
Other (please specify)	
Thermal Energy Storage	70%
Available/ unused	

Contact

Professor Yulong Ding - Y.Ding@bham.ac.uk

Organisation
University of Birmingham

Facility
Two-tank molten salt flow test rig

Location
Campus of the University of Birmingham, Edgbaston, Birmingham, B15 2TT

Summary of capability/facility

A two-tank molten salt test rig is located at the Birmingham Centre for Energy Storage (BCES) to conduct salt handling tests. The rig can be used to study appropriate ways to move, stop, measure, and preserve different types of molten salts. An inert gas environment with flowing nitrogen is implemented to minimise the levels of oxygen and moisture partial pressure and thus help mitigate oxidation and corrosion-related issues. The reliability of the rig was tested by continuous operating, thermal cycling, and repetitively shutting down and reheating. Valuable experiences are gained in terms of salt breach issues, inert atmosphere maintaining, selectivity of components, heating solutions of the rig, instrument installations, etc.

Instrument specification

Specifications of the rig is given as follows.

1. Size: 2.3m(L) *2m(H) *0.42m(W)
2. Operating temperature: 350 – 600 °C
3. Operating pressure: 0-5 bar
4. Salt type: nitride, chloride, fluoride, etc.
5. Current test capability: dynamic flow, gas lifting, freeze-valve, normal valve, thermal cycling, tec.
6. Potential test capability with rig modifications: dynamic corrosion test for various materials
7. Material of the rig: stainless steel 316
8. Instruments: type K thermocouple, venturi flow meter, Gefran specialised molten salt pressure transducer
9. Control system: multiple PID temperature controller
10. Insulation: fibre glass, ceramic fibre, etc.
11. Inert gas: nitrogen or argon

Related instrumentation/capabilities

Users of the BCES can also access to a wide range of thermal characterisation techniques, manufacturing equipment and test rigs.
Other equipment available in our facilities are:

- Particle size analysers (nm-to-cm range);
- Mechanical properties (~700 °C);
- Differential scanning calorimeters (DSC, -170 to +1800 °C);
- Thermal conductivity meters (-170 to +1800 °C);
- Rheometer (-150 to +700°C);
- Contact angle equipment (~1000 °C);
- FT-IR; IR Microscope;
- 2 TGA (-150 to +1700 °C);
- Dilatometer (-150 to 1000 °C)

Nuclear material capabilities (i.e. activity limits)

Non-active; the facility cannot process or test radioactive materials.

External user access arrangements

The group is always willing to consider opportunities for collaborative R&D or consultancy projects from industrial institutions. We can provide services to external users either in person or by offering technical support.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	30%
Advanced Nuclear	
Environmental	
Other (please specify)	
Thermal Energy Storage	70%
Available/ unused	

Other relevant information

Please visit us on:
https://www.birmingham.ac.uk/research/energy/research/centre-energy-storage/index.aspx

Contact

Professor Yulong Ding - Y.Ding@bham.ac.uk

Organisation
University of Birmingham

Facility
Scanditronix MC40 Cyclotron Facility

Location
University of Birmingham

Summary of capability/facility

The MC40 cyclotron is the latest in a series of accelerators operated at Birmingham since the 1930s. It delivers a flexible range of ions and energies. It is capable of accelerating hydrogen (protons and deuterons) and helium (helium-3 and helium-4) with high intensities to energies at which it is possible to perform nuclear reactions.

The flexibility and reliability of the cyclotron - and the expertise of our nuclear physics, particle physics and medical physics groups in manipulating its capabilities - have led to us carrying out a wide range of commercial and research work for, among others, hospitals, Formula 1 and CERN's Large Hadron Collider.

Our activities have expanded significantly in the past few years. With the cyclotron only half-way through its expected lifespan, we aim to further broaden our research, as well as continuing our long-established applications and commercial work, bringing benefits to more users from across the UK nuclear community.

Instrument specification

The cyclotron is capable of producing up to 10's of microamps of ions within the following energy ranges:

Protons 2.7 -> 36 MeV
Deuterons 5.4 -> 20 MeV
Helium-4 10.8 -> 40 MeV
Helium-3 8 -> 50 MeV

Irradiations are possible in air or vacuum with various water, air and helium cooling options.

Related instrumentation/capabilities

Gamma spectroscopy of irradiated samples.

Nuclear material capabilities (i.e. activity limits)

Open source activity limits for non specified isotopes:
Beta/gamma-emitting radionuclides: 100 GBq
Alpha-emitting radionuclides: 1GBq

External user access arrangements

Users from UK-based Higher education institutions (HEIs) (and other organisations that are eligible to apply for UKRI funding) can apply for funded access through NNUF, until March 2023 (please see www.nnuf.ac.uk/how-gain-access). Researchers from outside the UK can also apply for funded access through NNUF, if a faculty member in a UK university is included on the project team or if the experiment is part of establishing/expanding a substantial collaboration between the research group and the institution hosting the facility.

The facility is also open to industrial users.

Areas instrument used over last 12 months

Area	% Usage
Materials Irradiation	20
Other Science Programmes	20
Isotope Production	40
Radiation hardness testing	20

Other relevant information

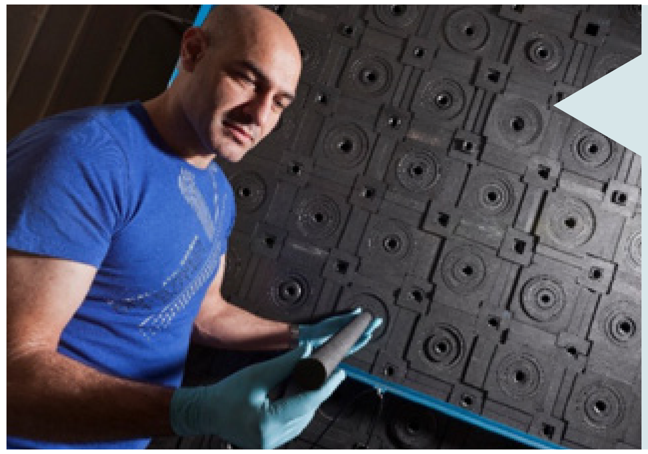
https://www.nnuf.ac.uk/high-flux-accelerator-driven-neutron-facility

https://www.birmingham.ac.uk/research/activity/nuclear/about-us/facilities/mc40-cyclotron-facility.aspx

https://www.birmingham.ac.uk/Documents/college-eps/energy/cyclotron_facility_brochure.pdf

Contact

To have an informal discussion regarding accessing these facilities as an external user, please contact Dr Ben Phoenix - B.Phoenix@bham.ac.uk



Organisation
University of Birmingham

Facility
Birmingham Centre for Nuclear Education and Research

Location
University of Birmingham, Edgbaston, Birmingham, B15 2TT

Summary of capability/facility

The Birmingham Centre for Nuclear Education and Research (BCNER), brings together the facilities, research programmes and educational courses within the University of Birmingham. The research facilities include:

- MC 40 cyclotron – particle accelerator (see separate section)
- High Flux Accelerator-Driven Neutron Facility (see separate section)
- Positron Imaging Centre. Capability for positron emission particle tracking studies for imaging radioactively labelled particles in a variety of systems including mixing and processing (contact Tzany Kokalova, t.kokalova@bham.ac.uk).
- National Centre for Nuclear Robotics. Funded through the UKRI robotics for extreme environments programme, the £40m centre includes a variety of advanced robotic systems for nuclear waste processing and decommissioning (contact Rustam Stolkin (Metallurgy and Materials) R.Stolkin@bham.ac.uk).
- Graphite test facilities associated with AGR moderator.

Nuclear education programmes include:

- Nuclear Engineering (4 year UG Masters)
- Nuclear Science and Materials (3 year UG BSc)
- Physics and Technology of Nuclear Reactors (1 year postgraduate taught Masters)
- Nuclear Decommissioning and Waste Management (1 year postgraduate taught Masters)

Instrument specification

See https://www.birmingham.ac.uk/research/activity/nuclear/index.aspx for more details.

Related instrumentation/capabilities

See https://www.birmingham.ac.uk/research/activity/nuclear/index.aspx for more details.

Nuclear material capabilities (i.e. activity limits)

The follow limits apply to the active facilities. Open source activity limits for non specified isotopes:
Beta/gamma-emitting radionuclides: 100 GBq
Alpha-emitting radionuclides: 1GBq

External user access arrangements

Access to facilities and programmes is via collaborative activity with the research groups at the University of Birmingham. See https://www.birmingham.ac.uk/research/activity/nuclear/index.aspx for more details.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (various)	
Other (please specify)	
Available/ unused	

Other relevant information

Contact

Director of the Birmingham Centre for Nuclear Education and research
Dr Paul Norman - p.i.norman@bham.ac.uk

Organisation
University of Bristol

Facility
Active Nano Mapping (ANM) Facility. High-speed Atomic Force Microscope (AFM), manufactured by Bristol Nano Dynamics Ltd.

Location
University of Bristol

Image: The Active Nano Mapping NNUF2 at the University of Bristol
© Oliver Payton

Summary of capability/facility

Full glovebox facility enables the processing and imaging of samples without exposure to ambient conditions.

Contact mode Atomic force microscope (AFM) that can collect video rate topography maps of surfaces with sub-atomic height and nanometre lateral resolution in ambient, controlled gas, and controlled liquid environments. Significantly higher throughput when compared to a conventional AFM - can collect and process a year's worth of AFM data in a matter of hours. This can be used:

1. To observe dynamic nano and micro scale processes in controlled liquid, gaseous, inert or ambient environments. (Easy-to-use navigation software and the ability to image under *in-vivo* conditions allows observation of processes such as corrosion, oxidation, or cracking with sub nanometre resolution, up to 100 frames per second.)
2. To map areas millimetres in size with nanometre resolution
3. To collect spatial maps of the distribution of the physical dimensions of nanostructures with world-leading statistical validity over millimetre sized areas

Instrument specification

The system has the following capabilities:
- Dynamic strain up to 2 kN
- Heated sample stage up to 200°C
- Image in ambient, liquid, gas environments with controllable humidity
- Ability to exchange liquid and gas environments while imaging
- Ability to load samples within an inert glovebox environment
- Sub-atomic height resolution, ~1 nm lateral resolution
- Topography, electrical, thermal and stiffness imaging modes
- Macro and micro optical images

Related instrumentation/capabilities

- Non-active HS-AFM
- Optical microscopes
- Sample preparation area
- Data analysis suite

Nuclear material capabilities (i.e. activity limits)

The microscope is housed in a dedicated active lab capable of handling samples up to a contact dose of 50 µSv/hr (or higher if the safety case can be made).

External user access arrangements

- Users from UK-based Higher Education Institutions (Higher education institutions (HEIs)) can apply for funded access through National Nuclear User Facility (NNUF), until March 2023 (please see www.nnuf.ac.uk/how-gain-access)
- To facilitate remote access by external users (given the COVID situation/ other situations in which this may be relevant), the facility allows remote imaging of samples via screen share and conference camera systems

Areas instrument used over last 12 months

The ANM's work will be mainly metallurgy (corrosion etc.), thin film actinide, and actinide work that falls under the waste management and advanced nuclear sectors listed.

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

Other relevant information

Please consult www.nnuf.ac.uk/active-nano-mapping-facility for further information.

Contact

Dr Oliver Payton
Oliver.Payton@bristol.ac.uk
07746 698405

Organisation
University of Bristol

Facility
Hot Robotics Bristol Facility

Location
Fenswood, North Somerset

(Equipment can also be hired out to users' own sites)

Image: © University of Bristol

Summary of capability/facility

The National Nuclear User Facility for Hot Robotics (NNUF-HR) is an Engineering and Physical Sciences Research Council (EPRSC) funded facility to support UK academia and industry to deliver ground-breaking, impactful research in robotics and artificial intelligence for application in extreme and challenging nuclear environments.

The facility is arranged across three regional nodes with four research partners: National Nuclear Laboratory (NNL), University of Manchester, University of Bristol and Remote Applications in Challenging Environments (RACE).

The University of Bristol's facility provides substantial space for developing mobile robotic applications as enhanced tools for environmental field surveying. Equipment can be hired out and delivered to a user's site. Its main capabilities focus on unmanned aerial vehicle (UAV) and mobile ground vehicles with a wide variety of sensor packages. The Bristol Fenswood Facility offers space to test deployments with sealed sources and create robotic detection systems.

Related instrumentation/capabilities

NNUF-HR also has hubs at UKAEA's RACE; NNL; and University of Manchester.

External user access arrangements

- As a first step, email the facility: nnuf-hr@bristol.ac.uk
- Users from UK-based Higher education institution (HEI) and other organisations that are eligible to apply for UK Research and Innovation (UKRI) funding can apply for funded access through NNUF, until March 2023 (please see www.nnuf.ac.uk/how-gain-access)
- Equipment can be used by industry, Small and medium-sized enterprises (SMEs) and academics at the Bristol Hot Robotics facility, or hired out to a users own sites

Other relevant information

Visit our website https://hotrobotics.co.uk for further information.

Nuclear material capabilities (i.e. activity limits)

The Bristol Hot Robotics facility currently has an array of sealed gamma sources for testing robotic detection systems. Sources comprise both Cs-137 and Naturally Occuring Radioactive Material (NORM) (natural uranium ore) to provide multiple gamma energies and source strengths for testing sensor and detector systems.

For security purposes we cannot provide specific operation information about number, strengths and locations of sources.

Contact

nnuf-hr@bristol.ac.uk

Instrument specification

Unmanned Aerial Vehicles
- 8 x Multi-rotors, including DJI Matrice 100, Mavic 2 Pro
- 2 x Fixed wing planes, including WingtraOne

Unmanned Ground Vehicles
- 1 x Proteus Lite System Pipe Crawler
- 3 x Lightweight vehicles, including Leo Rovers
- 3 x Heavyweight vehicles, including a Clearpath Husky
- 2 x A1 Quadruped Robot Dog

Manipulator Arms
- 2 x Kinova 7 Degrees of Freedom (DOF) Gen3 arms
- 2 x KUKA co-bots
- 1 x KUKA KR120 industrial robot

Sensors
- 3 x LiDARS, including a Velodyne VLP-16
- 3 x Gamma radiation detectors including a GR1+
- 1 x FLIR A35sc thermal camera
- 1 x Vanta C series handheld X-ray fluorescence (XRF) analyser
- 4 x Tracerco PED+ Dosimeters
- 1 x TN15 Thermal Neutron Detector
- 3 x Radhound Radiation Ratemeters, for Alpha or Beta
- 1 x High Purity Germanium (HPGe) detector
- 1 x Raman Robotic Laser System
- 2 x Diamond detectors for high dose radiation
- 1 x Specim IQ Hyperspectral camera

Equipment Bundles
- Lightweight and heavyweight Ground Indoor/Outdoor radiation mapping
- Multirotor Radiation mapping
- Photogrammetry
- 3D Scanning LiDAR

Facility
- Runway for testing UAVs
- Space for setting up and testing robot systems with sealed sources
- Meeting area
- Designated area for manipulator arms

Areas instrument used over last 12 months

Area	% Usage
Waste Management	0 - facility in construction
Advanced Nuclear	0 - facility in construction
Environmental	0 - facility in construction
Other (please specify)	0 - facility in construction
Available/ unused	N/A

Organisation
University of Bristol

Facility
Interface Analysis Centre

Location
HH Wills Physics Laboratory, Tyndall Avenue

Bristol BS8 1TL

Summary of capability/facility

Cutting-edge materials research is driven by a thirst for discovery and a pressing need to develop and better understand the materials we use to solve problems in everyday life. The Interface Analysis Centre is a multidisciplinary research hub at the University of Bristol. We work on a range of materials-science-based problems focused on real-world, problem-driven applications.

Our laboratories house a complementary array of analytical equipment for conducting surface, materials and solution analysis. This includes specially-equipped laboratories to safely handle radioactive materials, which form a major part of our research.

Our staff and postgraduate students solve real-world problems and make fundamental discoveries related to developing and understanding new and existing materials. Time is split between a broad portfolio of fundamental research, industrial research and short-term contract analysis.

Both undergraduate (BSc and MSci) and postgraduate (MSc and PhD) projects are hosted by us.

Related instrumentation/capabilities

South West Nuclear Hub
Bristol NanoESCA Laboratory | School of Physics | University of Bristol
Hot Robotics Facility | National Nuclear User Facility (nnuf.ac.uk)
Active Nano Mapping Facility | National Nuclear User Facility (nnuf.ac.uk)
Facility for Radioactive Materials Surfaces | National Nuclear User Facility (nnuf.ac.uk)
A National Focused Ion Beam Facility for Active Materials | National Nuclear User Facility (nnuf.ac.uk)

External user access arrangements

Equipment can be used by industry, Small and medium-sized enterprises (SMEs) and academics - contact us to discuss.

Other relevant information

Interface Analysis Centre | School of Physics | University of Bristol.

Nuclear material capabilities (i.e. activity limits)

Typically, materials capable of transport as excepted.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	TBD
Advanced Nuclear	TBD
Environmental	TBD
Other (please specify)	TBD
Available/ unused	TBD

Instrument specification

Transmission Electron Microscopy (TEM)
- Jeol 2010
- Philips CM30

Optical Microscopy and Image Analysis (OM)
- Olympus BH2
- Olympus BX60
- Olympus SZ11
- Zeiss Axioscope 7

Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Analysis (EDX) and Electron Backscatter Diffraction (EBSD)
- Zeiss Sigma HD VP - with EBSD and EDX
- Zeiss Evo MA10 - with EBSD and EDX
- FEI Helios NanoLab 600 - with EDX, Pt deposition and force measurement

Focused Ion Beam (FIB)
- FEI Helios NanoLab 600 - with EDX, Pt deposition and force measurement
- FEI Strata FIB201 - with Pt deposition, XF_2/I_2 etching and selective carbon milling

High-Speed Atomic Force Microscopy (HS-AFM)
- 2 x Custom-built - high-speed contact mode

Laser Raman Spectroscopy (LRS)
- Renishaw System 2000 - 514nm and 633 nm
- Horiba LabRam - 488 nm and 532 nm

Secondary Ion Mass Spectrometry (SIMS)
- IAC magnetic sector instrument

Surface Area Analysis (BET)
- Quantachrome NOVA 1200

Differential Scanning Calorimetry (DSC) / Thermogravimetric Analysis (TGA)
- Mettler Toledo TGA/DSC1

Thin-Film Sputter Deposition (TFSD)
- IAC Ultra-high vacuum (UHV) system

X-Ray Tomography (XRT)
- Zeiss Xradia 520 Versa

X-Ray Diffraction (XRD)
- Philips X'pert

X-Ray Fluorescence (XRF)
- Niton FXL
- Olympus Vanta

Gamma Spectrometry
- Mirion broad energy germanium (BEGe) HPGe
- Mirion small anode germanium well (SAGe) HPGe

Contact

Dr Keith R Hallam - Commercial Manager
Interface Analysis Centre, HH Wills Physics Laboratory, Tyndall Avenue, Bristol BS8 1TL Tel: 0117 331 1173 Email: k.r.hallam@bristol.ac.uk

Organisation
University of Bristol

Facility
Seismic testing facilities - EQUALS and SoFSI

Location
EQUALS, Faculty of Engineering, Queen's Building, University of Bristol, BS8 1TR
SoFSI, University of Bristol, Langford campus, Bristol, BS40 6DU

Summary of capability/facility

Earthquake and Large Structures (EQUALS) Laboratory

The EQUALS laboratory is a unique facility that combines strong walls and strong floors allowing a wide range of different types of structures (e.g. intake towers, bridges, buildings etc.) to be tested. The facility also houses the 15 t 6DOF shaking table so that large-scale seismic tests can be performed in addition to more conventional static or pseudodynamic testing.

National Facility for Soil Foundation Structure Interaction (SoFSI).

The SoFSI facility is capable of dynamic testing large prototype foundations and structures, and testing piles under static and dynamic loading. It is part of the national UK Collaboratorium for Research on Infrastructure and Cities (UKCRIC) network and is available for industrial and academic researchers to test large to full-scale equipment. The facility also houses the 50 t biaxial shaking table and the high performance 6DOF Hexapod which is suitable for seismic qualification and vibration testing of components.

Instrument specification

EQUALS:
- 3 m by 3 m platform supported by 8 hydraulic actuators. The table can carry up to 15 tonnes and (depending on the loading) can reach acceleration levels up to about 5 g with peak displacements of ±150 mm

See detailed spec:
https://www.bristol.ac.uk/engineering/research/earthquakegeo/equip/tablespec/

SoFSI:
- Bi-axial shaking table: 6 m x 4 m, 50 tonne capacity, capable of achieving BELLCORE test standards in horizontal axes
- Hexapod: 1 m x 1 m high performance shaking table - 800 kg capacity, capable of reaching 10 g
- Soil pit with actuators: 6 m x 5 m x 4 m deep with flexible capability for saturated and unsaturated soil. Additional actuators can be added and a 1.5 m trench allows for testing at multiple levels. Seismic testing of soils is also possible on the shaking table using a state-of-the-art laminar soil box

Related instrumentation/capabilities

UKCRIC network.
South West Nuclear Hub.

Nuclear material capabilities (i.e. activity limits)

Non-active.

External user access arrangements

Seismic qualification tests on mechanical equipment are carried out in the laboratory, whilst dynamic measurements (impact analysis and in-situ monitoring) on full scale structures are undertaken as part of integrity and safety assessments.
For more information or to request a quotation for work please contact Professor Dr Adam Crewe and see the link below:
https://www.bristol.ac.uk/engineering/research/earthquakegeo/commercial/
Collaboration and access can also be facilitated through South West Nuclear Hub membership.

Areas instrument used over last 12 months

Area	% Usage
Seismic Qualification	30
Research	40
Teaching	10
Available/unused	20

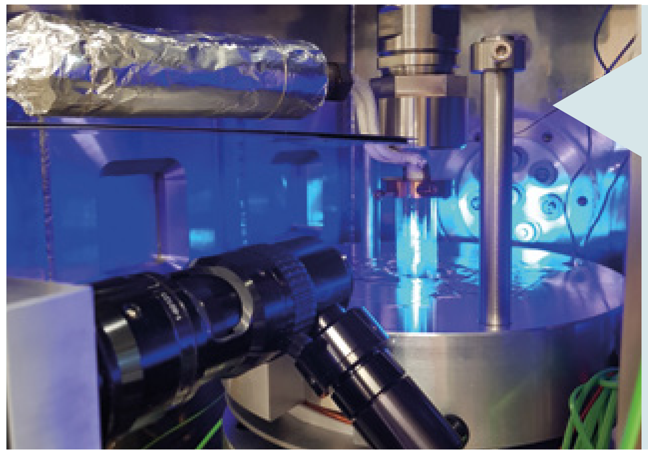
SoFSI:
Facility opens mid-2021 and expected to be available >30% for commercial activities.

Other relevant information

https://www.bristol.ac.uk/engineering/research/earthquakegeo/

Contact

Professor Adam Crewe - A.J.Crewe@bristol.ac.uk
Dr Patrick Tully - patrick.tully@bristol.ac.uk



Organisation
University of Bristol

Facility
Solid Mechanics Research Group - Creep and Residual Stress labs

Location
Faculty of Engineering, Queen's Building, University of Bristol, BS8 1TR

Summary of capability/facility

The high-temperature laboratory is a dedicated facility in a temperature-controlled environment, used to support research on understanding the behaviour of metals operating at high temperatures. We operate a suite of computer-controlled 10-100 kN Low Cycle Fatigue and constant-load machines permitting tests on metals at temperatures up to 1000°C. This includes novel capabilities for creep-fatigue and high-temperature tests with Digital Image Correlation, and small-punch testing in specialised environments.

The Residual Stress laboratory has capabilities for Deep Hole Drilling (DHD), Incremental Centre Hole Drilling (ICHD) and X-Ray Diffraction (XRD). Many residual stress projects are associated with determining residual stresses in high integrity components for the nuclear and oil & gas industries, although we can also measure residual stresses in non-metallic components such as fibre composites for aerospace applications.

Instrument specification

Zwick-Roell Kappa 100 SS-CF servo-electric creep testing machine equipped with high resolution capacitive extensometer for room and high temperature force-controlled or strain-controlled testing including creep, low cycle fatigue and creep-fatigue.

Phoenix servo-hydraulic benchtop testing machine is equipped with 10 kN load cell, clamshell IR heater, hot air blower, environmental chamber, and Video Extensometer for non-contact strain measurement. This machine is extremely versatile for performing a wide range of standard and bespoke testing.

Related instrumentation/capabilities

- XRD - Interface Analysis Centre, University of Bristol
- University of Bristol High Performance Computing facilities - BlueCrystal
- UKAEA's Materials Testing Facility (MTF)
- EDF High Temperature Centre

Nuclear material capabilities (i.e. activity limits)

External user access arrangements

The group is always willing to consider opportunities for collaborative R&D research projects from academic and industrial institutions.
See https://www.bristol.ac.uk/engineering/research/solids/
Collaboration and access can also be facilitated through South West Nuclear Hub membership

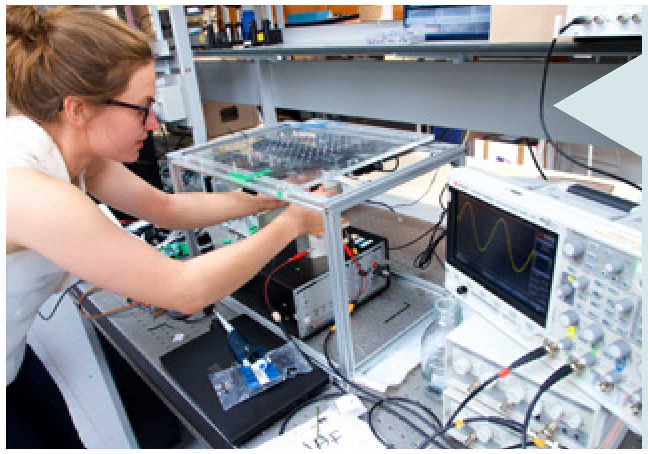
Areas instrument used over last 12 months

Area	% Usage
Waste Management	10
Advanced Nuclear	25
Environmental	
Other (please specify)	Life Extension (65)
Available/ unused	

Other relevant information

Contact

Dr Mehdi Mokhtarishirazabad - Technical Specialist
m.mokhtari@bristol.ac.uk



Organisation
University of Bristol

Facility
Ultrasonics and Non-Destructive Testing Group

Location
Faculty of Engineering, Queen's Building, University of Bristol, BS8 1TR

Summary of capability/facility

The Ultrasonics and Non-Destructive Testing (UNDT) group undertake internationally leading research into the fundamentals and applications of ultrasonics.

Ultrasonic array and imaging techniques are highly applicable to the nuclear industry as it provides an in-situ monitoring method of areas or installations that either cannot be accessed or removed/dismantled for inspection.

Research in this area focuses on advanced sensor and imaging technology, that seeks to develop the next generation of automated inspection, digital sensing networks and data analysis.

Large components and structures' conditions are difficult to monitor using conventional NDT where the positioning of measurement sensors varies with each test. Therefore, ultrasonic testing has been developed as an inspection method using guided waves capable of inspecting large areas to deal with the presence of environmental variation and minimise its effects.

Instrument specification

The University of Bristol Non-Destructive Testing Laboratory has specialist kit in the form of:

- a Faraday cage
- an ultrasonic frequency laser inteferometer (2-20 MHz)
- five ultrasonic phased array controllers (most with 128 channels)
- a large collection of ultrasonic phased arrays from 2-15 MHz including several 2D arrays for 3D imaging
- a high frequency pulser receiver (200 MHz)
- a Schlieren system (for ultrasonic wave visualisation)
- an ultrasonic particle manipulation controller
- a 3-axis ultrasonic scanning tank
- instrumentation for eddy-current testing

Related instrumentation/capabilities

- RCNDE (UK Research Centre in Non-Destructive Evaluation NDE)
- Inductosense - spin-out company specialising in ultrasonic in-situ monitoring devices and systems

Nuclear material capabilities (i.e. activity limits)

External user access arrangements

The group is always willing to consider opportunities for collaborative R&D or consultancy projects from industrial institutions. See https://www.bristol.ac.uk/engineering/research/ndt/industrial-collaborations/consultancy_projects/

Collaboration and access can also be facilitated through South West Nuclear Hub membership

Areas instrument used over last 12 months

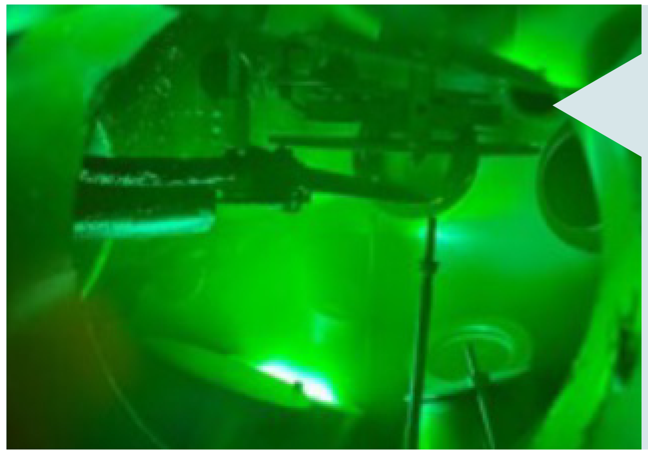
Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Plant life extension	
New build	
Available/ unused	

Other relevant information

https://www.bristol.ac.uk/engineering/research/ndt/

Contact

Professor Paul Wilcox - p.wilcox@bristol.ac.uk



Organisation
University of Bristol ational Nuclear User Facility (NNUF)
Facility for Radioactive Materials Surfaces (FaRMS)

Facility
Thin film growth chamber X-ray Photoemission Spectroscopy (XPS) system

Location
School of Physics, University of Bristol, BS8 1TL

Summary of capability/facility

NNUF FaRMS, based at the University of Bristol, hosts a thin film growth system capable of fabricating high quality active thin films and surfaces for fundamental and applied studies.

This system is already available for use, and will be upgraded and complemented with an X-ray Photoemission Spectroscopy (XPS) system enabling surface analysis and depth-profiling. Users can engineer samples, from idealised single crystal model systems, to more complex, multi-element, granular structures that more closely represent the real world. The properties of thin film samples are dominated by surface/interfacial effects, and hence are ideal to understand phenomena such as oxidation, dissolution, pitting, cracking, species migration, hydriding and interaction with water, which are of crucial importance across the nuclear sector.

A key aspect of this facility is that typically, sample activity will range from 0.1 –10 Bq/g, which means that samples can be easily accepted into universities and national facilities that do not currently have licenses for large quantities of active material.

Instrument specification

The Thin film growth chamber has the following capabilities:

- Four DC magnetron guns allow deposition of material individually, sequentially, or simultaneously, to fabricate single element systems, complex multilayer structures or binary/ternary compounds and alloys
- Range of high purity targets including, but not limited to: depleted U and Th, as well as Al, Ba, Co, Cr, Cu, Fe, Hf, Ho, Ir, Mg, Mo, Nb, Ni, Pd, Sc, Si, Sm, Ta, Tb, Ti, W, V, Yb, Zr. Typical deposition rates < 1 Ås^{-1}, allowing films of thicknesses in the range Å to µm
- Sputtering via inert with argon (Ar) gas
- Several additional gas-inlet ports for reactive sputtering, which allows for the deposition of oxide, nitride, and hydride compounds
- In-situ reflection high-energy electron diffraction to monitor the crystallinity and strain of the substrate and thin film structure
- Experience with growth on a range of commercial substrate materials from glass and oxidised silicon for polycrystalline or textured samples, to sapphire, YSZ, LSAT, CaF_2, $SrTiO_3$ and other single crystals for epitaxially-related growth
- Load-locked Ultra-high vacuum (UHV) chamber with main chamber base pressure in the 10-10 mbar range
- Residual gas analysis via a quadrupole mass spectrometer to analyse the sputter gases and composition at base pressure
- Uniform growth across a substrate size up to 25 mm diameter
- Substrate temperatures currently up to 900°C - shortly to be upgraded to > 1000°C

About the X-ray photoelectron spectroscopy (XPS) system
The system is expected to have the following capabilities:

- Lateral scanning with resolution in the tens of microns
- Ar cluster source system for depth profiling (expected < 0.3 Ås^{-1})
- Loadlock and UHV connection to the thin film growth chamber
- Auger detector for reliable, quantitative elemental compositional analysis
- More details will follow as the system is purchased and installed

Related instrumentation/capabilities

We recommend exploring available opportunities at the NNUF Active Nano Mapping Facility, as well as other capabilities in the Interface Analysis Centre and throughout other parts of the School of Physics at the University of Bristol.

External user access arrangements

- Users from UK-based Higher education institution (HEI) can apply for '56funded access through the NNUF User Access Scheme until March 2023 (please see www.nnuf.ac.uk/how-gain-access)
- Researchers from outside the UK can also apply for funded access through NNUF, if a faculty member in a UK university is included on the project team or if the experiment is part of establishing/expanding a substantial collaboration between the research group and the institution hosting the facility.
- Collaboration and access can also be facilitated through South West Nuclear Hub membership

Areas instrument used over last 12 months

Area	% Usage
Waste Management	35
Advanced Nuclear	35
Environmental	0
Other (please specify)	30 (fundamental science, nuclear data, alternative uses of nuclear materials)
Available/ unused	

Other relevant information

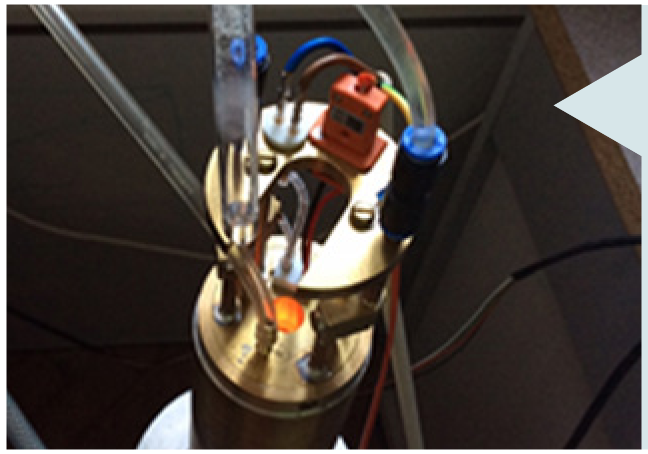
https://nnuf.ac.uk/farms

Nuclear material capabilities (i.e. activity limits)

Can use masses of DU up to kg quantities in the facility, although typical samples contain only µg quantities of DU – XPS capability in the future will allow for bulk active work.

Contact

Dr Ross Springell - phrss@bristol.ac.uk
Dr Chris Bell - christopher.bell@bristol.ac.uk
nnuf-farms@bristol.ac.uk



Organisation

University of Cambridge

Facility

Radiological NMR facilities. 500MHz and 400MHz nuclear magnetic resonance spectrometers (Varian CMX Infinity and Infinity plus)

Location

Department of Earth Sciences, University of Cambridge

Summary of capability/facility

Protocols are in place to perform high-resolution solid-state nuclear magnetic resonance (NMR) that require sample rotation at speeds of >60 kHz (4,000,000 rpm) on actinide systems. Two spectrometers both in a triple resonance configuration with a suite of probes allow the acquisition of isotope specific information for suitably 'NMR active' nuclides, e.g. ^{1}H, ^{2}H, ^{6}Li, ^{7}Li, ^{11}B ^{13}C, ^{17}O, ^{19}F, ^{23}Na, ^{25}Mg, ^{27}Al, ^{29}Si, ^{31}P, ^{35}Cl, ^{37}Cl …^{207}Pb

A high temperature system with a non-inductively wound furnace that can operate in horizontal configuration to 1300˚C and in vertical configuration to 1000˚C (see photo/figure) is largely used to examine atomic scale dynamics in solids and liquids.

Instrument specification

11.7 T and 9.4 T NMR system with triple resonance console and multinuclear NMR capability.
Magic angle spinning (MAS) and static NMR capability for uranium and thorium containing materials and neutron activated material (100µSv/hr contact dose).
1.3 mm ultra-fast spinning (67 kHz) MAS probe for U(IV) and U(V) paramagnetic systems.
Larger volume 2.5 mm, 3.2 mm, 4 mm MAS probes.
Static NMR up to 1300˚C for borosilicate and 1000˚C for halide salt liquid speciation and dynamics.

Related instrumentation/capabilities

Integrated furnace and anoxic glovebox (<1ppm O_2 and H_2O) for annealing U(IV) and direct sample loading without exposure to atmosphere and dry handling of halide salts.

Nuclear material capabilities (i.e. activity limits)

Uranium (U) and Thorium (Th) limited only by rotor sample volumes.

100 µSv/hr for neutron activated samples.

External user access arrangements

Consumable and time costs may apply depending on the nature of the work.
Point of contact:
Claire Armstrong
ca486@cam.ac.uk
01223 339977

Areas instrument used over last 12 months

Area	% Usage
Waste Management	50
Advanced Nuclear	50
Environmental	
Other (please specify)	
Can be made available	5

Other relevant information

There is a possibility to access international transuranic actinide NMR facilities at Karlsruhe (EU JRC), Tokai (ASC JAERI) and Richland WA (PNNL) after proof of principle work on U or Th through former EURACT NMR collaborators.

Contact

Ian Farnan - If203@cam.ac.uk
01223 333431

Organisation

The University of Edinburgh

Facility

Pyrochemical Research Laboratory (PRL). Four dual side access and interconnected MBraun Argon gloveboxes (<0.1 ppm H_2O and O_2). These contain a suite of furnaces (rated to T < 1200 °C) and other related equipment pertinent to pyrochemical research/reprocessing and associated characterisation. These include: High precision scale, mortar grinder, microscope, potentiostats, STA (TGA/DSC), ONH analyser, Optional UV/VIS, NIR and Raman).

Location

The University of Edinburgh School of Chemistry, David Brewster Rd, Edinburgh EH9 3FJ

Summary of capability/facility

The Pyrochemical Research Laboratory (PRL) is an open access national user facility, established to provide academic, public, and private sector organisations with access to state of the art equipment to support world leading research in molten salt pyrochemical processing.

This makes the PRL not only relevant to the development of pyrochemical reprocessing but also to wider molten salt systems and extreme condition applications, e.g. high temperature electrical batteries, thermal storage, heat transfer, and thermochemical reactions.

New additions to the facility's capabilities, through our collaboration with the co-located Molten Salts in Nuclear Technology Laboratory (MSNTL), include rheometric studies of molten salts and handling of fluoride salts.

The laboratory consists of a suite of interconnected controlled atmosphere dry-boxes. These are equipped with the necessary furnaces, cell systems, potentiostats and other equipment for characterisation, required for research into, and development of, each of the essential elements of pyrochemical reprocessing at the laboratory scale.

There is flexibility in the configuration of the PRL, with users able to request individual modules to demonstrate the feasibility of individual components of pyrochemical reprocessing. Alternatively the entire facility may be utilised to demonstrate a complete pyrochemical process, including monitoring and analysis.

Instrument specification

Glove Boxes X 4 - MBRAUN MB200MOD (< 0.1 ppm H_2O and O_2)

Potentiostats x 6 AUTOLAB with MUX and FRA modul
High current module AUTOLAB X 3 (20 A)

Value Oven - MBRAUN - MB VOH 250 °C 3x10^{-2} mbar

Tube Furnace x 5 and Optical Furnace - Severn Thermal TF2260 with CU2260 control Unit (up to 1200 °C)

Well Furnace - Severn Thermal TF2042-CU2042B - 3 heating zones (up to 1200 °C)

TGA/DSC - Perkin Elmer STA 6000 (up to 1000 °C)

ONH Analyer - ELTRA ELEMENTAL ANALYZERS - ONH 2000

Spectroscopy - Ocean Optics
UV-VIS-NIR DH-2000-BAL
UV - HL-2000-FHSA
Raman Laser - 0811A100-B FATBOY

Related instrumentation/capabilities

Mortar Grinder - Fritsch PULVERISETTE 2 finesse 10 to 20 µm
Microscope with high resolution camera - Yenway
Long working distance optics 5 to 100X magnification
Glove box Integrated Microscope and camera - Leica M60
KL1600 light source
Weighing Balances x3 120 g to 0.1 mg - Sartorius - Practum124-1S

Nuclear material capabilities (i.e. activity limits)

The PRL is an inactive facility allowing the high throughput study of inactive and surrogates species.

External user access arrangements

The PRL has a work application form that can be found on the PRLs website www.prl.chem.ed.ac.uk/work-application-form. Alternatively feel free to email Andy Mount or Justin Elliott for advice or questions at the emails addresses provided.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	80
Environmental	
Thermal Storage	20
Other (please specify)	
Available/ unused	

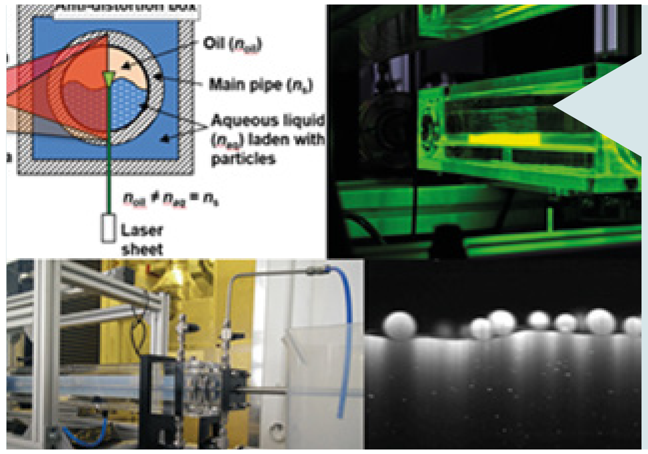
Other relevant information

For further PRL capability information please visit our website (www.prl.chem.ed.ac.uk) or contact us by email.

Contact

PRL Facility Director
Professor Andy Mount
a.mount@ed.ac.uk / 0131 650 4747

PRL Facility Manager
Dr Justin Elliott
Justin.Elliott@ed.ac.uk



Organisation Imperial College London

Facility

The Clean Energy Processes (CEP) Laboratory is based in the Department of Chemical Engineering at Imperial College London. Our mission is to conduct significant research in collaboration with industry, international research centres and universities on fundamental aspects of thermodynamics, fluid flow, heat and mass transfer processes, as well as their applications to a range of components, devices, technologies and systems for energy recovery, conversion and storage. Our research covers theoretical, experimental and modelling approaches and the full range of scales from molecules to systems.

Location

Department of Chemical Engineering, South Kensington Campus, London SW7 2AZ

Summary of capability/facility

A suite of experimental facilities is available for the experimental study of complex multiphase flow systems. The bespoke facilities include horizontal, vertical and inclined flow apparatuses that can be used to investigate a multitude of both isothermal and/or heated/cooled single-phase, two-phase (gas-liquid, liquid-liquid) flows, including flows accompanied by phase change phenomena (boiling, freezing), inside conduits with hydraulic diameters up to 0.1 m. The facilities provide adaptability to different fluids, duct sizes and geometries over a wide range of experimental conditions.

The measuring equipment and instrumentation includes, amongst other, high-speed and infrared cameras, lasers and other specific components needed to implement optical, laser-based diagnostic techniques. Methods such as particle image/tracking velocimetry (PIV/PTV), laser-induced fluorescence (LIF), etc., can be applied to flows of interest in order to provide detailed, high spatiotemporal resolution information such as phase distributions, interface tracing, concentration, temperature and velocity field data.

Related instrumentation/capabilities

Advanced image post-processing capabilities to extract instantaneous and time-averaged information on, for example, mean and fluctuating velocity fields, Reynolds stresses and other turbulent characteristics, film-thickness statistics, wave/droplet/bubble statistics, phase fraction and concentration distributions, heat and mass transfer and concentration gradients. Other complementary diagnostic techniques available include twin-wire sensors, multi-capacitance probes and differential pressure transducers, thermocouples and other conventional gauges and instruments.

External user access arrangements

The CEP Laboratory has its own website where additional information can be found. Please contact Professor Markides with any suggestions or questions you might have.

Other relevant information

For more details on the CEP Laboratory's facilities and capabilities, please visit our website (https://www.imperial.ac.uk/cep) or contact us by phone/email.

Nuclear material capabilities (i.e. activity limits)

The facilities of the CEP Laboratory are not designed to deal with radioactive substances.

Contact

Professor Christos N. Markides
c.markides@imperial.ac.uk
+44 (0)20 759 41601

Instrument specification

Multiple lasers are available for advanced diagnostic techniques, including:

- Litron Nano L 50-100 double-pulsed Nd:YAG laser, pulse energy 50 mJ, pulse width 10 ns, repetition rate 200 Hz, wavelengths 266, 355, 532, 1064 nm;
- Litron Nano L 200-15 double-pulsed Nd:YAG laser, pulse energy 200 mJ, pulse width 10 ns, repetition rate 15 Hz, wavelengths 266, 355, 532, 1064 nm;
- Litron LD30-527 double-pulsed Nd:YLF laser, pulse energy 30 mJ @ 1 kHz, pulse width 150 ns, repetition rate 20 kHz, wavelengths 527, 1053 nm;
- Oxford Lasers single-pulsed Cu-vapour laser, output power 30 W @ 10 kHz, pulse width 15-30 ns, repetition rate 10 kHz, wavelengths 510.6, 578.2 nm;
- SIRAH Cobra-Stretch single-pulsed dye laser, diffraction grating 1800 lines/mm, dye-emission spectral range 400-920 nm, pump laser Quantel Q-smart 850, pulse energy 430 mJ @ 532 nm, repetition rate 10 Hz;
- FLIR X6540sc IR-camera, resolution 640x512 pixel, detector pitch 15 µm, frame rate 4011 Hz @ 64x8 pixel;
- Olympus i-Speed 3 high-speed CMOS-camera (3 pcs.), resolution 1280x1024 pixel, pixel size 21 µm, frame rate 150 kHz @ 60x44 pixel, digital output 10 bit, min. shutter time 1 µs;
- LaVision Phantom VEO-E 310L CMOS-cameras (2 pcs.), resolution 1280x800 pixel, pixel size 20 µm, frame rate 11.5 kHz @ 512x512 pixel, digital output 12 bit, min. interframe time 0.48 µs;
- Imager MX 2M-160 double-frame CMOS-camera (2 pcs.), resolution 1936x1216 pixel, pixel size 3.45 µm, frame rate 155 Hz @ 8 bit, digital output 12 bit, min. interframe time 41.5 µs @ 8 bit;
- Imager M-lite 2M single-frame CMOS-camera, 1920x1280 pixel, pixel size 5.86 µm, frame rate 155 Hz @ 8 bit, digital output 12 bit;
- IRO X Intensified Relay Optics, spectral range 190-900 nm, min. exposure time 10 ns, frame rate 100 Hz, photo cathode S25, phosphor screen P43;
- Zeiss SteREO Discovery.V20 modular stereo-microscope with motorised 20x zoom, magnification 18.8-375x @ object field 13.3-0.7 mm (with W 25x/10 foc eyepiece and PlanApo S 1.0x 60 mm objective), object field 48.7-2.4 mm @ magnification 4.7-94.5x (with WPL 10x/23 Br. foc eyepiece and Achromat S 0.63x 115 mm objective).

Examples of techniques/methods include:

- Particle image/tracking velocimetry (PIV/PTV) with spatial resolution down to 1 µm in 3 dimensions and acquisition frequency up to 20 kHz;
- Laser induced fluorescence (LIF) with spatial resolution does to 1 µm in 3 dimensions, temperature resolution down to 0.5 °C, concentration resolution down to 1 ppb and acquisition frequency up to 20 kHz;
- High-speed direct imaging and shadowgraphy with spatial resolution down to 10 µm and acquisition frequency up to 125 kHz.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	50
Environmental	50
Other (please specify)	
Available/ unused	

Organisation

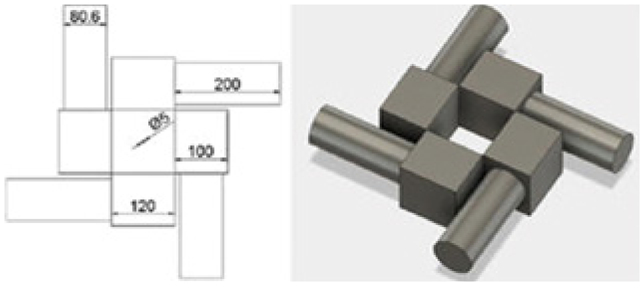
Lancaster University

Facility

ADRIANA (Advanced Digital Radiometric Instrumentation for Applied Nuclear Activities). Digital neutron assay system, comprised of 32 detectors with a combination of EJ-309 scintillation liquid and photomultiplier tubes sources from Scionix (NL).

Location

Lancaster University (can be shipped elsewhere on request).



A photograph and drawings of a detector array. Photograph and CAD drawings of a 4-detector array.

Summary of capability/facility

The digital neutron assay system at Lancaster comprises > 32 organic liquid scintillation detectors (EJ-309) and, given the frequent need to access various neutron and gamma sources, this component of ADRIANA is portable. Users are responsible for shipping costs and arrangements (UK-based university researchers, and those from other organisations that are eligible to apply for UK Research and Innovation (UKRI) funding, can apply to the National Nuclear User Facility (NNUF) funded access scheme to recoup shipping costs).

The system can be used with its associated 32 channels of digital pulse-shape discrimination firmware (Mixed-field analysers - Hybrid Instruments) to separate neutron events from γ-ray events and to explore coincidence phenomena or time-of-flight correlations between these events. For example, part of the system (15 detectors) has been used at the Oak Ridge National Laboratory, USA. In this set-up the system was used to record high-order neutron multiplicity events (triples and quadruples events) to investigate the angular distribution of these emissions from spontaneous fission in ^{252}Cf, for safeguards applications.

Related instrumentation/capabilities

As well as the instruments at Lancaster University, ADRIANA also incorporates the following instrumentation elsewhere:

- a digital position-sensitive CZT/germanium detector array with mechanical cooler (Dr Laura HarkNess-Brennan, University of Liverpool)
- digital systems for environmental radioactivity assay including a broad energy germanium (BEGe™) and small anode germanium (SAGe™) detector systems (Dr Chantal Nobs, CCFE)

External user access arrangements

- Users from UK-based Higher education institution (HEI) and other organisations that are eligible to apply for UKRI funding can apply for funded access through NNUF, until March 2023 (please see www.nnuf.ac.uk/how-gain-access)
- All enquiries are welcome direct to any of the ADRIANA team partners
- Lancaster's ADRIANA capability can accommodate external users, either in person or (even easier) by Lancaster scientists delivering experiments on behalf of externals. In the first instance please do reach out to the Lancaster ADRIANA team to discuss requirements.

Other relevant information

Please consult www.nnuf.ac.uk/adriana for further information regarding contacts and usage.

Instrument specification

- > 32 organic liquid scintillation detectors (EJ-309) with photomultiplier tubes
- Eight 4-channel Hybrid Instruments Mixed Field Analysers (MFAs) providing 32 channels of high-order pulse-shape discrimination firmware

Nuclear material capabilities (i.e. activity limits)

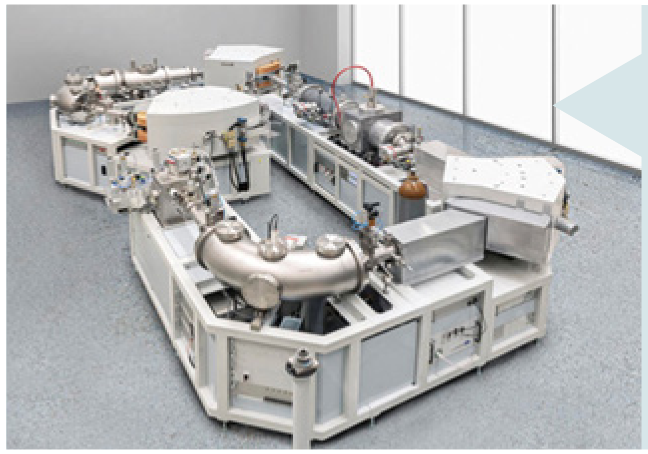
Limit of Detection (LoD) (mixed field neutron/gamma) of the ADRIANA arrays at Lancaster are as low as background level. The upper limit is generally decided by the saturation of detectors by the gamma field. The apparatus is highly adjustable to specific measurement conditions so we encourage any interested parties to get in touch to discuss their possible detection requirements.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	20
Advanced Nuclear	60
Environmental	20
Teaching	
Other (please specify)	
Available/ unused	

Contact

Prof. Malcolm Joyce - m.joyce@lancaster.ac.uk



Organisation
Lancaster University

Facility
Lancaster Accelerator Mass Spectrometer (LAMS-UK)

Location
Lancaster University

Image: IonPlus manufactured Accelerator Mass Spectrometer. Pictured is the Multi-Isotope Low Energy AMS (MILEA) to be used at the Lancaster University based facility © IonPlus

Summary of capability/facility

The LAMS-UK facility comprises a compact accelerator mass spectrometer capable of identifying actinide isotopes at 'trace level' sensitivity, of order 10^{-15} g/g. This capability is relevant to the characterisation needs of remediated and decommissioned sites, especially concerning trace plutonium assay at levels below the limit of detection for conventional radioactivity analysis. The facility will be the first of its kind within the UK, available for the dedicated use for UK nuclear needs.

AMS Capabilities
- Ability to analyse 55 different radionuclides at fg-pg/g concentrations, with Plutonium and Uranium isotopes as the facility's primary foci
- Distinguish samples to a greater extent utilising isotopic ratio measurement
- Analyses are carried out with small sample masses (1-5 g), easily allowing for multiple repeats

Research Applications
- Isotopic contaminant monitoring; Environmental (Terrestrial/Marine), Ecological, Fallout, Pollution, characterisation following an emergency
- Hydrology
- Nuclear physics / neutron activation
- Materials analyses for dating
- etc

Related instrumentation/capabilities

Further LAMS-UK Facilities
- Sample spiking (dependent - please get in touch)
- Raw sample preparation
- Strong acid digestion for variety of samples
- In-house measurements
- Dedicated enclosed facility for safe storage of sensitive sample materials

External user access arrangements

- Users from UK-based Higher education institutions (HEIs) and other organisations that are eligible to apply for UKRI funding can apply for funded access through NNUF, until March 2023 (please see www.nnuf.ac.uk/how-gain-access)
- We are open to remote access options from potential users and happy to discuss access following discussion of experimental aims

Instrument specification

The LAMS-UK facility is centred around the MILEA accelerator mass spectrometer manufactured by IonPlus (SUI).

Detailed instrument specification can be found at: www.ionplus.ch/milea

Nuclear material capabilities (i.e. activity limits)

- Mass limits vary in the attogram - picogram range
- The activity range is more varied as it is dependent on the isotope. For plutonium isotopes 0.0001 - 0.001 becquerels is desired, higher activities would need to be discussed in depth prior to approval due to system sensitivity
- There are some limitations for detection caused by summation of the masses of different isotopes and molecules, therefore we thoroughly encourage interested parties to correspond with their research aims

Areas instrument used over last 12 months

(The following figures represent predicted usage, as LAMS-UK is a new facility)

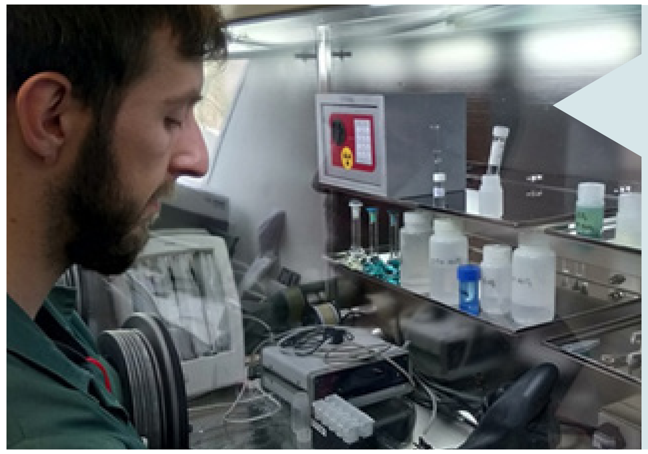
Area	% Usage
Waste Management	30
Advanced Nuclear	10
Environmental	60
Teaching	
Other (please specify)	
Available/ unused	

Other relevant information

Please consult https://www.nnuf.ac.uk/lancaster-accelerator-mass-spectrometer for further information.

Contact

Dr. Chris Tighe
AMS Experimental Officer
Lancaster University Engineering Department
c.tighe@lancaster.ac.uk



Organisation
Lancaster University

Facility
UTGARD Laboratory Phase I

Location
Lancaster University

Image: © Lancaster University, 2021

Summary of capability/facility

Constructed in 2016, UTGARD (U/Th/Beta-Gamma Active process chemistry R&D facilities) is a process chemistry laboratory for work on β/γ active fission products, uranium, thorium and low level Alpha tracers.

UTGARD Phase I is equipped with a range of instruments for the provision of thermodynamic and kinetic data to underpin both fundamental and application driven research (including scale up) in recycle and waste management. Specifically, behavioural studies of α/β/γ active materials under a range of conditions relevant to the back end of the fuel cycle - including wet/dry interim storage, geological disposal and new reprocessing routes, can be carried out using the laboratory suite of equipment.

UTGARD Phase I also retains a constantly evolving library of well-characterised SIMFUELs for use by external researchers. The opening of the attached UTGARD phase II fabrication facility in 2020 aims to further this collection considerably in the next few years.

Related instrumentation/capabilities

Users of UTGARD Phase I also have access to UTGARD Phase II if required.

Nuclear material capabilities (i.e. activity limits)

Alpha - 200 MBq
Other Beta/Gamma - 4 GBq
Natural/Depleted Thorium or Uranium - Up to 5 kg
Please note these are maximum limits, therefore available capacity will be dependent on current stocks.

External user access arrangements

Users from UK-based Higher education institution (HEI) can apply for funded access through National Nuclear User Facility (NNUF), until March 2023 (please see www.nnuf.ac.uk/how-gain-access)

We can accommodate academic or industrial users either in person or by remotely delivering experiments on samples provided. In the first instance please do reach out to the UTGARD team to discuss requirements.

Researchers from outside the UK can also apply for funded access through NNUF, if a faculty member in a UK university is included on the project team or if the experiment is part of establishing/expanding a substantial collaboration between the research group and the institution hosting the facility.

Instrument specification

Radiation handling and measurement
- α/β tray counter
- Multi-sample gamma counter / spectrometer
- Large negative pressure glove box, fully HEPA filtered for α-sample preparation
- Anoxic, positive pressure glovebox
- Two banks of two centrifugal contactors and pumps

Electrochemistry
- Multiple potentiostats, including low current and Electrochemical impedance spectroscopy (EIS) models
- Rotating Disk Electrodes (RDE and RRDE)
- Quartz Crystal Microbalances (QCM)

Spectroscopy
- Two Raman microscopes
- Fourier transform infrared spectroscopy with Attenuated Total Reflection (ATR) stage
- UV-VIS-NIR spectrophotometer and Stop-Flow adaptor

Chromatography
- High Pressure Liquid Chromatography (HPLC)
- Anion and Cation Ion Chromatography system with combined Mass Spectrometer (IC-MS)

Thermal Analysis
- TGA/DSC system with combined gas mass spectrometer (TGA-MS) up to 1050°C
- Raman hot stage up to 1100°C

Elemental characterisation/imaging
- Scanning electron microscope (SEM) with Energy Dispersive X-Ray Analysis (EDX)
- Large chamber X-ray Fluorescence (XRF) system

Areas instrument used over last 12 months

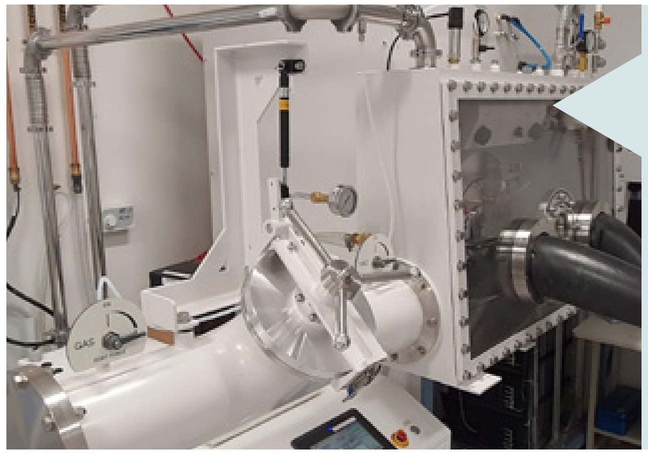
Area	% Usage
Waste Management	50
Advanced Nuclear	50
Environmental	
Other (please specify)	
Available/ unused	

Other relevant information

Please consult https://www.nnuf.ac.uk/utgard-laboratory for further information.

Contact

Dr Richard Wilbraham, UTGARD Research Officer
Email: r.wilbraham@lancaster.ac.uk
Tel: +44(0) 1524 594866



Organisation
Lancaster University

Facility
UTGARD Laboratory Phase II

Location
Lancaster University

Image: © Lancaster University, 2021

Summary of capability/facility

UTGARD Phase II is a university facility for simulated spent nuclear fuel (SIMFUEL) fabrication and characterisation that is unique within the UK landscape.

Reflecting the fuel used in the UK's current Advanced Gas-cooled Reactor (AGR) and light-water reactor (LWR), and to be used in new build LWRs, UTGARD Phase II focuses on oxide SIMFUELs - although, with an eye to future fuel cycles, including mixed oxide fuel MOX, accident tolerant fuels (ATF) and ThO_2 based fuels.

UTGARD Phase II enables research into the development of new, advanced sintering routes for the fabrication of SIMFUELs with porosities, fission product loadings, and defect microstructures that better simulate those of real spent nuclear fuel.

Behavioural studies of such advanced SIMFUELs, as well as those prepared using also available conventional techniques, under a range of conditions relevant to the back end of the fuel cycle - including wet/dry interim storage, geological disposal and new reprocessing routes, can also be carried out in the attached UTGARD Phase I facility.

Related instrumentation/capabilities

Users of UTGARD Phase II also have access to UTGARD Phase I if required.

External user access arrangements

Users from UK-based Higher education institution (HEI) can apply for funded access through National Nuclear User Facility (NNUF), until March 2023 (please see www.nnuf.ac.uk/how-gain-access)

We can accommodate academic or industrial users either in person or by remotely delivering experiments on samples provided. In the first instance please do reach out to the UTGARD team to discuss requirements.

Researchers from outside the UK can also apply for funded access through NNUF, if a faculty member in a UK university is included on the project team or if the experiment is part of establishing/expanding a substantial collaboration between the research group and the institution hosting the facility.

Other relevant information

Please consult https://www.nnuf.ac.uk/utgard-laboratory for further information.

Instrument specification

For SIMFUEL powder precursor preparation:
- A single user licence for the FISPIN fuel depletion code, for calculation of target SIMFUEL compositions as functions of burnup and cooling time
- A powder cabinet-isolated planetary ball mill (Retsch) and particle sizer (Horiba) for control and measurement of the size of SIMFUEL precursor powders that have been purchased or fabricated using UTGARD's synthetic facilities

For sintering of SIMFUEL precursors into pellet form:
- An up to 100% hydrogen tube furnace (Nabertherm) for conventional sintering of green pellets prepared using existing powder presses
- A spark plasma sintering (SPS) system for advanced binder-free field assisted rapid sintering studies (pictured)
- A modified dilatometer (Netzsch), both for monitoring pellet densification during sintering and for the study of the new and novel route of flash sintering

For post-sintering sample preparation and characterisation:
- A mercury porosimeter (Anton-Paar) to assess pellet porosity post-sintering
- A powder cabinet-isolated diamond saw and grinding and polishing machine (Struers) for sample preparation

Nuclear material capabilities (i.e. activity limits)

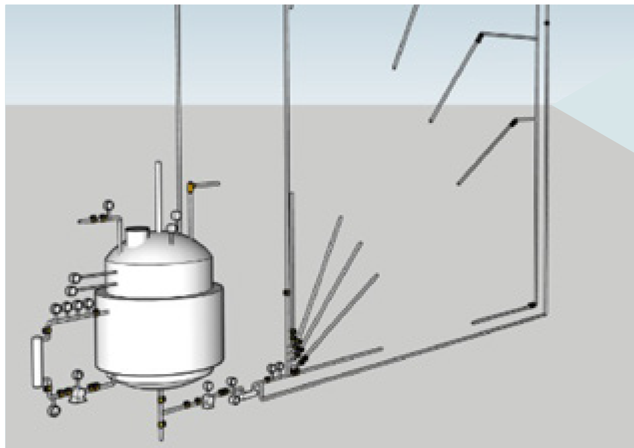
Alpha - 200 MBq
Other Beta/Gamma - 4 GBq
Natural/Depleted Thorium or Uranium - Up to 5 kg
Please note these are maximum limits, therefore available capacity will be dependent on current stocks.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	50
Advanced Nuclear	50
Environmental	
Other (please specify)	
Available/ unused	

Contact

Dr Richard Wilbraham, UTGARD Research Officer
Email: r.wilbraham@lancaster.ac.uk
Tel: +44(0) 1524 594866



Organisation
Leeds University

Facility
MUltiphase Fluid Flow In Nuclear systems (MUFFIN)

Location
University of Leeds, Woodhouse, Leeds LS2 9JT

Summary of capability/facility

MUFFIN (MUltiphase Fluid Flow In Nuclear systems) will be part of the National Nuclear User Facility (NNUF) based at the University of Leeds and scheduled to open in October 2023 with the dedicated aim to enable world class research on multiphase fluid flow, at a scale that is representative of a real system. MUFFIN will enable researchers to understand the turbulence, heat transfer characteristics and the impact of gas injection on liquid mobility in bubbly reactor flows, and critically, future salt reactors. Our facility will provide top-of-the-range instrumentation for high-fidelity validation of computational fluid dynamics models in order to predict performances in a variety of nuclear reactors, transportation or separation units.

Related instrumentation/capabilities

Research areas that MUFFIN will support include:
Decommissioning of legacy facilities in the UK
- Waste retrievals – sludge management in legacy ponds and silos, exploring sludge transport in pipelines and modification of its behaviour to enable improved flow, mixing and separation of wastes during processing activities
- Utilisation of the test beds – advanced characterisation instrumentation for online monitoring of nuclear wastes
- Effluent treatment wastes – flows through concentrated sediments, transportation and stability of precipitated flocs, and bubble-particle dynamics for effluent separation
- Highly active liquors – transportation of precipitated fission wastes from storage and evaporation operations, as part of Post Operational Clean Out (POCO) activities

Current reactors and new build
- Management of 'crud' in cooling circuits to examine the rate and mechanisms of particle (corrosion product) deposition on solid surfaces and its impact on clogging cooling circuits
- Performance of heat transfer under fouling to examine the rate and mechanisms of particle deposition on solid surfaces and its impact on thermohydraulic performance
- Characterisation of bubbly and boiling flows to evaluate flow characteristics, the critical heat flux and departures from nucleate boiling

Advanced reactors
- Developing main cooling circuits and testing heat transfer in a dynamic salt system for Small Modular Reactors (SMR) and Advanced Modular Reactors (AMR)
- Scaling techniques and processes up from the lab and into industry Advanced fuel cycles
- Providing direct support to the Molten Salts Advisory Group (MSAG), recently convened by The Department for Business, Energy & Industrial Strategy (BEIS) for the development and exploitation of molten salt technologies in the UK. Includes online monitoring/analysis, salt clean-up, materials and fuel cycle integration; where research on dynamic (rather than static) salt systems allows development of novel technology

Contact

Professor Bruce Hanson
B.C.Hanson@Leeds.ac.uk
0113 343 0475

Ms Megan Herbert
(Project Manager)
M.C.Herbert@Leeds.ac.uk

Instrument specification

MUFFIN consists of 3 major components:
1. A bank of high precision, state-of-the-art, instruments for measuring a wide range of fluid flow properties.
2. A pilot scale test bed, based on a water flow system [pressure (=<5atm), temperature (=<100°C)].
3. A pilot scale test bed, based on a molten chloride flow system [pressure (=<5atm), temperature (=<600°C)].

Both test beds will be reconfigurable to incorporate new specialist instrumentation for fluid flow measurements and/or used to develop new instruments and equipment for future research.
High-precision instrumentation and testing capabilities
All the measurement techniques mountable within 2m test sections on the two MUFFIN test beds are recognised as the most advanced available for these types of flows and our research team are world experts in applying them.

External user access arrangements

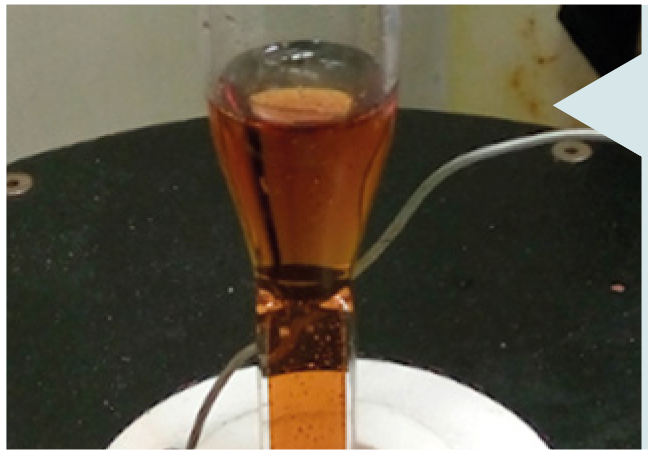
If fluid dynamics or multiphase flows are your areas of interest, we look forward to hearing from you.
MUFFIN will have a resident team of research staff, including academic experts in the field and a dedicated experimental officer, available to assist with planning, conducting and managing experiments.
We expect to welcome a substantial number of researchers and researchers-in-training from institutions across the UK, in addition, MUFFIN will be available for training to undergraduates (UG) and post graduate taught students.
Also, MUFFIN will be open to welcome industry and international users from October 2023. We look forward to offering remote access as well as in-person support including training and live in-house support throughout your work with the MUFFIN facility.
Researchers may also apply for funded access through NNUF, if a faculty member in a UK university is included on the project team or if the experiment is part of establishing/expanding a substantial collaboration between the research group and the institution hosting the facility.
Should users wish to cost MUFFIN access fees into grant applications (including for UKRI grants), they are invited to get in touch to discuss how we may support you in your application.

Nuclear material capabilities (i.e. activity limits)

Non-Active.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	Unavailable until October 2023
Advanced Nuclear	Unavailable until October 2023
Environmental	Unavailable until October 2023
Other (please specify)	Unavailable until October 2023
Available/ unused	Unavailable until October 2023



Organisation
The Universities of Manchester and Edinburgh

Facility
Molten Salts in Nuclear Technology Laboratory (MSNTL) - Manchester and Edinburgh hubs

Location
The University of Manchester and the University of Edinburgh

Image: Np(IV) in molten LiCl-KCl eutectic. Image courtesy of Hugues Lambert and Clint Sharrad - University of Manchester

Summary of capability/facility

The Molten Salts in Nuclear Technology Laboratory (MSNTL) aims to provide molten salt R&D capability for studying fluoride salts in nuclear systems within the UK for the first time, offering an interdisciplinary hub for molten salts research with radioactive materials.
The MSNTL offers tailored facilities for the study of molten salts in nuclear systems across various scales and interest areas. Examples include:

- Materials behaviour in contact with molten salt;
- Fundamental behaviour of salts containing radioactive elements probed by various techniques;
- Salt behaviour under flow and associated materials performance;
- Salt clean-up and waste management.

The MSNTL currently offers infrastructure for the safe handling of fluoride salts at small scales, and will possess capability that will allow the handling of large (up to kg) quantities of fluoride salts by the end of 2022. The MSNTL is currently available for the study of all non-fluoride salt systems in conjunction with the Pyrochemical Research Laboratory at the University of Edinburgh.

Related instrumentation/capabilities

MSNTL also possesses a hub at the Dalton Cumbrian Facility to support interests in irradiation effects (see associated description) and is closely linked with the Pyrochemical Research Laboratory NNUF at the University of Edinburgh which offers state-of-the art infrastructure for studying non-fluoride salts.

We strongly encourage user access across multiple NNUF facilities given the interdisciplinary nature of developing molten salt technologies.

External user access arrangements

Users from UK-based HEIs can apply for funded access through NNUF, until March 2023 (please see www.nnuf.ac.uk/how-gain-access).

- For industrial or international users, please contact the MSNTL directly (contact details provided above). to discuss access arrangement options
- Feel free to contact the MSNTL to discuss your research needs

Other relevant information

Please consult https://www.nnuf.ac.uk/molten-salts-nuclear-technology-laboratory for further information on the MSNTL. Please be aware of the associated Pyrochemical Research Laboratory at the University of Edinburgh (for further details please see: https://www.nnuf.ac.uk/prl)

Instrument specification

- Numerous materials corrosion test rigs (available for use)
- Tailored furnace systems for dynamic studies (in construction)
- High temperature column for dynamic ion exchange studies with molten salts (in construction)
- Bespoke MBraun ISO-NANOPRO gloveboxes and supporting infrastructure for handling and interrogating fluoride molten salts (to be commissioned ~ Sep 2022)
- Supporting furnaces of various types (available for use)
- Mettler Toledo TGA/DSC 3+ with sample robot coupled with GC-MS (Agilent 8890 GC with 5977B MSD). The TGA/DSC alone is currently available for use. GC-MS to be coupled with TGA/DSC at the end of 2022.
- Anton Paar high temperature modular compact (MCR302) rheometers (to be commissioned and housed in bespoke gloveboxes)
- Potentiostats including those with high current capability (available)
- Various existing spectroscopic and electrochemical equipment (available)

Nuclear material capabilities (i.e. activity limits)

Current infrastructure at the Manchester hub of the MSNTL allows the handling of up to 200 g of uranium (natural or depleted) and thorium in single experiments although we anticipate the majority of studies will use 0.1 – 10 g. For Beta/Gamma emitters, up to 35 MBq of activity can be handled but would typically handle < 6 MBq per experiment. The implementation of the Nuclear Engineering, Science and Technology (NEST facility), to be completed by the end of 2022, which will house the Manchester hub of the MSNTL will increase these activity limits and extend our capability to handling small quantities of transuranic elements.
The Edinburgh hub of the MSNTL will provide support for in-active and potentially low-active (e.g. small quantities of depleted uranium) experimental studies.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	30
Advanced Nuclear	60
Environmental	10
Other (please specify)	
Other (please specify)	
Available/ unused	30 % of the MSNTL facilities are currently available. All remaining MSNTL infrastructure to be commissioned and available for use by early 2023.

Contact

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Prof Andy Mount,
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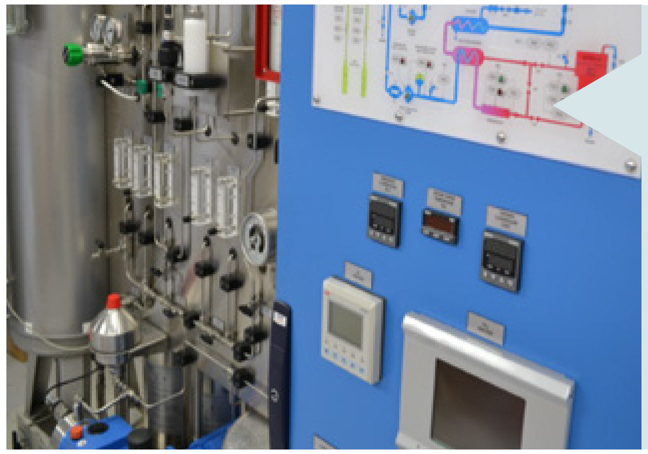
(0)131 650 4747



Organisation
The University of Manchester

Facility
High Temperature High Pressure Autoclaves for Testing

Location
Henry Royce Hub, Henry Royce Institute, The University of Manchester

Summary of capability/facility

Capability to investigate stress corrosion cracking initiation, crack propagation and corrosion fatigue in high temperature water. Servo-electric tensile machines provide capability for ultra-slow rate strain and low cycle fatigue with Direct Current Potential Drop (DCPD) equipment for measurements of in-situ crack growth rate with a nominal resolution of 1µm. Capability of in-situ digital image correlation and surface oxide Raman spectroscopy examination through a highly transparent sapphire window.

Capability to conduct tests (including hydrogen embrittlement, creep and carburisation) in reactive environment H_2, CO, CO_2 at high pressure (300 bar) and high temperatures under active load.

Several autoclave vessels are manufactured from a highly corrosion resistant alloy C-276 and Alloy 625 which are therefore suitable for studies in oxygenated and demanding water chemistry.

Experimental facility also allows us to clarify the interrelation existing between the thermal-fluid phenomena of flow boiling, electrochemistry and surface physics that control corrosion deposition at high flow rate (3.5 m^3/h) and high velocity (up to 50 m/s).

Related instrumentation/capabilities

Our laboratories are well suited to produce and analyse a wide range of materials. We provide a range of in-situ and ex-situ techniques designed to carry out detailed interrogation of the effects of exposure on materials, including direct current and alternating current potential drop (ACPD – DCPD) measurements of cracks. We also provide a range of water chemistry (dissolved H_2, O_2), pH and conductivity, as well as electrochemical corrosion potential measurements. A number of other analytical instruments and techniques are also available - please contact the facility for details. We also provide facilities and guidance for sample preparation, making all necessary steps of characterisation easily accessible in one place.

External user access arrangements

Users from HEIs and industry can apply for access via the Henry Royce Institute - https://www.royce.ac.uk
Work can be carried out by University of Manchester staff on behalf of organisations who send samples to the facility.

Other relevant information

Please consult https://www.royce.ac.uk/equipment-and-facilities/recirculating-autoclave-for-materials-testing for further information.

Instrument specification

The Henry Royce Institute provides a suite of 16 Autoclaves:

- Flow system to understand the interrelation between heat flux, electrochemistry and corrosion at 340°C and high flow rates (3.5 m^3/h)
- Two Environmentally Assisted Cracking (EAC) rigs, with 100 kN tensile machining for ultra-slow rate strain and low cycle fatigue. Testing of up to 3 0.5T-CT samples either in oxygenated or hydrogenated water at temperatures up to 360°C and 200 bar.
- One autoclave for high temperature (300°C), high pressure (300 bar) gaseous environment (H_2, CO, CO_2) under active load.
- Two windowed autoclaves connected with a recirculating loop which provides precise control of the water chemistry spanning from hydrogenated to oxygenated water up to 250°C and 350°C.
- Four Slow Strain Rate Testing (SSRT) recirculating autoclaves, capable of constant load and slow strain rate testing at up to 360°C in high temperature/high pressure water.
- Four fully refreshed autoclaves for electrochemical studies, rated at up to 360°C for hydrogenated, oxygenated or doped water chemistry. One system is manufactured from titanium for oxidation characterisation
- One galling autoclave manufactured from Hastelloy C-276 and rated at up to 350°C
- One quasi-static autoclave manufactured from Alloy 625 for aggressive environments and rated at up to 360°C.

Nuclear material capabilities (i.e. activity limits)

Majority of the work is conduct on non-active material, but there is the possibility to test proton irradiated materials. Contact experimental officer to discuss on ad hoc case.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	90%
Environmental	
Other (please specify)	
Demanding environments	10%
Available/ unused	

Contact

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Department of Materials
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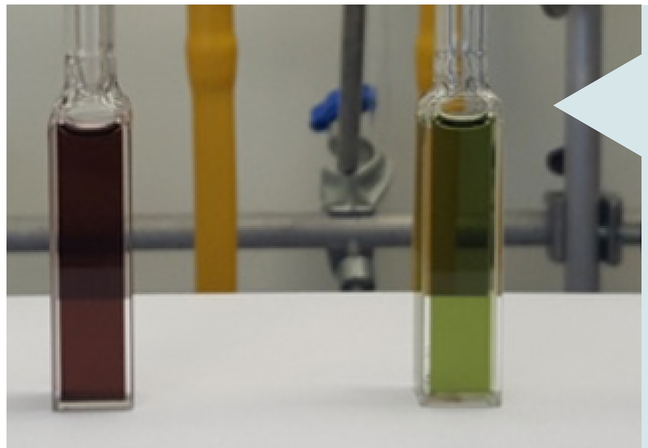


Organisation
The University of Manchester

Facility
National Nuclear User Facility at the Centre for Radiochemistry Research

Location
The Oxford Road Area, The University of Manchester

Actinide complexes in solution
Image reproduced with permission of Dr David P. Mills

Summary of capability/facility

The 'National Nuclear User Facility (NNUF) @ Centre for Radiochemistry Research (CRR)' has been designed to be an accessible 'one-stop-shop' for making and studying compounds of relevance to academic and industrial radiochemistry and other nuclear-related research, enabling new generations of researchers to overcome the barriers that have long prevented discovery, analysis, and synthesis in this area.
The CRR will be composed of controlled and supervised areas underpinned by state-of-the-art analytical techniques. High Efficiency Particulate Air (HEPA) -filtered controlled areas will support medium-activity level radiochemistry in low-pressure glove boxes for synthesis, molten salts, and recycling. The supervised areas will be laboratories equipped with fume cupboards for handling aqueous and organic solvents and large quantities of acids to support more traditional, low-activity level radiochemistry. The facility will hold radioisotopes, and as such the NNUF @ CRR will support a wide range of radiochemistry and other nuclear-related research.

Related instrumentation/capabilities

An indicative list of science that the NNUF @ CRR will support includes:
(i) speciation of coordination/organometallic complexes;
(ii) spectroscopy;
(iii) magnetism;
(iv) reprocessing;
(v) computational modelling;
(vi) precursors to materials, fuels (e.g. accident tolerant fuels (ATF), and molten salts, the latter in the Molten Salts in Nuclear Technology Laboratory (MSNTL) NNUF Facility;
(vii) collaboration with the RADioactive waste management and Environmental Remediation (RADAR) NNUF Facility, including in areas such as environmental radiochemistry, geochemistry, mobility, nuclear forensics, decommissioning, colloids.

External user access arrangements

Users from UK-based Higher education institution (HEI) (and other organisations that are eligible to apply for UK Research and Innovation funding) can apply for funded access through NNUF, until March 2023 (please see www.nnuf.ac.uk/how-gain-access). Researchers from outside the UK can also apply for funded access through NNUF, if a faculty member in a UK university is included on the project team or if the experiment is part of establishing/expanding a substantial collaboration between the research group and the institution hosting the facility. We also offer remote access to users and the facility is open to industrial users.

Other relevant information

We are able to handle very air and moisture sensitive materials.
Although not part of NNUF itself, we also have capabilities within the CRR for confocal Raman spectroscopy and micro Raman mapping, and Electron Paramagnetic Resonance (EPR)" Spectroscopy spectroscopy through the EPSRC National Service for EPR Spectroscopy: https://www.chemistry.manchester.ac.uk/epr/

Contact

Professor Steve Liddle
steve.liddle@manchester.ac.uk
01612754612

Instrument specification

'NNUF @ CRR' currently offers single crystal X-ray diffraction, alpha-counting and liquid scintillation, and fluorescence, multi-photon, confocal microscopy and lifetime imaging, and laser-induced breakdown spectroscopies. The remaining instrumentation and capabilities are scheduled to become available later. Please reach out to the 'NNUF @ CRR' team to discuss requirements if you are interested in working with us. Specific capabilities include:

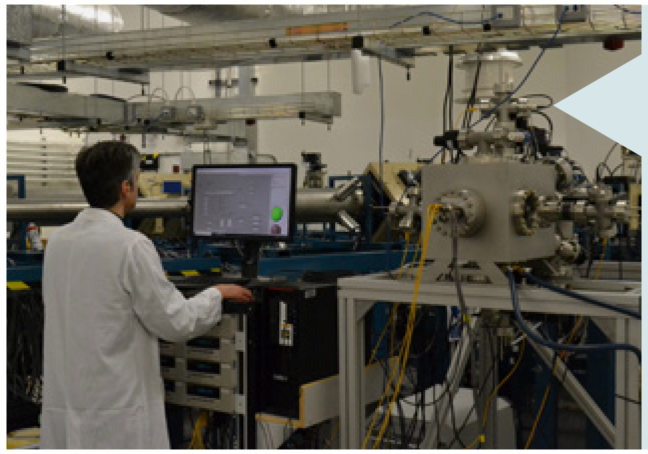
- Single crystal X-ray diffraction with Mo and Cu Ka sources;
- 400 MHz NMR spectroscopy with multi-nuclear and variable temperature capability;
- SQUID 7 Tesla Magnetometry with variable temperature, VSM, and AC susceptibility capability;
- Low-pressure glove boxes for handling, synthesising, and recycling of active compounds;
- Alpha counters;
- Liquid scintillation;
- Gamma counters;
- Fluorescence and phosphorescence steady state and time resolved variable temperature spectroscopy (Ultra-violet, visible, and near infrared);
- One photon confocal land multiphoton fluorescence and phosphorescence microscopy lifetime image mapping;
- Laser-induced breakdown spectroscopy;
- Attenuated total reflectance infrared spectroscopy;
- Ultra-violet, visible, and near infrared electronic absorption spectroscopy;
- Ball milling;
- Centrifugation;
- Stocks of various actinides and other radioisotopes.

Nuclear material capabilities (i.e. activity limits)

Currently, all our instrumentation resides in laboratories that are radiation supervised areas and we are able to handle uranium and thorium samples capable of transport as excepted. Higher activities with other radionuclides in controlled areas will become available later.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	40
Advanced Nuclear	5
Environmental	20
Materials Science	5
Radionuclides for Health	5
Available/unused	25



Organisation
The University of Manchester

Facility
Particle accelerator systems at the Dalton Cumbrian Facility

Location
Westlakes Science Park, Moor Row, Cumbria, CA24 3HA
www.manchester.ac.uk/dalton

Summary of capability/facility

The University of Manchester's Dalton Cumbrian Facility (DCF) is the UK's largest academic research facility dedicated to radiation science. The facility incorporates large scale irradiation equipment complemented by high-end instruments supporting a wide range of in-situ and ex-situ analytical techniques. DCF houses two accelerators, a 5 MV tandem and a 2.5 MV Pelletron, configured to provide a range of ion irradiation and analysis capabilities across eight beam lines. Ion beam irradiation allows rapid achievement of materials damage levels accumulated during many years of in-service exposure and provides data on the effects of radiation under very specific conditions of temperature, radiation dose rate and radiation dose.
Set-up allows for tightly controlled in-situ interrogation of materials properties during irradiation, providing data to develop and validate predictive radiation effects models.
Dual ion beam capability, currently under development, allows for investigation of damage effects (from heavy ion bombardment) whilst simultaneously maintaining a radiation rich field.

Related instrumentation/capabilities

A bespoke fluid recirculation loop that operates at high temperature and pressure can be coupled to an end station, allowing for extreme conditions relevant to nuclear reactor coolant to be probed.
For irradiation capability using photons or for analytical equipment, see other pages in this brochure.
We also provide facilities and guidance for sample preparation as well as irradiation and characterisation, making all necessary steps easily accessible in one place.

External user access arrangements

For all equipment at DCF, there are a range of access routes for prospective users:

- Users from UK-based Higher education institution (HEI) can apply for funded access through National Nuclear User Facility (NNUF), until March 2023 - please see www.nnuf.ac.uk/how-gain-access
- Users from HEIs and industry can apply for access via the Henry Royce Institute - https://www.royce.ac.uk
- Users from UK-based HEIs can apply for funded access to the ion accelerator systems via the EPSRC UK National Ion beam Centre - http://www.ukNibc.co.uk
- Users from UK and overseas HEIs, other technology providers and industry can also contact the facility directly - dcfreception@manchester.ac.uk
- Researchers from outside the UK can also apply for funded access through NNUF, if a faculty member in a UK university is included on the project team or if the experiment is part of establishing/expanding a substantial collaboration between the research group and the institution hosting the facility.

N.B. Work can be carried out by University of Manchester staff on behalf of organisations who send samples to the facility.

Other relevant information

Please consult www.dalton.manchester.ac.uk and www.nnuf.ac.uk/daltoncumbrian-facility for further information.

Contact

For all experiments: dcf.experiments@manchester.ac.uk
General enquiries: dcfreception@manchester.ac.uk
DCF Director, Professor Fred Currell
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Dalton Nuclear Institute - Head of Operations: Kevin Warren
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Instrument specification

The 5 MV Pelletron (model 15SDH-4 from NEC) has two sources:

- Toroidal volume ion source (TORVIS) can generate up to 100 µA of proton current (up to 10 MeV), or 1 µA of He ion (α) current (up to 15 MeV)
- Multi-cathode source of negative ions by caesium sputtering (MC-SNICS) for the production of heavy ion beams (up to 35 MeV), provides up to 50 hours of continuous beam at constant current with 20 cathodes per wheel for quick changeover.

Four standalone end-stations, plus two shared with the 2.5 MV accelerator, each with unique capability:

- Line 1 terminates in a hotcell so that high damage studies (utilising protons up to 10 MeV) can be performed
- Line 2 incorporates fast reaction valves (35 ms response) for direct coupling to liquid or gas filled enclosures relevant to in-situ corrosion studies, or simulation of radiation chemistry in deep-space ice cores
- Line 3 is dedicated to low dose rate (few nA), high energy irradiations for radiation chemistry. A collimator and exit window allow for ex-vacuum studies on liquid or biological samples.
- Line 7 is dedicated to ion beam analysis. An NEC RC43 end-station incorporates PIXE (Particle Induced X-ray Emission), RBS (Rutherford Backscattering Spectroscopy), ERD (Elastic Recoil Detection) and NRA (Nuclear Reaction Analysis).

The 2-5 MV Pelletron (model 7.5SH-2 from NEC) is a source of high current (100 µA) proton or helium ion beams, and other noble gas ion beams e.g. krypton and xenon. It shares its two end-stations with two from the larger accelerator:

- Line 5/A: Single or dual beam radiation damage, using either in-house sample stages, or users own special stage
- Line 6/B: Single or dual beam radiation damage with built in SIMS and HR-EELS analysis

Nuclear material capabilities (i.e. activity limits)

DCF holds a permit granted by the Environment Agency under the Environmental Permitting Regulations 2016 to hold a number of high activity sealed sources (HASS) and other sealed sources.
Low quantities (i.e. under exemption from EPR16) are allowable for specific experiments.
The facility incorporates the infrastructure to handle and process samples activated through ion irradiation for onward transportation to facilities where they can be analysed (e.g. UKAEA Materials Research Facility (MRF).

Areas instrument used over last 12 months

Area	% Usage
Waste Management	15
Advanced Nuclear	20
Environmental	
Continued operation of current reactors	30
Fuel cycle	25
Decommissioning	-
Other sectors requiring radiation effects research: medical & health, space	10
Available/ unused	15

Organisation
The University of Manchester

Facility
Gamma & X-ray Irradiators at the Dalton Cumbrian Facility

Location
Westlakes Science Park, Moor Row, Cumbria, CA24 3HA
www.manchester.ac.uk/dalton

MR350 X-ray Irradiator

Summary of capability/facility

The University of Manchester's Dalton Cumbrian Facility (DCF) is the UK's largest academic research facility dedicated to radiation science. The facility incorporates large scale irradiation equipment complemented by a number of high-end instruments supporting a wide range of in-situ and ex-situ analytical techniques. For irradiation using photons we have two complementary items. Our high dose rate gamma irradiator is designed and operated to support a wide range of research applications, with the aim of developing understanding of the mechanistic effects of gamma radiation on materials, systems and components. The instrument is capable of delivering dose rates from around 25 kGy/h to less than 100 Gy/h. Current maximum dose rate of 14 kGy/hour (April 2022).
For experiments where lower energy photons are more applicable, our Precision X-ray Multi-Rad 350 irradiator is capable of dose rates up to 140 Gy/min (unfiltered beam).

Related instrumentation/capabilities

A bespoke fluid recirculation loop that operates at high temperature and pressure can be fed through the gamma irradiator service ports and coupled to an autoclave (can withstand up to 350 °C and 220 bar), allowing for extreme conditions relevant to nuclear reactor coolant to be probed.
For irradiation capability using ions or for analytical equipment, see other pages in this brochure.
We also provide facilities and guidance for sample preparation as well as irradiation and characterisation, making all necessary steps easily accessible in one place.

External user access arrangements

For all equipment at DCF, there are a range of access routes for prospective users:

- Users from UK-based Higher education institution (HEI) can apply for funded access through National Nuclear User Facility (NNUF) , until March 2023 (please see www.nnuf.ac.uk/how-gain-access)
- Users from HEIs and industry can apply for access via the Henry Royce Institute - https://www.royce.ac.uk
- Users from UK-based HEIs can apply for funded access to the ion accelerator systems via the EPSRC UK National Ion beam Centre - http://www.ukNibc.co.uk
- Users from UK and overseas HEIs, other technology providers and industry can also contact the facility directly - dcfreception@manchester.ac.uk
- Researchers from outside the UK can also apply for funded access through NNUF, if a faculty member in a UK university is included on the project team or if the experiment is part of establishing/expanding a substantial collaboration between the research group and the institution hosting the facility.

N.B. Work can be carried out by University of Manchester staff on behalf of organisations who send samples to the facility.

Other relevant information

Please consult www.dalton.manchester.ac.uk and www.nnuf.ac.uk/daltoncumbrian-facility for further information.

Nuclear material capabilities (i.e. activity limits)

DCF holds a permit granted by the Environment Agency under the Environmental Permitting Regulations EPR16 to hold a number of high activity sealed sources (HASS) and other sealed sources.
Low quantities (i.e. under exemption from EPR16) are allowable for specific experiments.
The facility incorporates the infrastructure to handle and process samples activated through ion irradiation for onward transportation to facilities where they can be analysed (e.g. UKAEA Materials Research Facility (MRF).

Instrument specification

Gamma irradiator (Foss Therapy Services Model 812):

- Currently loaded with three source rods (60Co) with activity evenly distributed along each rod, suppling a planar radiation field
- Two turntable positions centred at 10 or 15 cm from the source with central dose rates of ~71 and ~42 Gy/min respectively (April 2022)
- Irradiation chamber measures 20 cm wide by 25 cm deep by 27 cm high, providing 9 L capacity – can be extended to 30 cm height for planar irradiations, if turntable mechanism removed
- Two 19 mm diameter shielded service ports for feed through of instrument cables or carrier lines for liquid/gas for in-situ monitoring of samples or electronics
- Attenuators provide up to ×32 reduction in dose rates and dose rates can be further reduced by raising only 1 or 2 sources

X-ray irradiator, model MR350 cabinet irradiator (manufactured by Precision X-Ray Irradiation):

- Maximum dose rate 24 Gy/min
- Broad X-ray energy spectrum provided by Bremsstrahlung, after accelerating an electron beam onto a tungsten plate
- Peak x-ray energies are approximately 10 – 115 keV (electron acceleration voltage 30 – 350 keV)
- Electron current of 0.1 – 30 mA (maximum total power is 4 kW)
- Irradiation chamber measures 41 cm wide by 88 cm deep and 58 cm high
- Automatic dose rate sensing, a range of apertures, and a turntable to improve dose homogeneity
- Insertion chambers can be used to change the gas atmosphere (e.g. CO_2 or hypoxic)
- Access ports allow for connection to external instruments

Areas instrument used over last 12 months

Area	% Usage
Waste Management	25
Advanced Nuclear	10
Environmental	15
Continued operation of current reactors	10
Fuel cycle	5
Decommissioning	15
Other sectors requiring radiation effects research: medical & health, space	20
Available/ unused	25

Contact

For all experiments: dcf.experiments@manchester.ac.uk
General enquiries: dcfreception@manchester.ac.uk
DCF Director, Professor Fred Currell
+44(0) 7909 588656 frederick.currell@manchester.ac.uk
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Organisation
The University of Manchester

Facility
Molten Salts in Nuclear Technology Laboratory (MSNTL) - Dalton Cumbrian Facility (DCF) hub

Location
Dalton Cumbrian Facility

Gamma irradiator

Summary of capability/facility

The Molten Salts in Nuclear Technology Laboratory (MSNTL) aims to provide molten salt R&D capability for studying fluoride salts in nuclear systems within the UK for the first time, offering an interdisciplinary hub for molten salts research with radioactive materials.

The MSNTL offers tailored facilities for the study of molten salts in nuclear systems across various scales and interest areas. The Dalton Cumbrian Facility (DCF) hub in particular will offer studies in the irradiation effects of molten salts and materials in contact with molten salts combining with the irradiation capabilities available at the Dalton Cumbrian Facility.

The MSNTL currently offers infrastructure for the safe handling of fluoride salts at small scales, which will support the likely sample requirement for the irradiation studies to be offered at DCF. The MSNTL is currently available for the study of all non-fluoride salt systems in conjunction with the Pyrochemical Research Laboratory at the University of Edinburgh.

Related instrumentation/capabilities

DCF houses two accelerators for ion irradiation and a high dose rate gamma irradiator to support studies on the irradiation behaviour of materials in contact with molten salts. Full specifications of these irradiation capabilities can be found on p.152 of this catalogue.

MSNTL also possesses hubs at the Universities of Edinburgh and Manchester to support salt preparation and characterisation activities (see p.148) and is closely linked with the Pyrochemical Research Laboratory NNUF at the University of Edinburgh which offers state-of-the art infrastructure for studying non-fluoride salts p.141.

We strongly encourage user access across multiple National Nuclear User Facility (NNUF) facilities given the interdisciplinary nature of developing molten salt technologies.

External user access arrangements

Users from UK-based HEIs can apply for funded access through NNUF, until March 2023 (please see www.nnuf.ac.uk/how-gain-access)

- For industrial or international users, please contact the MSNTL directly (contact details provided above) to discuss access arrangement options.
- Feel free to contact the MSNTL and the DCF to discuss your research needs

Instrument specification

- Bespoke high temperature irradiation box for the gamma irradiation of materials in contact with molten salts. The box is specially designed to be accommodated in the Co-60 gamma irradiator at DCF.
- Bespoke high temperature rigs for the ion irradiation of materials while in contact with molten salts.
- Both rigs are currently in construction and anticipated to be available for use by the end of 2022.

Other relevant information

Please consult https://www.nnuf.ac.uk/molten-salts-nuclear-technology-laboratory for further information on the MSNTL, and https://www.nnuf.ac.uk/dalton-cumbrian-facility on the DCF.
Please be aware of the associated Pyrochemical Research Laboratory at the University of Edinburgh (for further details please see: https://www.nnuf.ac.uk/prl).

Nuclear material capabilities (i.e. activity limits)

Details on allowances for studies with radioactive materials at DCF are provided on p.151 and p.152 of this catalogue.

Low quantities or radioactive materials (i.e. under exemption from Environment Agency under the Environmental Permitting Regulations 2016 (EPR16) are allowable for specific experiments. It is likely though that initial molten salt studies at the DCF hub of the MSNTL hub will focus on salts without radioactive material before progressing to active salt studies.
DCF incorporates the infrastructure to handle and process samples activated through ion irradiation for onward transportation to facilities where they can be analysed.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	5 (anticipated)
Advanced Nuclear	90 (anticipated)
Environmental	5 (anticipated)
Other (please specify)	
Other (please specify)	
Available/ unused	Note: The irradiation rigs at the MSNTL DCF hub are currently in construction.

Contact

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Professor Andy Mount
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Organisation
The University of Manchester

Facility
Analysis and Characterisation at the Dalton Cumbrian Facility

Location
Westlakes Science Park, Moor Row, Cumbria, CA24 3HA
www.manchester.ac.uk/dalton

Electron Paramagnetic Resonance (EPR)

Summary of capability/facility

The University of Manchester's Dalton Cumbrian Facility (DCF) is the UK's largest academic research facility dedicated to radiation science. The facility incorporates large scale irradiation equipment (see other pages in this brochure) complemented by a number of high-end instruments supporting a wide range of in-situ and ex-situ analytical techniques.
Our analysis and characterisation capability extends to materials science and radiation chemistry.
For materials, determination and mapping of the texture and crystal structure of metals and composites can be achieved with our high end X-ray diffraction (XRD) and Scanning Electron Microscope (SEM) and SEM. This is complemented by the Raman microscope and further spectroscopic capability.
In radiation chemistry, a combination of Raman and Infra-red spectroscopy has been used to determine radiation-induced changes to polymers while UV-VIS-nIR in concert with Electron Paramagnetic Resonance (EPR) has been used to probe chemical changes to the structure of glass. Chromatography is used extensively to determine the radiolytic production of gases such as hydrogen and oxygen, and other products in solution.

Related instrumentation/capabilities

We also provide facilities and guidance for sample preparation, making all necessary steps of characterisation easily accessible in one place.
Spark plasma sintering system (vacuum, Ar, N atmosphere, up to 100 MPa and 2000 °C) is available for custom pellet preparation.
This complements the irradiation capabilities provided by the particle accelerator systems, gamma irradiator and x-ray cabinet detailed on other pages of this brochure.

External user access arrangements

For all equipment at DCF, there are a range of access routes for prospective users:

- Users from UK-based Higher education institution (HEI) can apply for funded access through National Nuclear User Facility (NNUF), until March 2023 - please see www.nnuf.ac.uk/how-gain-access
- Users from HEIs and industry can apply for access via the Henry Royce Institute - https://www.royce.ac.uk
- Users from UK-based HEIs can apply for funded access to the ion accelerator systems via the EPSRC UK National Ion beam Centre - http://www.ukNibc.co.uk
- Users from UK and overseas HEIs, other technology providers and industry can also contact the facility directly - dcfreception@manchester.ac.uk
- Researchers from outside the UK can also apply for funded access through NNUF, if a faculty member in a UK university is included on the project team or if the experiment is part of establishing/expanding a substantial collaboration between the research group and the institution hosting the facility

N.B. Work can be carried out by University of Manchester staff on behalf of organisations who send samples to the facility.

Other relevant information

Please consult www.dalton.manchester.ac.uk and www.nnuf.ac.uk/daltoncumbrian-facility for further information.

Contact

For all experiments: dcf.experiments@manchester.ac.uk
General enquiries: dcfreception@manchester.ac.uk
DCF Director, Professor Fred Currell
+44(0) 7909 588656 frederick.currell@manchester.ac.uk
Dalton Nuclear Institute - Head of Operations: Kevin Warren
+44(0) 7826 868991 kevin.warren@manchester.ac.uk

Instrument specification

Materials Characterisation:

- Scanning electron microscopy (Quanta 250 FEG SEM) with Electron Backscatter Diffraction Analysis (EBSD), Energy Dispersive X-Ray (EDX) and wavelength dispersive X-ray (WDS) detectors
- X-ray diffraction (Panalytical Empyrean K-alpha) with Pixcel 3D detector (reflection/transmission mode; 2D XRD; powder, thin film, microbeam, texture analysis, non-ambient, capillary stage available)
- X-ray cabinet: Ultrafocus 100 (Faxitron) provides energies from 10 – 100 kV. Imaging area up to 23 by 29 cm and spatial resolution of 5 µm at ×10 magnification

Spectroscopy:

- FT-IR & FT-Raman (Bruker Vertex series FTIR) coupled with Ram II for macro Raman of liquids, solids or powders
- Dispersive Raman Microscope (Bruker Senterra with RamanScope) with a choice of 3 lasers (532, 633 or 785 nm) and Ram II liquid nitrogen cooled detector
- UV-VIS-nIR spectrometer (Agilent Technologies Cary Series), with diffuse reflectance accessory. For wavelengths of 175 –3300 nm
- EPR X-band spectrometer (Bruker EMX nano) with variable temperature unit for 100 –373 K measurements and in situ UV irradiation capability with Hg Arc lamp
- Fluorescence spectrometer (Agilent Cary Eclipse) with liquid, powder and monolith sample holders, for wavelength of 190 –900 nm

Chromatography:

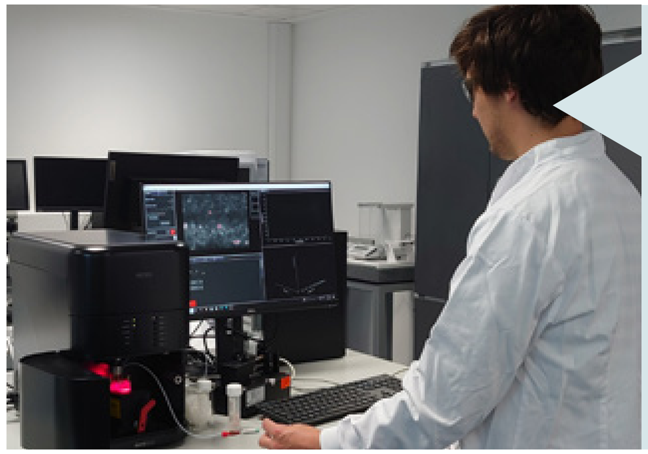
- Gas Chromatography using an Agilent 7890B fitted with three detectors: Flame ionisation, Thermal conductivity electron Capture
  A PAL3 autosampler allows rapid analysis from samples in crimp-cap vials
- An SRI gas analyser supply complementary gas chromatography capability using the crush tube method
- High Performance Liquid Chromatography (Agilent 1260 with UV/Vis absorption detector)
- Ion Chromatography (Thermo Fisher ICS1600 and ICS2100) for both cation (ICS1600) and anion (ICS2100) separation chromatograph

Nuclear material capabilities (i.e. activity limits)

DCF holds a permit granted by the Environment Agency under the Environmental Permitting Regulations (EPR16) to hold a number of high activity sealed sources (HASS) and other sealed sources.
Low quantities (i.e. under exemption from EPR16) are allowable for specific experiments.
The facility incorporates the infrastructure to handle and process samples activated through ion irradiation for onward transportation to facilities where they can be analysed (e.g. UKAEA MRF).

Areas instrument used over last 12 months

Area	% Usage
Waste Management	20
Advanced Nuclear	10
Environmental	15
Continued operation of current reactors	15
Fuel cycle	5
Decommissioning	20
Other sectors requiring radiation effects research: medical & health, space	15
Available/ unused	20



Organisation
The University of Manchester

Facility
RADER (RADioactive waste management and Environmental Remediation)

Location
Co-located with the University of Manchester's Research Centre for Radwaste Disposal (RCRD) and embedded within the Natural Environment Research Council (NERC)-funded Williamson Research Centre for Molecular Environmental Science (WRC)

Image: A doctoral student analysing samples on the nanoparticle tracking analysis instrument

Summary of capability/facility

The RADioactive waste management and Environmental Remediation (RADER) user facility supports research into characterising and understanding the behaviour of radioactive species in engineered and natural environments. This science base is crucial for underpinning large parts of the UK's >100 year, >£130 billion nuclear decommissioning, clean-up and waste management programmes.

Uniquely in the UK, RADER offers dedicated laboratories enabling users to undertake low activity radiometrics, environmental characterisation of solids (inorganic and biological), environmental characterisation of solutions and sample preparation, all in one location and with dedicated Experimental Officer support. These integrated state-of-the-art facilities enable low level separations and microbiological, mineralogical and molecular-scale environmental research with a wide range of environmentally relevant radionuclides.

Relevant topics for investigation within RADER include radioactive waste disposal, decontamination, land management, effluent treatment and radionuclide transport in the biosphere, especially where radioactive sample handling and characterisation are required.

Related instrumentation/capabilities

RADER augments the existing infrastructure in the Williamson Research Centre (WRC) (https://www.ees.manchester.ac.uk/wrc/research/facilities/). Support is also provided from 'National Nuclear User Facility (NNUF) @ Centre for Radiochemistry Research (CRR)', in the Department of Chemistry, on aspects of spectroscopy, magnetism, reprocessing and computational modelling. This creates a suite of RADER laboratories able to handle low-level radiochemical separations and environmental chemistry/biogeochemistry experimental work with radioactive samples.

External user access arrangements

Users from UK-based Higher education institution (HEI) and other organisations that are eligible to apply for UKRI funding can apply for funded access through NNUF, until March 2023 (please see www.nnuf.ac.uk/how-gain-access).
Researchers from outside the UK can also apply for funded access through NNUF, if a faculty member in a UK university is included on the project team or if the experiment is part of establishing/expanding a substantial collaboration between the research group and the institution hosting the facility. We are happy to be contacted to discuss access for industry, other research institutions or non-UK institutions.

Other relevant information

Please consult https://www.nnuf.ac.uk/rader for further information.

Nuclear material capabilities (i.e. activity limits)

Low activity environmental samples.

Instrument specification

Low level radiometric counting

- Low level scintillation counting for environmental samples
- Alpha spectroscopy
- Gamma spectroscopy
- Autoradiography to identify radioactive regions in samples

Environmental characterisation - solutions

- ICP-MS/MS. Ultra-dilute element concentrations, isotopic information
- Capillary IC. Small volume anion analyses, including speciation
- Zetasizer. Colloid molecular particle size, zeta potential, and molecular weight
- Nanoparticle Tracking Analysis. Nanoparticle size distribution and concentration

Environmental characterisation - solids

- Powder X-ray diffraction
- Surface area analyser
- Fourier Transform Infra-Red spectrometer - LN_2 cooled, high resolution detection
- UV Visible Near Infra-Red Spectrophotometer
  (with access facilitated to existing WRC Quanta 650FEG Environmental Scanning electron microscope)

Environmental characterisation - biological

- Real-Time PCR & Homogenzier for DNA extraction
  (with access facilitated to existing Illumina Next Generation Sequencing Platform. DNA sequencing and bioinformatics platforms)

Sample preparation

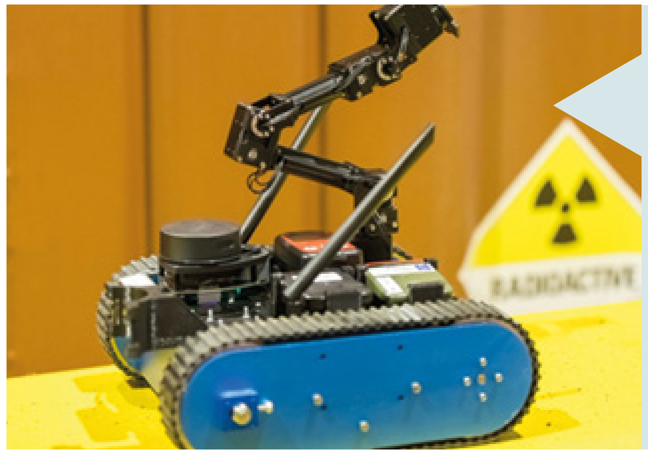
- Chemostat. Controlled reaction vessel
- Isocratic / Peristaltic Pumps for flow-through column experiments
- Sectioning saw and polisher/grinder system for sample preparation.
- Anaerobic Cabinets. O_2 / CO_2 control

Areas instrument used over last 12 months

Area	% Usage
Waste Management	50
Advanced Nuclear	
Environmental	50
Other (please specify)	
Available/ unused	

Contact

Dr Anthony Stockdale | NNUF RADER EO anthony.stockdale@manchester.ac.uk
Prof. Kath Morris | NNUF RADER PI katherine.morris@manchester.ac.uk



Organisation
The University of Manchester

Facility
Robotics for Extreme Environments Lab. Hot Robotics Facility - University of Manchester component

Location
RAICo1, Whitehaven, Cumbria
(Equipment can also be hired out to users' own sites)

Image: © DSRL

Summary of capability/facility

The National Nuclear User Facility for Hot Robotics (NNUF-HR) is an EPSRC funded facility to support UK academia and industry to deliver ground-breaking, impactful research in robotics and artificial intelligence for application in extreme and challenging nuclear environments.
The facility is arranged across three regional nodes with four research partners: The National Nuclear Laboratory (NNL), The University of Manchester, University of Bristol and UKAEA's Remote Applications in Challenging Environments (RACE). Located at the centre of the UK's nuclear industry in West Cumbria, The University of Manchester component of the Hot Robotics Facility provides mock-ups and robotic equipment to enable researchers to address nuclear decommissioning challenges.
Specific capabilities include a pond equipped with an underwater positioning system, robotic manipulators and a variety of submersible robots, several mock-ups of commonly encountered decommissioning challenges and a range of ground and aerial vehicles, with associated sensors, which can be used in an environment equipped with a Vicon and Qualisys positioning systems.

Related instrumentation/capabilities

NNUF-HR also has hubs at UKAEA's RACE; University of Bristol; and NNL.

External user access arrangements

- Users from UK-based Higher education institution (HEI) can apply for funded access through NNUF, until March 2023 (please see www.nnuf.ac.uk/how-gain-access)
- Equipment can be used by industry, small medium enterprises (SMEs) and academics at our Cumbrian site, or hired out to users' own sites
- Researchers from outside the UK can also apply for funded access through NNUF, if a faculty member in a UK university is included on the project team or if the experiment is part of establishing/expanding a substantial collaboration between the research group and the institution hosting the facility

Other relevant information

Please consult https://hotrobotics.co.uk for further information.

Nuclear material capabilities (i.e. activity limits)

Non-active.

Contact

nnuf-hr@manchester.ac.uk

Instrument specification

Manipulators
2 x Kinova 7 DOF Gen 3 arms with associated 2 and 3 finger grippers
Haption Virtuouse 6D Haptic System
Kuka iiwa LBR with 2 and 3 finger grippers
Blueprint Labs Alpha 5

ROVs
Agile Scout Mini
Agile X Scout 2.0
Husarion ROSbot 2.0 Pro
Vega/Lyra UGV
Unitree A1 explorer quadruped
MallARD surface platform

Aerial Vehicles
DJI Matrice 300 RTK
Yuneec H520

Submersible ROVs
Blue Robotics BlueROV2
Deep Trekker DTG3

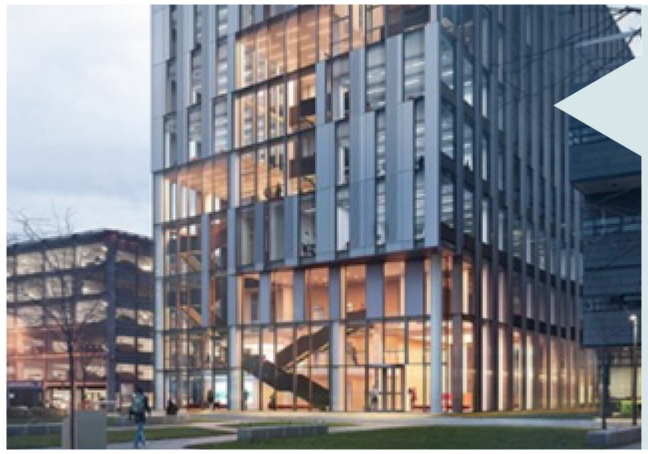
Sensors & Detectors
Olympus Handheld XRF
Radeye G10, DP6 probe for RadeyeSX and simulated sources and detectors
Water Linked DVL (Doppler Velocity Log)
Hydromea Luma 500
Various LiDAR including Velodyne, Ouster OSI-64 and OSI-128, Intel Realsense L-515 and Livox Mid 40

Pond Test/Demo Facility
4.8 m length x 3.6 m width x 2.4 m deep with viewing windows and platform
Underwater (Qualisys) and Ground/Aerial (Vicon) positioning systems

Other
dSpace real time controller
Varjo XR-3 mixed reality headset

Areas instrument used over last 12 months

Area	% Usage
Waste Management	40
Advanced Nuclear	
Environmental	
Teaching	35
Other (please specify)	25
Available/ unused	



Organisation
The University of Manchester

Facility
Nuclear Fuel Centre of Excellence (NFCE)

Location
Department of Mechanical Aerospace and Civil Engineering, Royce Hub Building, The University of Manchester, Manchester, UK

Summary of capability/facility

The nuclear fuel technology facilities housed within the Nuclear Fuel Centre of Excellence (NFCE) and the Henry Royce Institute at The University of Manchester include various experimental capabilities to synthesis, fabricate and characterise representative fuel materials. A suite of inert atmosphere gloveboxes, housing a variety of equipment, provided the capability to handle and process uranium and thorium bearing metals, ceramics and intermetallics. The research team at Manchester has developed capabilities to synthesis and fabricate representative fuel forms from a variety of uranic materials, including; metal alloys, nitrides, silicides, carbides, borides and oxides. An array of experimental techniques have been developed over the past decade to allow thermophysical analysis, material characterisation and various forms of microscopy to be utilised on uranium bearing materials.

Related instrumentation/capabilities

SIMFUEL and alpha active characterisation facility.
Various characterisation facilities installed at The University of Manchester.

External user access arrangements

- Users from UK-based Higher education institution (HEI) can apply for funded access through NNUF, until March 2023 (please see www.nnuf.ac.uk/how-gain-access)
- Equipment can be used by industry, SMEs and academics at our Cumbrian site, or hired out to users' own sites
- Researchers from outside the UK can also apply for funded access through National Nuclear User Facility (NNUF), if a faculty member in a UK university is included on the project team or if the experiment is part of establishing/expanding a substantial collaboration between the research group and the institution hosting the facility

Other relevant information

The nuclear fuel technology facilities at the University of Manchester are currently in the process of relocating to the Henry Royce Institute Hub, this is due to be completed within 2022. As part of this move, manufacturing and characterisation equipment will be upgraded and additional capabilities will come online.

Nuclear material capabilities (i.e. activity limits)

Natural and depleted uranium and thorium, Beta and gamma emitting materials can be handled in the facilities pending a dose assessment.

Instrument specification

Manufacture;
- Arc melter (inert atmosphere glovebox)
- Vacuum/inert atmosphere graphite furnace (2200°C)
- Spark plasma sintering furnace (Glovebox coupled, 2700°C)
- H_2/N_2/Ar tube furnace (1800°C)
- H_2/N_2/Ar tube furnace (inter atmosphere glovebox, 1400°C)
- Flash sintering Furnace (1600°C)
- Mixer/ball/rotary milling
- Chemical vapour deposition furnace*
- Hot isostatic press*

Characterisation
- Thermogravimetric analysis (1600°C) – including water vapour
- Differential scanning calorimetry (1600°C) – including water vapour
- Dilatometry (1200°C)
- Laser Flash Analysis (1200°C)
- Dynamic mechanical analysis (600°C)
- Laser confocal microscopy
- Raman microscopy
- Electron microscopy (Electron Backscatter Diffraction Analysis (EBSD) and Energy Dispersive X-Ray (EDX), nano-indentation)
- Atomic force microscopy
- X-ray diffraction crystallography
- X-ray computer tomography
- Metallographic sample preparation (inert atmosphere glovebox)
- He-pycnometry
- Particle size analysis – laser diffractio
- Surface area analysis – BET *due to come online 2022

Areas instrument used over last 12 months

Area	% Usage
Waste Management	5
Advanced Nuclear	95
Environmental	
Other (please specify)	
Available/ unused	

Contact

Tim Abram - tim.abram@manchester.ac.uk
James Buckley - james.buckley-2@manchester.ac.uk
Rob Harrison - r.w.harrison@manchester.ac.uk
Joel Turner - joel.turner@manchester.ac.uk

Organisation
The University of Manchester

Facility
Irradiated Materials Laboratory

Location
Department of Mechanical Aerospace and Civil Engineering , Royce Hub Building, The University of Manchester, Manchester, UK

Summary of capability/facility

The irradiated materials facilities housed within the Henry Royce Institute at The University of Manchester include various experimental capabilities to investigate irradiated materials high temperature nuclear systems and materials degradation in these environments. The research team at Manchester has developed a dedicated radioactive laboratory to prepare, characterise and test irradiated samples including graphite and Zr alloys. Equipment capabilities include:

- Sample machining, preparation, radiometric and radiological fingerprint characterisation (α, β and γ)
- Microstructural characterisation (2 and 3D) including spectroscopic & crystallographic
- In situ testing - both mechanical and environmental
- Chemical and physical treatments with on line spectroscopic evaluation

Related instrumentation/capabilities

SIMFUEL and alpha active characterisation facility.
Various characterisation facilities installed at The University of Manchester.

External user access arrangements

Facilities within The Henry Royce Institute Hub building are available to use through the Royce access schemes others are open to collaboration on advanced nuclear technology projects, please contact the key contacts named above for enquiries.

Other relevant information

The irradiated materials facilities at the University of Manchester are currently in the process of relocating to the Henry Royce Institute Hub, this is due to be completed within 2022.

Nuclear material capabilities (i.e. activity limits)

Beta and gamma emitting materials can be handled in the facilities pending a dose assessment.

Instrument specification

Active sample prep
- A water jet cutter
- TEM mill and associated ancillaries
- Spark erosion machine
- Optical microscopes
- Supplementary facilities including ovens, balances
- Electropolishers
- Various cutters, Diamond saws and active lathe

High Temperature Testing
- 2 x 1000°C thermal treatment rigs with online Mass Spec analysis of evolved gases and 3H/14C analysis
- Instron load frame and 30 KN load clee coupled to a 2000 °C Creep furnace rig complete with gas analysis and 3D micro DIC
- High (3000 °C) sintering furnace
- Beta high pressure (200 bar) high temperature (360 °C) Autoclave, 1.6 l vessel

Physical characterisation
- PoreMaster 60GT pore volume measurement
- Porometer 3G pore size distribution
- Resonance frequency and damping analyser
- Olympus panametric Ultrasonic testing
- Pheonix TE66 dynamic mechanical analyser
- Micromeritic Tristar II surface area analyser

Radiometric characterisation
- Packard Tri-Carb 3100TR
- Canberra NAIS-2x2
- Canberra HPGe detector
- Autoradiography

Areas instrument used over last 12 months

Area	% Usage
Waste Management	45
Advanced Nuclear	45
Environmental	
Other (please specify)	
Other (please specify)	

Contact

Key contact:
Sarah-jane Clelland
sarah-jane.clelland@manchester.ac.uk

Abbie Jones
Abbie.Jones@manchester.ac.uk

Alex Theodosiou
alex.theodosiou@manchester.ac.uk

Organisation
The University of Manchester

Facility
SIMFUEL and alpha active characterisation facility

Location
Department of Mechanical Aerospace and Civil Engineering, Henry Royce Institute Hub, The University of Manchester, Manchester, UK

Summary of capability/facility

The SIMFUEL and alpha active characterisation facility is a National Nuclear User Facility (NNUF) funded facility, consisting of an alpha active focused ion beam-scanning electron microscopy (FIB/SEM) and scanning transmission electron microscope (S/TEM). A range of alpha active manufacturing and microstructural/thermophysical characterisation facilities are coupled with the microscope facility (see related instruments/capabilities).

The facility is capable of machining small lamella using the enhanced radiological protections of the bespoke FIB/SEM for S/TEM analysis or other techniques (such as APT). The FIB/SEM has a range of chemical spectroscopy and crystallographic characterisation equipment including energy dispersive spectroscopy (EDS) and electron back scatter diffraction (EBSD) capable of 2-D mapping or 3-D tomography. The S/TEM is equipped with dual EDS and electron energy loss spectroscopy (EEELS) for elemental mapping and oxidation state characterisation as well as ability to perform high resolution atomic imaging and collection of localised electron diffraction patterns for phase analysis.

Related instrumentation/capabilities

Nuclear Fuel Centre of Excellence (NFCE)

External user access arrangements

The alpha active electron microscopy facility within the Henry Royce Institute Hub is available to use via the National Nuclear User Facility (NNUF) user access, please contact the key contacts named above for enquiries.

Other relevant information

The electron microscopy facility is currently under installation with the S/TEM having been installed in March 2022 and currently undergoing non-active commissioning anticipated to be U active in summer 2022. The FIB/SEM is currently undergoing coupling with an MBraun glovebox at the microscope manufacturer, due for delivery to UoM in late May 2022 with installation expected to be completed by August 2022 and active commissioning in autumn 2022.

Nuclear material capabilities (i.e. activity limits)

Natural and depleted uranium and thorium,Beta and gamma emitting materials can be handled in the facilities pending a dose assessment.

Instrument specification

The FIB/SEM is a ThermoFisher Scientific Helios system equipped with;
- Field Emission Gun (FEG) electron source
- Secondary Electron (SE), Backscattered-Electron (BSE), Circular Backscatter Detector (CBS), scanning transmission electron microscope (stem) detector - resolution of 0.7 nm
- Oxford instruments Ultimax EDS 170 mm^2 detector
- Oxford instruments Symmetry fast CMOS EBSD camera
- AutoTEM lamella preparation
- Slice and view software for 3-D electron image, EDS or EBSD capture
- Alpha active loader with coupling to MBraun glovebox to permit fully contained workflow for alpha active nuclides

The S/TEM is a ThermoFisher Scientific Talos 200i system equipped with;
- FEG electron source with probe size down to 1 nm
- Bright-field (BF), Annular dark-field (ADF), High Angle Annular Dark Field (HAADF) detectors
- Dual Bruker EDS systems with energy resolution of 129 eV
- Gatan Continuum EELS camera for spectroscopy of EFTEM image acquisition, energy resolution of 0.9 eV
- Range of holders, including low background EDS, Cryogenic and Vacuum/inert transfer holders to go from FIB glovebox to S/TEM without breaking of containment/exposure of the sample to air

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	Main use envisioned. Facility is anticipated to start operation in Summer 2022
Environmental	
Other (please specify)	
Available/ unused	

Contact

Tim Abram - tim.abram@manchester.ac.uk
Rob Harrison - r.w.harrison@manchester.ac.uk
Joel Turner - joel.turner@manchester.ac.uk
Diana Ruiz - dianatalia.alvarezruiz@manchester.ac.uk
Matthew Rogers - matthew.rogers@manchester.ac.uk

Organisation
Nottingham Trent University

Facility
Hidex Gamma Counter

Location
Clifton campus, Nottingham Trent University

Summary of capability/facility

The instrument is used to measure Gamma radiation in either solid or liquid samples.

It can run solitary samples or multi-rack on a continuous conveyor system.

Instrument specification

https://hidex.com/products/hidex-automatic-gamma-counter/

Related instrumentation/capabilities

https://hidex.com/products/hidex-automatic-gamma-counter/

Nuclear material capabilities (i.e. activity limits)

Non-Active As Standard - Although irradiation of radioactive samples may be possible upon request.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	100
Other (please specify)	
Available/ unused	

External user access arrangements

By application to Darren.hodgkinson@ntu.ac.uk

Other relevant information

Contact

Darren Hodgkinson - Darren.hodgkinson@ntu.ac.uk

Organisation
Nottingham Trent University

Facility
Packard Cobra Gamma Counter

Location
Clifton campus, Nottingham Trent University

Summary of capability/facility

The instrument is used to measure Gamma radiation in either solid or liquid samples.

It can run solitary samples or multi-rack on a continuous conveyor system.

More information can be found here https://americanlaboratorytrading.com/lab-equipment-products/packard-bioscience-company-cobra-ii-auto-gamma-counter-model-d5005_9356

Instrument specification

https://americanlaboratorytrading.com/lab-equipment-products/packard-bioscience-company-cobra-ii-auto-gamma-counter-model-d5005_9356

Related instrumentation/capabilities

https://americanlaboratorytrading.com/lab-equipment-products/packard-bioscience-company-cobra-ii-auto-gamma-counter-model-d5005_9356

Nuclear material capabilities (i.e. activity limits)

https://americanlaboratorytrading.com/lab-equipment-products/packard-bioscience-company-cobra-ii-auto-gamma-counter-model-d5005_9356

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	100
Other (please specify)	
Available/ unused	

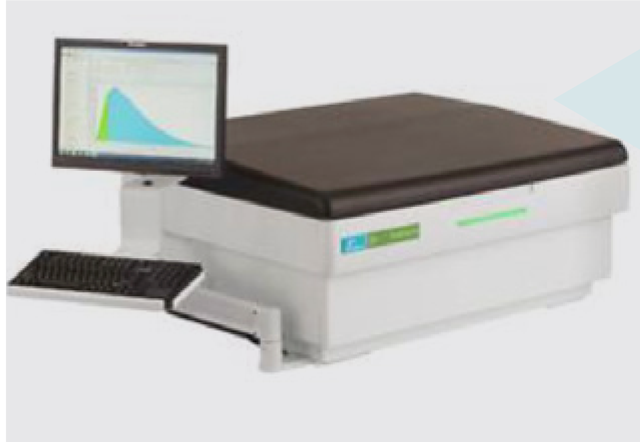
External user access arrangements

By application to Darren.hodgkinson@ntu.ac.uk

Other relevant information

Contact

Darren Hodgkinson - Darren.hodgkinson@ntu.ac.uk



Organisation
Nottingham Trent university

Facility
Tricarb 5110 TR Perkin Elmer

Location
Clifton campus, Nottingham Trent University

Summary of capability/facility

The instrument measures Alpha and Beta activity in liquid samples using liquid scintillation. The machine can internally differentiate between the two types of radioactivity.

The machine is capable of running single or multi sample runs using the conveyor rack system.

Instrument specification

https://www.perkinelmer.com/uk/product/tri-carb-lsc-5110tr-110-v-a511000

Related instrumentation/capabilities

https://www.perkinelmer.com/uk/product/tri-carb-lsc-5110tr-110-v-a511000

Nuclear material capabilities (i.e. activity limits)

https://www.perkinelmer.com/uk/product/tri-carb-lsc-5110tr-110-v-a511000

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	100
Other (please specify)	
Available/ unused	

External user access arrangements

By application to Darren.hodgkinson@ntu.ac.uk

Other relevant information

Contact

Darren Hodgkinson - Darren.hodgkinson@ntu.ac.uk

Organisation
Nottingham Trent University

Facility
Tricarb 2910 Perkin elmer

Location
Clifton campus, Nottingham Trent University

Summary of capability/facility

This instrument is used to measure Beta radiation in liquid samples, primarily C^{14} and H^{3} but also a range of liquid Beta samples.

The conveyor rack system can cope with single or multi sample runs.

Instrument specification

https://www.perkinelmer.com.cn/CMSResources/Images/46-73886SPC_TriCarb2910TRLSA.pdf

Related instrumentation/capabilities

https://www.perkinelmer.com.cn/CMSResources/Images/46-73886SPC_TriCarb2910TRLSA.pdf

Nuclear material capabilities (i.e. activity limits)

https://www.perkinelmer.com.cn/CMSResources/Images/46-73886SPC_TriCarb2910TRLSA.pdf

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	100
Other (please specify)	
Available/ unused	

External user access arrangements

By application to Darren.hodgkinson@ntu.ac.uk

Other relevant information

Contact

Darren Hodgkinson - Darren.hodgkinson@ntu.ac.uk

Organisation
Oxford University

Facility
Nuclear Materials Atom Probe (NuMAP) Facility

Location
Department of Materials, University of Oxford, Parks Road, Oxford OX1 3PH

Summary of capability/facility

The National Nuclear User Facility (NNUF) funded Nuclear Materials Atom Probe (NuMAP) Facility at the University of Oxford provides access to the microscopy technique Atom Probe Tomography (APT) for the atomic-scale microstructural characterisation of active materials related to fission and fusion energy applications.
APT is increasingly used to underpin research across all stages in the nuclear energy cycle: materials design for new reactor manufacturing, component safety and failure analysis, waste/storage and even accident investigation.
Unique 3D nanoscale insights that can be provided by APT include: investigating radiation-induced atomic-scale solute clustering, characterising solute segregation to microstructural interfaces (dislocations, grain boundaries, phase boundaries), analysing surface corrosion and precisely locating low concentration transmuted elements - all vital information for developing new engineering materials for nuclear applications.
NuMAP provides:

- Fully supported access to APT, across all aspects of specimen preparation, experiment and data analysis
- Support for FIB-based specimen preparation at UKAEA MRF
- Training in all aspects of APT
- Commercial services

Instrument specification

Local Electrode Atom Probe (LEAP) 5000 XR

Related instrumentation/capabilities

Sample fabrication of non-active materials can be carried out at the University of Oxford, either via electropolishing or using the Focused Ion Beam (FIB) microscopes at the David Cockayne Centre for Electron Microscopy.
FIB-based preparation of activated material can be conducted at the Materials Research Facility (MRF). Sample transfer under vacuum and at cryogenic temperatures is enabled by a Vacuum and Cryo Transfer Module.

Nuclear material capabilities (i.e. activity limits)

Due to the small specimen volume (< 10 μm^3) the activity is negligible.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	10
Nuclear Fission	75
Nuclear Fusion	10
Aerospace	5

External user access arrangements

- Users from UK-based Higher Education Institutes and other organisations that are eligible to apply for UKRI funding can apply for funded access through NNUF, until March 2023 (please see www.nnuf.ac.uk/how-gain-access)
- Researchers from outside the UK can also apply for funded access through NNUF, if a faculty member in a UK university is included on the project team or if the experiment is part of establishing/expanding a substantial collaboration between the research group and the institution hosting the facility.
- The NuMAP staff are also happy to discuss other forms of collaborations or commercial work, and can advise in the planning of experiments based around APT characterisation.

Other relevant information

Contact

Dr. Christina Hofer
christina.hofer@materials.ox.ac.uk

Organisation
Oxford University

Facility
Oxford Micromechanics Laboratory

Location
Department of Materials, University of Oxford, Parks Road, Oxford OX1 3PH

Summary of capability/facility

The Oxford Micromechanics Laboratory is a suite of instruments capable of probing the fundamental mechanical properties of materials at the length scales of individual microstructural features. These systems are particularly effective at studying ion irradiation damage and its effects on mechanical properties.

We operate 6 nanoindenters from all three major manufactures (KLA, Bruker, MicroMaterials). Between the 6 instruments we can cover testing temperatures from -40°C to 1000°C, test in air, invert atmospheres or vacuum, perform in situ stress corrosion cracking using a electrochemical system, and watch the deformation using in Scanning Electron Microscope (SEM) testing.

Alongside the indentation based testing we have two Deben load frames for microscale tension/compression testing. These can be used either in SEM or in a glove box with testing temperatures from 20°C to 800°C. Both systems have a range of grips and can be used with Digital Image Correlation (DIC) cameras and/or electrical monitoring of samples.

Instrument specification

6 Nanoindenters allow a range of testing specifications including:

- Range of testing temperatures from -40°C to 1000°C
- Wet cell work for corrosion testing
- In situ electrical measurements
- In situ SEM testing for deformation visualisation
- High loading rate (up to 1000s^{-1}) testing
- Scanning probe imaging
- High speed mechanical mapping
- Inert environment of vacuum testing of reactive materials
- Max load 500 mN

2 Micro tensile stages allow for

- Range of testing temperatures from 20°C to 800°C
- In situ SEM testing for deformation visualisation
- In situ electrical measurements
- Inert environment of vacuum testing of reactive materials
- Max load 2 kN

Related instrumentation/capabilities

Sample fabrication of non-active materials can be carried out at the University of Oxford, either via electropolishing or using the Focused Ion Beam (FIB) microscopes at the David Cockayne Centre for Electron Microscopy.
FIB-based preparation of activated material can be conducted at the Materials Research Facility (MRF). Sample transfer under vacuum and at cryogenic temperatures is enabled by a Vacuum and Cryo Transfer Module.

Nuclear material capabilities (i.e. activity limits)

Nil

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	60
Environmental	
Aerospace	30
Geological	10
Available/ unused	

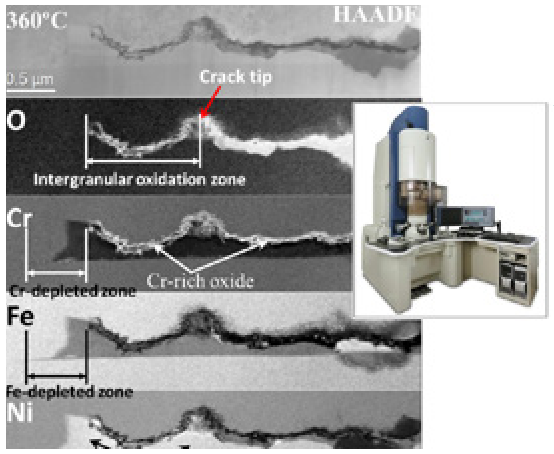
External user access arrangements

Available for external use by trained users as Small Research Facility with access charge

Other relevant information

Contact

Dr David Armstrong
David.armstrong@materials.ox.ac.uk



Organisation
Oxford University

Facility
Jeol ARM 200F/DCCEM/Analytical (S)TEM

Location
Department of Materials, University of Oxford, Parks Road
Oxford OX1 3PH

HAADF and EELS maps from SCC crack tip - Shen, Z. et al.

Summary of capability/facility

The Jeol ARM 200F analytical (Scanning) Transmission Electron Microscope ((S)TEM) at the University of Oxford provides access to high-resolution imaging and analytical techniques for the characterisation of materials for nuclear applications. Available techniques include: High-Angle Annular Dark Field (HAADF), Energy Dispersive X-Ray (EDX) and Electron Energy Loss Spectroscopy (EELS).

This electron microscope has been extensively used in nuclear-related projects, including:

- Zr-cladding alloys: oxide phase characterisation, SPP composition evolution with oxidation/irradiation, alloying elements oxidation state
- Stress Corrosion Cracking (SCC) of austenitic alloys: crack tip/surface oxide composition/phases, intergranular cavitation, atomic-resolution characterisation of oxide-metal interface
- Reactor Pressure Vessels (RPV) embrittlement: analytical precipitate mapping, Radiation Induced Segregation (RIS)
- Fusion materials (e.g. Be and W): Phase identification, microstructural changes after plasma interaction (erosion, re-deposition)

Other TEMs, such as a Jeol 2100 LaB6, optimised for diffraction, can also be accessed by request.

Instrument specification

Cold field emission source (CFEG) Cs probe corrected 200kV TEM (STEM).

Related instrumentation/capabilities

High resolution analytical TEM with Cs probe, featuring 100mm^2 Centurion EDX detector and Gatan GIF Quantum 965 ER featuring Dual EELS and Energy-filtered transmission electron microscopy (EFTEM) capabilities.

Nuclear material capabilities (i.e. activity limits)

Only Focused Ion Beam (FIB) lift-outs with no measurable activity can be used (e.g. bulk sample is active but no activity can be measured on the lift-out).

Areas instrument used over last 12 months

Area	% Usage
Waste Management	0
Advanced Nuclear	20
Environmental	10
Other areas	70
Available/ unused	

External user access arrangements

Access can be arranged at proposal stage or via collaborations. Contact Dr Neil Young for more details.

Other relevant information

Contact

Dr Neil Young
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Organisation
Oxford University

Facility
Xradia Versa 610 X-ray Microscope for computed tomography

Location
Department of Materials, University of Oxford, Parks Road,
Oxford OX1 3PH

Image from https://www.zeiss.com/microscopy/int/products/x-ray-microscopy/zeiss-xradia-610-and-620-versa.html

Summary of capability/facility

A robust, high performance X-ray tomography microscope for 3-dimensional imaging of the internal structure of materials. This instrument has synchrotron-equivalent resolution. It allows 4D studies (3D+time) with in situ testing of load and environment effects. The instrument is designed for: materials science (structural characterisation, damage mechanisms); Earth sciences (pore characterisation, fluid flow); life sciences (virtual histology, cellular and sub-cellular structures, developmental biology; and in situ 4D studies (heating, curing, deformation, discharge, wetting, drainage...). It has high throughput, wide field mode (using image stitching) and high resolution at large working distance to facilitate in situ loading, in particular tension and compression up to 5 kN load with temperatures from -20°C to 250°C. Networked data storage and software (Avizo Fire software for 3D visualisation and quantitative analysis) with high-memory workstations support multi-user operation and data analysis.

Instrument specification

Versa 610 (30-160 keV, maximum source power 25 W, spatial resolution 500 nm). See https://www.zeiss.com/microscopy/int/products/x-ray-microscopy/zeiss-xradia-610-and-620-versa.html

Related instrumentation/capabilities

Deben CT5000 loading rigs (TEC and HT250) for tension, compression and flexure up to 5 kN load at temperatures from -20°C to 250°C

Nuclear material capabilities (i.e. activity limits)

Nil

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	50%
Environmental	
Other (please specify)	50% (general materials science)
Other (please specify)	
Available/ unused	0% (Microsocope runs 24/7)

External user access arrangements

Available for external use by trained users as Small Research Facility with access charge

Other relevant information

Contact

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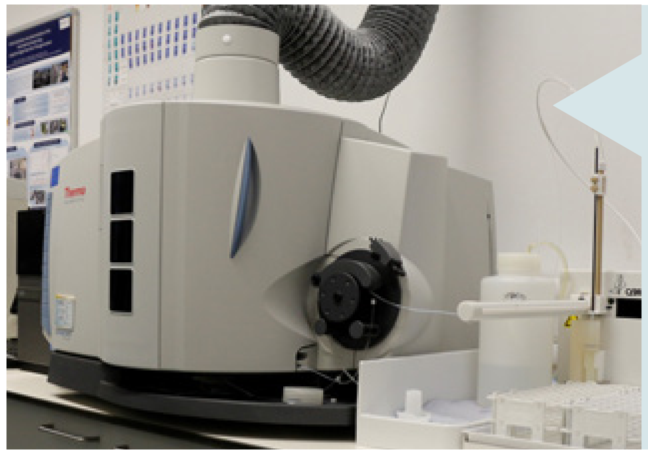

Organisation
The University of Sheffield

Facility
PLEIADES (Platform for Long-term Experimental Investigation of Alteration Disposal Environments and Storage)

Location
Co-located with HADES (High Activity Decommissioning Engineering Science) in the Department of Materials Science and Engineering

Summary of capability/facility

The PLEAIDES facility is being established as a national centre of research excellence to support the UK nuclear decommissioning and disposal programme, as part of the National Nuclear User Facility (NNUF). It will allow the determination of radio-material corrosion and long-term degradation relevant to radioactive waste storage, disposal and decommissioning associated with legacy, new-build and future fuel cycles.

PLEIADES will enable transformative research of radio-material alteration in realistic environments and over extended timescales. Materials of interest include, but are not limited to, glasses, ceramics, activated metals, cement and graphite. Users will be able to study corrosion under conditions relevant to sub-surface disposal including reducing conditions as well as long-term corrosion studies to understand slow degradation processes. Experiments into degradation and corrosion within a radiation field can also be performed in association with the Dalton Cumbrian Facility (DCF).

Additionally, users will have seamless access to the equipment and technical support in the High Activity Decommissioning Engineering Science (HADES). facility.

Instrument specification

Wet anoxic glovebox suite
Variable temperature and atmosphere corrosion reactors compatible with γ-irradiators at the Dalton Cumbrian Facility
Acid fumehood
Ovens for long term experiments
Ring Mill
Chemical analysis. Inductively coupled plasma mass spectrometry (ICP-MS) and inductively coupled plasma optical emission spectroscopy (ICP-OES); ion chromatography

Related instrumentation/capabilities

The co-location of PLEIADES and HADES offers a unique capability to explore radioactive waste materials and their degradation. It also encompasses key equipment from the Sheffield Henry Royce Institute, e.g. optical profilometry for in situ analysis of degrading surfaces.

Nuclear material capabilities (i.e. activity limits)

All laboratories are designated as supervised Areas with relatively low hazard work with radionuclides permissible throughout the facility (kBq nat. U Th). Additionally, there are controlled Areas for more hazardous work with inventories of radionuclides with high specific activity (MBq nat. U/Th; MBq ^{99}Tc; MBq mixed β/γ e.g. ^{3}H, ^{14}C, ^{60}Co, ^{90}Sr, ^{137}Cs)

External user access arrangements

- Users from UK-based Higher education institutions (HEIs) (and other organisations that are eligible to apply for UKRI funding) can apply for funded access through NNUF, until March 2023 (please see www.nnuf.ac.uk/how-gain-access)/.
- Researchers from outside the UK can also apply for funded access through NNUF, if a faculty member in a UK University is included on the project team or if the experiment is part of establishing/expanding a substantial collaboration between the research group and the institution hosting the facility.
- Prospective industrial users should contact the facility directly to discuss access

Areas instrument used over last 12 months

Area	% Usage
Waste Management	80
Advanced Nuclear	10
Environmental	10
Other (please specify)	
Available/ unused	

Other relevant information

Contact

Prof Claire Corkhill (Director of Facility) c.corkhill@sheffield.ac.uk
Dr Sarah Pepper (Experimental Officer) sarah.pepper@sheffield.ac.uk

Organisation
The University of Sheffield

Facility
HADES (High Activity Decommissioning Engineering Science)

Location
Co-located with PLEIADES (Platform for Long-term Experimental Investigation of Alteration Disposal Environments and Storage) in the Department of Materials Science and Engineering

Summary of capability/facility

The HADES Facility at the University of Sheffield is established as a national centre of research excellence to support the UK nuclear decommissioning and disposal programme, as part of the National Nuclear User Facility (NNUF). The Facility is accommodated within 500 m^2 of high quality radiomaterials chemistry laboratories, refurbished in 2015, with state-of-the-art equipment and instrumentation for materials formulation, processing, characterisation and performance assessment.
All HADES laboratories are designed and operated as supervised areas, for research with limited inventories of radioactive materials (unsealed sources). Controlled area laboratories enable work with MBq quantities of α and β/γ nuclides. The integrated nature of the Facility enables acceleration of materials optimisation, through rapid feedback between synthesis and characterisation.
A trained team of highly experienced researchers and experimental officers support operation of the Facility, providing user training, supervision, and equipment calibration and servicing.

Related instrumentation/capabilities

The HADES Facility was established with investment of £1M by UKRI EPSRC and the University of Sheffield, in new state-of-the-art materials processing and characterisation equipment, to enable higher throughput research and work with high radionuclide inventories. The Facility incorporates prior investment of ca. £8M in laboratory space and equipment, within the MIDAS facility, and allied Henry Royce Institute, to provide a single point of user access. Additionally, users will have seamless access to the equipment and technical support in the STX Facility, the UK's first capability for laboratory based X-ray Absorption Spectroscopy, and the PLEIADES facility.

External user access arrangements

- Access to the facility may be in person, remote, or via sample mail in
- Users from UK-based Higher education institutions (Higher education institutions (HEIs)) and other organisations that are eligible to apply for UKRI funding can apply for funded access through NNUF, until March 2023 (please see www.nnuf.ac.uk/how-gain-access)
- Prospective industrial or overseas users should contact the facility directly to discuss access

Other relevant information

Please consult https://www.nnuf.ac.uk/hades for further information.
See also: *The HADES Facility for High Activity Decommissioning Engineering & Science*: part of the UK National Nuclear User Facility, N.C. Hyatt, C.L. Corkhill, M.C. Stennett, R.J. Hand, L.J. Gardner, IOP Conference Series: *Materials Science and Engineering*, 818, 012022, 2020. https://doi.org/10.1088/1757-899X/818/1/012022.

Nuclear material capabilities (i.e. activity limits)

Supervised Areas: kBq nat U or Th.
Controlled Areas: MBq nat. U or Th; MBq ^{99}Tc; MBq mixed β/γ e.g. ^{3}H, ^{14}C, ^{60}Co, ^{90}Sr, ^{137}Cs.

Instrument specification

The Facility is organised in a suite of capability platforms, for working with radioactive materials:

- Materials handling. Enabling glove box manipulation of α and β/γ nuclides under air or inert conditions (<ppm O_2, <ppm H_2O); comprehensive metallography suite with equipment for cutting and sectioning of materials, grinding and polishing
- Materials processing. Thermal treatment of materials up to 1800°C under controlled atmosphere, with off gas analysis and quenching capability; the platform incorporates the UK's only radiological Hot Isostatic Press operating up to 2000°C and 200 MPa; suite of ball mills
- Diffraction and spectroscopy. Including: X-ray diffraction (room temperature; high temperature and controlled atmosphere to 1200°C; grazing angle capability); Raman and IR, ^{57}Fe Mossbauer; X-ray absorption and emission spectroscopy X-ray emission spectroscopy (XES) X-ray Absorption Near Edge Structure (XANES), Extended X-ray Absorption Fine Structure (EXAFS)
- Microscopy and microanalysis. Optical microscopy; scanning electron microscopy with energy-dispersive X-ray analysis; and - via the Sheffield Hub of the Royce Institute - atomic force microscopy, optical profilometry, and electron probe microanalysis
- Thermal and physicochemical analysis. Coupled thermo-gravimetric, differential thermal / scanning calorimetry, and mass spectroscopy analysis; surface area analyser; pycnometer; particle size analyser; and high temperature glass rheology
- Chemical and radiochemical analysis
- Radiometrics and radiological protection. High resolution γ-spectroscopy; fixed personal contamination monitors in controlled areas; a suite of large area survey meters, contamination monitors, and dose rate detectors are available; personal dosimetry available if required

Predicted area usage over 12 month period

Area	% Usage
Waste Management	50
Environmental / Disposal	30
Advanced Nuclear Materials	10
Decommissioning	10

Contact

Prof. Claire Corkhill (Facility Director) c.corkhill@sheffield.ac.uk
Dr. Martin Stennett (Experimental Officer and Radiation Protection Supervisor) m.c.stennett@sheffield.ac.uk
Facility postal address: FAO: Dr Martin Stennett, Department of Materials Science and Engineering, Sir Robert Hadfield Building, Mappin Street, Sheffield, S1 3JD

Organisation
Southampton University

Facility
NNUF-EXACT (Next Generation Accelerated Characterisation Technologies). Hidex 300SL Super Low Level TDCR LSC, Hidex AMG Automatic Gamma Counter, Anton Paar Quadrasorb evo surface area/pore size SBET, Kromek GR1-A+ CZT gamma detector, Sample handling glove box (from mid-2022), Customisable flow-rig system (mid-2022)

Location
The National Oceanography Centre Southampton (NOCS), European Way, Southampton, SO14 3ZH, UK

Image: A view of the main NNUF-EXACT active laboratory. Image © University of Southampton

Summary of capability/facility

NNUF-EXACT aims to be a world-leading radiochemistry facility enabling research and training in accelerated nuclear characterisation and remediation technologies underpinning civil nuclear programmes, decommissioning and site clean-up and new nuclear infrastructure.

The laboratory facility provides a flexible space for the development and testing of new methodologies and technologies with low-level active reference materials and radiotracers.

A dedicated active laboratory features fume cupboards and flexible bench/floor space that can be configured to specific user requirements. A modular and customisable flow-rig will also be available so researchers can integrate test equipment such as in-line sensors or prototype equipment relevant to their application (mid-2022).

A glove box system will also be available for the containment of radiologically/chemically hazardous sample materials (mid-2022).

Users will benefit from the experience of the facility staff in radiochemistry, radiation measurement and radiation safety.

A comprehensive training programme in characterisation, remediation and radiochemistry is offered by EXACT, please see our website for the latest courses and availability.

Instrument specification

Hidex 300 SL Low-level Liquid Scintillation Counter
- Triple to double coincidence counting
- Alpha/Beta discrimination
- Low-levels PMTs and active guard detector

Hidex AMG Automatic Gamma Counter
- 0-4000 keV energy range
- Integrated sample weighing balance
- Automatic sample changer

Anton Paar Quadrasorb evo SBET
- Simultaneous analysis of four samples
- $0.01 m^2/g$ surface area minimum
- Pore size range 0.35-500 nm

Kromek GR1-A+ CZT detector
- High-resolution room temperature gamma spectrometry
- Independent Energy, Gate & Timing connections.

Sample containment glove box system
- Negative pressure glove box for handling of hazardous samples

Customisable flow-rig system
- Aqueous flow-rig capable of 'active' operation
- Modular design to facilitate rapid reconfiguration

Related instrumentation/capabilities

Users of NNUF-EXACT have access to the following supporting facilities:
- GAU-Radioanalytical Laboratories (GAU)
- The University of Southampton's Geochemistry Research Group
- The Organic Geochemistry lab at the University of Southampton's newly established SEAPORT laboratories
- Access to the Bristol Interface Analysis Centre is provided through the NNUF-EXACT partner organisation, the South West Nuclear Hub.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	20
Advanced Nuclear	20
Environmental	30
Remediation	30
Other (please specify)	
Available/ unused	

External user access arrangements

Please consult the facility's own website for further information on access (www.southampton.ac.uk/nnuf-exact/access/index.page).

Users from UK-based Higher education institution (HEI) are eligible to apply for funded access through National Nuclear Users Facility (NNUF) (www.nnuf.ac.uk/how-gain-access). Researchers from outside the UK can also apply for funded access through NNUF, if a faculty member in a UK university is included on the project team or if the experiment is part of establishing/expanding a substantial collaboration between the research group and the institution hosting the facility.

Other relevant information

Please consult https://www.southampton.ac.uk/nnuf-exact/ and https://www.nnuf.ac.uk/exact for further information.

Nuclear material capabilities (i.e. activity limits)

Indicative upper activity limits:

Beta/Gamma (excludes $^{3}H/^{14}C$):	kBq-MBq
Beta ($^{3}H/^{14}C$):	MBq-GBq
Alpha:	kBq

Contact

Project PI - Prof Phil Warwick
Contact No.: 023 80596600
Email: nnuf-exact@soton.ac.uk

Postal address: Dr Richard Marsh, NNUF-EXACT Facility Manager, University of Southampton, National Oceanography Centre Southampton European Way, Southampton SO14 3ZH, UK

Access Enquiry Form:
https://www.southampton.ac.uk/nnuf-exact/access/access-enquiry-form.page

Organisation
Strathclyde University

Facility
Advanced Forming Research Centre (AFRC) Mechanical Testing Lab

Location
Advanced Forming Research Centre, University of Strathclyde. Inchinnan, Renfrew, Scotland

Summary of capability/facility

The Advanced Forming Research Centre (AFRC) based at the University of Strathclyde, has a comprehensive range of mechanical testing equipment capable of testing at conditions which simulate those from a sub-zero oil and gas pipeline, to the forging conditions of an advanced metallic alloy. Able to perform uniaxial tensile tests at temperatures ranging from -20˚C to 1130˚C, in air, Argon, or in a vacuum, and at strain rates of 10-5 /s to 10 /s, means flow curves can be developed to simulate conditions arising from most practicable situations. The bespoke High Strain Rate Forging Simulator which is unique to the AFRC, can test at strain rates from 10/s to 250/s and up to temperatures of 1400˚C, making it perfect for simulating the forging conditions of metallic alloys. The AFRC also offers a growing range of micro-mechanical testing capabilities, capable of testing samples as small as 40x1x1 mm using their state of the art Electro-Thermal Mechanical Testing (ETMT) system as well as their Scanning Electron Microscope (SEM) Mounted Hot Tensile Stage which allows real-time SEM image collection during mechanical testing.

Instrument specification

- Uniaxial Tensile techniques including room temperature and elevated temperature tensile and compression testing, low cycle fatigue testing, high Strain Rate Techniques
- Uniaxial high strain rate compression testing
- Micro-mechanical techniques [ambient and elevated temperature tensile and compression testing; ambient and elevated temperature fatigue testing; In-situ room temperature and elevated temperature testing using SEM Mounted Hot Stage]
- Bi-Axial Sheet Metal Testing techniques [Nakajima, Marciniak Testing. Erichsen Cupping Testing]
- Hardness Testing Equipment [Vickers hardness testing (micro and macro ranges); KNoop hardness testing (micro range); Damage/Impact Testing; Charpy Impact Testing; Izod Impact Testing]

Related instrumentation/capabilities

AFRC also houses extensive residual stress measurement capabilities - see other info.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	0
Advanced Nuclear	20
Environmental	5
Teaching	65
Non-nuclear sector - aero, offshore, etc	10
Available/ unused	

External user access arrangements

Facilities are available for use within projects under University of Strathclyde commercial terms.

Other relevant information

Nuclear material capabilities (i.e. activity limits)

The facility is not licensed to process or test radioactive materials.

Contact

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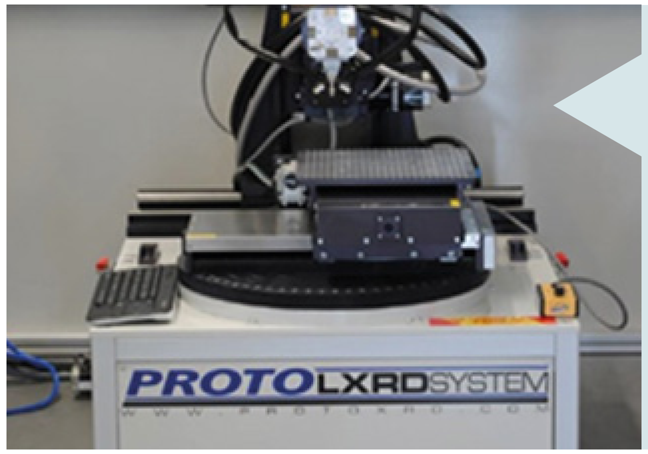

Organisation
Strathclyde University

Facility
AFRC Residual Stress Lab

Location
Advanced Forming Research Centre, University of Strathclyde, Inchinnan, Renfrew, Scotland

Summary of capability/facility

Strathclyde's Advanced Forming Research Centre (AFRC) has a suite of capabilities for multi-scale modelling, measurements and control of residual stress (RS). These are a range of non-destructive and destructive techniques including x-ray diffraction (XRD), ultrasonic, incremental central hole-drilling (ICHD) based on strain gauge rosette and electronic speckle pattern interferometry (ESPI), the contour method, and slitting method. Through a team of scientists and engineers who are dedicated to translational research in residual stress management, the AFRC is developing new capabilities, combined with the kNowledge and kNow-how of industry, to provide the UK manufacturing sector with the confidence to put materials into service with far less conservatism. As an ISO17025 accredited measurement service, the RS laboratory is uniquely positioned to provide a unique combination of scientific kNowledge and experience coupled with a pragmatic approach to application for industrial clients. The team has extensive experience in the application of mid-TRL Technology Readiness Level technology for commercial benefit, while addressing systematic gaps in the underlying science where necessary, an approach which has broad applicability across the nuclear sector.

Instrument specification

Non destructive techniques
- X-Ray Diffraction, 2 off PROTO LXRD
- Ultrasonic techniques, an in-house developed system and an UltraMars Equipment

Semi destructive techniques
- SINT-MTS3000 hole drilling system
- Stresstech Electronic Speckle Pattern Interferometry (ESPI) based hold-drilling

Destructive techniques (contour and slitting methods)

Related instrumentation/capabilities

AFRC also houses extensive materials characterisation and metrology capabilities - see other info.

Nuclear material capabilities (i.e. activity limits)

The facility is not licensed to process or test radioactive materials

Areas instrument used over last 12 months

Area	% Usage
Waste Management	0
Advanced Nuclear	20
Environmental	5
Non-nuclear sector - aero, offshore, etc	75
Other (please specify)	
Available/ unused	

External user access arrangements

Facilities are available for use within projects under University of Strathclyde commercial terms.

Other relevant information

Contact

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01415345243

Organisation
Strathclyde University

Facility
Advanced Manufacturing Research Laboratory (AMRL)

Location
University of Strathclyde, Glasgow

Summary of capability/facility

Strathclyde's Advanced Materials Research Laboratory, or AMRL, is a leading laboratory and testing centre that offers a vast array of opportunities for standout research and kNowledge exchange in materials engineering and science. The expertise of the team ranges from nanoscale through to full-scale component testing, and capabilities include microstructural, compositional and thermal analyses, and mechanical testing.

Instrument specification

A broad range of materials test capability including

- Mechanical testing [Tension / compression; Axial fatigue; Rotary bending fatigue; 3- or 4- point bending; Creep; Impact V-Charpy; Vickers macro and micro hardness]
- Thermal analysis [Thermal diffusivity up to 2000°C and in inert conditions; Specific heat (up to 2000°C in inert conditions); weight change phase transformations (to 1600°C); coefficient of thermal expansion (to 1600°C); Thermal conductivity - (to 2000°C and inert conditions); Thermal conductivity - direct measurement (-10°C - 70°C)]
- Compositional analysis [Qualitative and semi-quantitative elemental analysis; Quantitative mapping; Phase and material identification (to 2000°C); compositional depth profiling (to 150µm); quantitative surface interaction and bulk analysis; microstructural analysis; morphological and topographical imaging; crystallography

Related instrumentation/capabilities

Nuclear material capabilities (i.e. activity limits)

The facility is not licensed to process or test radioactive materials.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	0
Advanced Nuclear	5
Environmental	10
Teaching	65
Other (please specify)	10
Available/ unused	

External user access arrangements

Other relevant information

Contact

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Organisation
Strathclyde University

Facility
Advanced Materials Research Laboratory (AMRL)

Location
University of Strathclyde, Glasgow

Summary of capability/facility

Strathclyde's Advanced Materials Research Laboratory (AMRL) is a leading laboratory and testing centre that offers a vast array of opportunities for standout research and kNowledge exchange in materials engineering and science.

The expertise of the team ranges from nanoscale through to full-scale component testing, and capabilities include microstructural, compositional and thermal analyses, and mechanical testing. We apply a wide range of techniques to:

Mechanical testing
- Tension / compression
- Axial fatigue
- Rotary bending fatigue
- 3- or 4- point bending
- Creep
- Impact V-Charpy
- Macro and micro hardness

Thermal analysis (up to 1600°C)
- Thermal diffusivity
- Specific heat
- Weight change phase transformations
- Coefficient of thermal expansion
- Thermal conductivity

Compositional analysis
- Qualitative and semiquantitative elemental analysis
- Quantitative mapping
- Phase and material identification (to 2000°C)
- Compositional depth profiling (to 150µm)
- Quantitative surface interaction and bulk analysis

Microstructural analysis
- Morphological and topographical imaging
- Crystallography (grain size and texture analysis)

Instrument specification

Scanning electron microscope (SEM):
- Hitachi S-3700N SEM with a tungsten filament
- Hitachi SU-6600 High resolution field emission FE-SEM

X-ray diffractometer:
- Bruker D8 ADVANCE at ambient and high temperatures (up to 2000°C)

Glow discharge optical emission spectrometer (GD-OES):
- Horiba GD-Profiler 2™ for compositional bulk analysis and depth profiles
- The AMRL is home to the only GD-OES in Scotland.

Mercury intrusion porosimeter (MIP):
- Quantachrome PoreMaster-60® for density and porosity measurements

Thermal property analysers:
- Netzsch STA 449 F1 Jupiter®, simultaneous thermal gravimetric analyser (TGA), differential thermal analyser (DTA) and differential scanning calorimeter (DSC)
- Netzsch DIL 402C, dilatometer
- Netzsch LFA 427 laser flash analyser
- Netzsch HFM 436 Lambda heat flow meter

Mechanical testing instruments:
- Shimadzu USF 2000A ultrasonic gigacycle fatigue testing system (frequency of 20kHz)
- Two Instron 8800 servo-hydraulic systems (up to 250kN load capacity)
- Instron Electropuls E3000 system
- Instron Electromechanical 5969 system with video extensometer
- Environmental chamber from -150°C to +350°C
- Furnace up to 1000°C
- Instron RR-Moore rotating bending fatigue testing

Mechanical property instruments:
- Qness Q60A+ automated (x,y,z) hardness tester with Vickers and KNoop indenters, 2D/3D mapping, contour scan function and load range 0.2-62.5kg.

X-ray computed tomography:
- Nikon XT H 225 LC fitted with a Deben CT 10kN cell

Nuclear material capabilities (i.e. activity limits)

The facility is not licensed to process or test radioactive materials.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	15
Advanced Nuclear	5
Environmental	35
Other (please specify)	O&G, 25
Other (please specify)	Mining, 10
Available/ unused	10

Related instrumentation/capabilities

External user access arrangements

Facilities are available for use within projects under University of Strathclyde commercial terms.

Other relevant information

Contact

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Organisation
Strathclyde University

Facility
Centre for Ultrasonic Engineering - Facility for Innovation and Testing (FIRST laboratory)

Location
University of Strathclyde, Glasgow

Summary of capability/facility

The Centre for Ultrasonic Engineering (CUE) has over 30 years of expertise in the design and implementation of ultrasonic transducers and transducer systems across a broad range of industrial sectors. CUE is well placed to meet the increasingly stringent demands for future ultrasonic technology development and is an important contributor towards economic development. The Centre addresses markets in non-destructive testing, industrial process ultrasound, condition monitoring, automation, underwater sonar and biomedical applications. We have expertise in ultrasonic transducer manufacture, system prototyping, instrumentation hardware, system simulation, robotics, metrology, data processing software and image analysis.

The Facility for Innovation and Testing (FIRST laboratory) was established in 2009 as a technology transfer laboratory for Non-Destructive Testing and Evaluation (NDT & E) research. At present the typical time taken to effectively transfer research findings into actual commercial commodities is around 20 years for the NDE industry; FIRST is working to reduce this timescale. To date over £10M in projects have occurred in FIRST.

Instrument specification

Equipment Available in FIRST Tech Transfer Lab:
- Ultrasonic Phased Array Controllers
- Robotic Crawlers and Manipulators
- SAM / SEM
- Precision Motion Tracking
- Materials Characterisation
- Scanning Test Tanks
- Laser Vibrometry (including 3D)
- FARO Laser Scanner
- Large collection of NDE samples for characterisation

Nuclear material capabilities (i.e. activity limits)

Related instrumentation/capabilities

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	20
Environmental	
Other (various)	80
Other (please specify)	
Available/ unused	

External user access arrangements

Facilities are available for use within projects under University of Strathclyde commercial terms.

Other relevant information

Contact

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Organisation
Strathclyde University

Facility
Industrial Informatics Cluster

Location
University of Strathclyde, Glasgow

Summary of capability/facility

Strathclyde's industrial informatics cluster is a collaboration across all faculties of the university which aims to leverage state of the art research methods in engineering, statistics, computer science, analytics and decision science to deliver evidence-based industrial decision-making built on Artificial Intelligence AI. The work of the cluster has many areas of applicability to the nuclear sector, for example.

- Lifetime extension of plant and equipment (Classification of current condition, prediction of likely degradation)
- Reduced unplanned outages (improved anomaly detection, fault diagnosis, prediction of likely degradation and failure timescales)
- Optimisation of maintenance (classification of current condition, prediction of likely degradation)
- Optimisation of operations (understanding of operational state, prediction of improved operational state, autonomous control)

Instrument specification

A broad range of capabilities related to data analytics, artificial intelligence, structured decision support, and implementation of machine learning methodologies into challenging, highly regulated environments.

Related instrumentation/capabilities

Nuclear material capabilities (i.e. activity limits)

Desk based work.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	75
Environmental	
Other (various)	25
Other (please specify)	
Available/ unused	

External user access arrangements

Facilities are available for use within projects under University of Strathclyde commercial terms.

Other relevant information

Contact

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Organisation
Strathclyde University

Facility
PANAMA (Plasma Accelerators for Nuclear Applications and Materials Analysis)

Location
University of Strathclyde

Image: Laser wakefield accelerator beamline A2 in Bunker A, SCAPA
© Dept of Physics, University of Strathclyde

Summary of capability/facility

The PANAMA facility, based in the Scottish Centre for the Application of Plasma Accelerators (SCAPA), will provide state-of-the-art characterisation and testing capabilities for nuclear materials from across the nuclear sector, from new build and fuel development and manufacture, to decommissioning, waste management and geological disposal.

Capabilities being developed at PANAMA include:

- X-ray and γ-ray Computed Tomography (X-CT/γ-CT)
- γ-radiography imaging
- X-ray Absorption Spectroscopy (XAS)
- X-ray Diffraction
- Time-resolved diffraction & spectroscopy
- Radiation damage (particle beams, including protons and ^{4}He ions)
- Pump-probe on radiation damage combining particle beams with diffraction/spectroscopy/imaging

Instrument specification

The SCAPA facility uses two state of-the-art Ti:sapphire lasers: a 40 TW (1.4 J, 35 fs; at 10 Hz) and a 350 TW (8.75 J, 25 fs; at 5 Hz) system, to generate:

Radiation pulses:

- High brightness THz and infra-red radiation;
- Partially coherent Betatron (plasma wiggler) radiation in the X-ray to γ-ray (10s of MeV) range;
- Coherent radiation from a free-electron laser (FEL) in the VUV- X-ray (sub-nm) range

Particle beams:

- Monoenergetic electron beams of energy 100 MeV - 4 GeV;
- Proton and light ion beams of energy up to 100 MeV/c

Related instrumentation/capabilities

Nuclear material capabilities (i.e. activity limits)

400MBq α
Please contact the facility for further details.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

External user access arrangements

- Users from UK-based HEIs can apply for funded access through NNUF, until March 2023 (please see www.nnuf.ac.uk/how-gain-access)
- For all other potential users, including from industry, please contact Pieter Bots for further information
- Remote access options are available

Other relevant information

For further information please consult:
https://www.nnuf.ac.uk/panama
https://www.scapa.ac.uk/

Contact

Pieter Bots - pieter.bots@strath.ac.uk

Organisation
Strathclyde University

Facility
SCAPA (Scottish Centre for the Application of Plasma-based Accelerators)

Location
University of Strathclyde (under development)

Summary of capability/facility

The Scottish Centre for the Application of Plasma-based Accelerators (SCAPA) research centre is a major initiative within the Scottish Universities Physics Alliance to use state-of-the-art laser laboratories, laser-driven plasma accelerators and radiation sources to conduct research focused on the development and application of next generation accelerator technology. It comprises 1200 m² of shielded area in three radiation bunkers with space for up to 7 programmable beamlines, laser labs, preparation labs and a control area. After some seed funding from European Space Agency (ESA), SCAPA is currently engaging with the UK community, including major institutions such as National Physical Laboratory (NPL) and Rutherford Appleton Laboratory's Central Laser Facility (RAL's CLF), aiming at bringing the plasma accelerator and space radiation community together. The vision is to establish, in collaboration with ESA and UK Space Agency (UKSA), an advanced, flexible testing environment for the UK and European space radiation testing community at the SCAPA beamlines.

Instrument specification

SCAPA uses high intensity, femtosecond laser pulses as the driver for novel high brightness sources of high energy particle beams (electrons, protons, neutrons and light ions) and radiation pulses (THz, infra-red, X-rays and gamma rays). It consists of ~1200 m² total area comprising shielded areas, laser labs, preparation labs and control area. There are 3 shielded areas for a total of 7 accelerator beam lines and 300 m² total working space (compared to 37 m² for the old Alpha-X shielded area). The SCAPA laser labs are located on top of the shielded areas.

Related instrumentation/capabilities

PANAMA- see other sheet.

Nuclear material capabilities (i.e. activity limits)

A new dedicated active lab, being implemented through PANAMA will also enable safe manipulations of radioactive samples, including subsequent analysis at the PANAMA beamline.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Teaching	
Other (please specify)	
Available/ unused	

External user access arrangements

Facilities are available for use within projects under University of Strathclyde commercial terms.

Other relevant information

Contact

Prof Dino Jaroszynski
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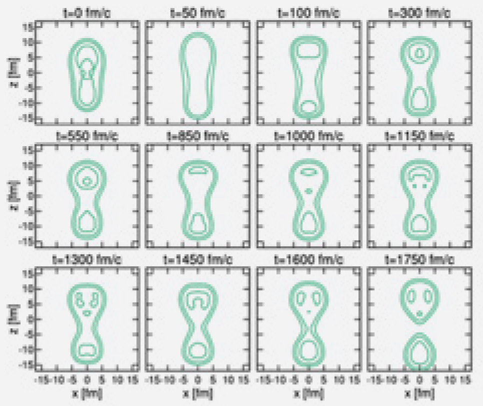
0141 5483057



Organisation
Surrey & York University

Facility
Theoretical methods and codes for nuclear fission

Location
Virtual

Image: This is a sample figure from one of our publication showing the simulation of a fission event.

Summary of capability/facility

The theoretical nuclear physics group at the Universities of Surrey and York are active in research into fundamental questions in nuclear physics, such as the nature of the strong nuclear interaction and how observed properties of nuclei arise from the most basic forces between nucleons.

The expertise of the groups includes, in particular, the development and use of computer codes which calculate properties of fissioning nuclei. Such properties include the pathway taken by the deforming and fissioning nucleus, the yield of different daughter products, their kinetic energies and excitation properties.

The research groups are linked to wider expertise around the world to a community of physicists looking at different aspects of fission in terms of understanding it as a physical phenomenon and part of the natural world.

More details of the abilities and ambitions of the groups can be found in a recent white paper at https://doi.org/10.1088/1361-6471/abab4f

Instrument specification

Our codes work on a variety of computers from single PCs to cluster high performance computing facilities for some of the more computationally intensive calculations.

Related instrumentation/capabilities

Nuclear material capabilities (i.e. activity limits)

Areas instrument used over last 12 months

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	
Basic nuclear physics	100
Available/ unused	

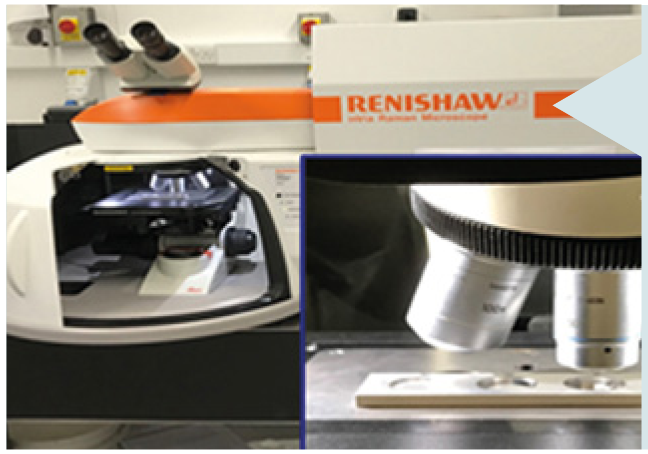
External user access arrangements

We are a group of academic researchers and are interested in discussions leading to potential collaboration or application of our work.

Other relevant information

Contact

Dr Paul D Stevenson
p.stevenson@surrey.ac.uk
01483 686796



Organisation
Surrey University

Facility
Multi-Laser Raman (Renishaw), TRLFS (Edinburgh Instruments), Tandem LIBS/LA-ICPMS (Applied Spectra)

Location
Dept of Chemistry

Summary of capability/facility
Suite of complementary techniques for 'stand-off' structural and compositional characterisation of radioactive and hazardous materials.

Instrument specification
See manufacturers specifications
Raman - InVia Reflex, five laser system
TRLFS - FLS980, continuum & fixed lasers
LIBS/LA-ICPMS - ASIJ200

Related instrumentation/capabilities
Surrey Ion Beam Centre, Physics Radiation Laboratories, New ARIEL radiochemistry laboratory to be constructed 2021.

Nuclear material capabilities (i.e. activity limits)
Currently limited to environmental levels (e.g. natural uranium minerals). New grant awarded (Jan 2021) for radiochemistry laboratory will allow increased scope from 2022.

Areas instrument used over last 12 months

Area	% Usage
Waste Management	50
Advanced Nuclear	
Environmental	10
Other (please specify)	
Available/ unused	40

External user access arrangements
All of above available to academic users subject to permit limitations on samples. Campus access currently suspended owing to Covid.

Other relevant information
Work on radioactive samples ~10% of Raman capacity. New LIBS/LA-ICPMS capability installed but not yet fully commissioned owing to Covid.

Contact
Prof. David Read - d.read@surrey.ac.uk

NANA+ array based at the NPL

Organisation
University of Surrey & National Physical Laboratory

Facility
The Fast TIMing Array (FATIMA) and The National Nuclear Array (NANA+). FATIMA is a 36 LaBr3(Ce) gamma-ray coincidence detection capability which is based on fast-timing scintillation detectors. This is complemented by the NANA (National Nuclear Array) and the NANA+ upgrade, which consists of 20 CeBr3 coincidence gamma-ray scintillation detectors.

Location
FATIMA is based at the University of Surrey, Guildford. The complementary NANA+ is based within the Nuclear Metrology Group at the National Physical Laboratory, Teddington.

Summary of capability/facility
The UK FAst TIMing Array (FATIMA) can be used to determine the lifetime of excited nuclear states down to the picosecond level, and for detailed nuclear spectroscopy of radioactive isotopes produced in nuclear fission. FATIMA is a modular system of up to 36 LaBr3 (Ce) crystals, each with 1.5" diameter and 2" length. In the standard configuration, FATIMA consists of three rings with 12 detectors in each. The scintillators are coupled to fast R9779 photomultiplier tubes. Each detector is equipped with a removable lead shield of 4 mm thickness around the crystal to minimise scattering among neighbouring detectors. The fast-timing capability is achieved by measuring the time difference between two detected rays in a decay cascade and/or the time difference between a gamma-ray in FATIMA, and a decay charge particle (e.g. beta particle) detected by the an ancillary plastic detector.
The array has been designed in a way such that the detector number and size, as well as angular coverage, can be customised according to an experiment.
The detector system have been used in a number of high-profile international nuclear data experimental campaigns at international facilities in recent years. Specific highlights are (1) the NuBALL collaboration studies of neutron induced fission on uranium isotopes at the IJC Lab, Paris (between 2018-2019 and 2022) and (2) the DEcay SPECtroscopy (DESPEC) experimental campaign held at the GSI-FAIR-0 facility in Germany (2020-21).
FATIMA has been used in STFC-funded and UK led nuclear structure physics experiments and also as part of the UKRI, Nuclear Data Network (see https://gtr.ukri.org/projects?ref=ST%2FN00244X%2F1 & http://www.ukndn.ac.uk/).

Instrument specification
FATIMA array consists of 36 LaBr3 cylindrical crystals. The material is B380, i.e. LaBr3(Ce) with 5% Ce doping. The crystals are cylindrical with a diameter of 1.5 inches and a height of 2 inches. As a photomultiplier tube (PMT) the Hamamatsu model H10570 assembly was chosen. The heart of this assembly is the R9779 PMT, featuring eight dynode stages.
The measured response characteristics of the full array in the FATIMA frame are (see https://doi.org/10.1016/j.nima.2020.163967) :
- Gaussian FEP energy resolution of ~3% at 662 keV;
- Full energy peak gamma-ray detection efficiency of 2% at 1408 keV.
- Coincidence timing of <330 ps FWHM using a 60Co source.

NANA+ consists of 20 CeBr3 detectors and is instrumented using CAEN V1751 1 GHz digitisers for both energy and time coincidence information.
NANA+ also included 2 high-resolution HPGe detectors with thin entrance windows for low-energy, coincidence gating is required.

Related instrumentation/capabilities
National Nuclear Array (NANA) capability based at the NPL.
Also significant high-resolution gamma-ray spectrometers (HPGe) both at the University of Surrey and the NPL for environmental radioactivity and nuclear standards measurements.

Nuclear material capabilities (i.e. activity limits)

External user access arrangements
The use of the STFC funded FATIMA detector array and digital electronics is overseen through a UK collaboration board. Requests for access to these detectors either for source mode experiments or for application at in-beam accelerator facilities should be made to Paddy Regan P.Regan@surrey.ac.uk. NANA+ is based at the National Physical Laboratory and can be used for source-based radionuclide standardisation and nuclear decay data measurements with agreement from the Nuclear Metrology Group at NPL. Contact Sean Collins (sean.collins@npl.co.uk) in the first instance.

Predicted area usage over 12 month period

Area	% Usage
Waste Management	
Advanced Nuclear	
Environmental	
Other (please specify)	50% Nuclear Data analysis at GSI-FAIR (2021)
Other (please specify)	50% Nuclear Structure Research at NuBALL2 (Paris) 2022
Available/ unused	NANA+ under final commissioning at NPL.

Other relevant information
Research using these arrays of detectors has led to these recent publications related to nuclear fission spectroscopy and nuclear decay data including.
1) Angular momentum generation in nuclear fission, J.N.Wilson et al., Nature 590, 566–570 (2021). https://doi.org/10.1038/s41586-021-03304-w
2) FATIMA—FAst TIMing Array for DESPEC at FAIR. M.Rudigier et al., Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 969, p.163967 (2020) https://doi.org/10.1016/j.nima.2020.163967

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