UK Atomic Energy Authority

Tritium Fuel Cycle Division

Powering the Future of Fusion

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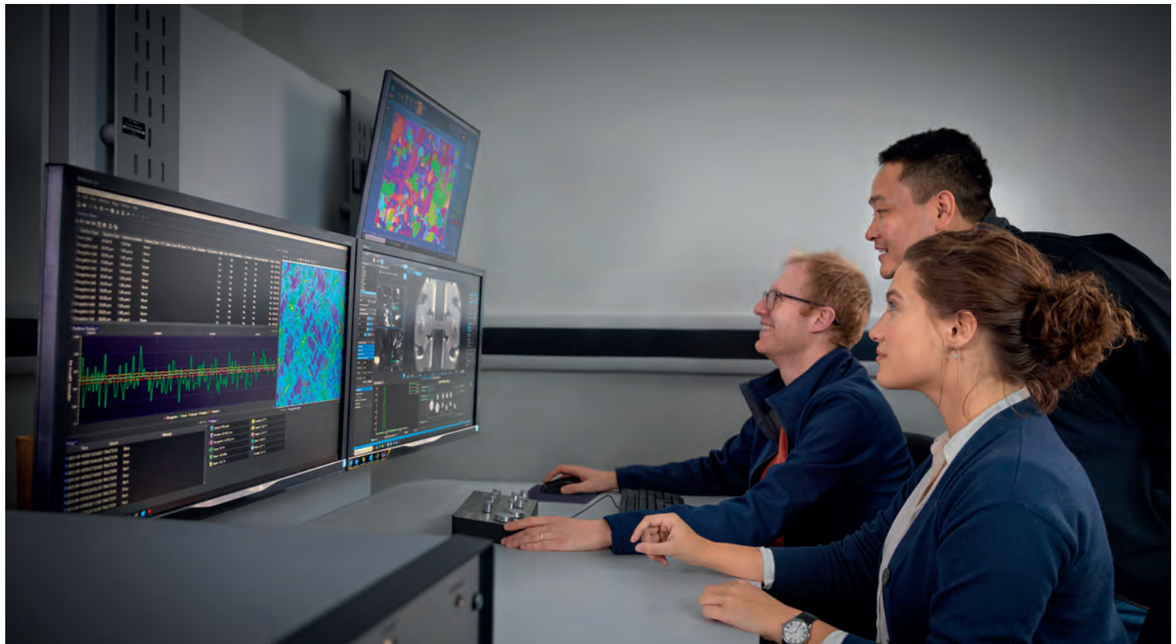
Why Tritium Matters

The Tritium Fuel Cycle (TFC) Division enables UKAEA's mission of delivering sustainable fusion energy. We develop the technology and expertise needed to make commercial fusion a reality.

Fusion is the process that powers the Sun. By recreating it here on Earth, we could generate clean, safe, and virtually limitless energy. Almost all fusion power plant designs rely on tritium as fuel - but it is scarce and requires expert handling.

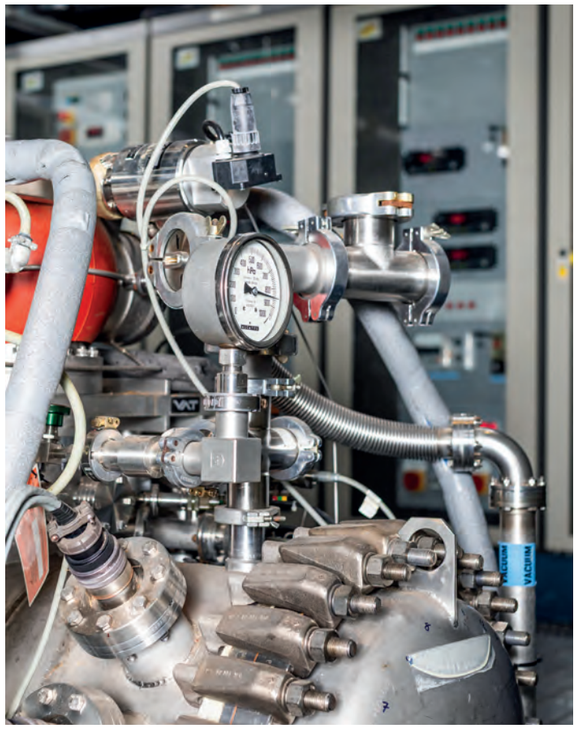
One of fusion's greatest engineering challenges is fuel self-sufficiency: operating the tritium fuel cycle without relying on an external supply. Solving this places TFC at the heart of fusion power plant delivery. Our research develops the technology and processes needed to manage tritium safely and efficiently so that fusion power plants can one day run continuously and cleanly.



Our Priorities

TFC aims to deliver fuel cycle technology for sustainable fusion energy. Our expertise is centred on:

- **Current operations** - Over 30 years of safe real-world tritium handling giving us the expertise and facilities to lead the way in fusion fuel cycle development
- **Delivering facilities** - Critical for demonstrating the closed loop continuous fuel cycles necessary for power plants
- **Tritium research** - Understanding fundamental behaviour and how to build on that to deliver the necessary processes and tools
- **Skilled people** - Building the skilled workforce the fusion sector needs to move from research to commercial operation



Current Operations

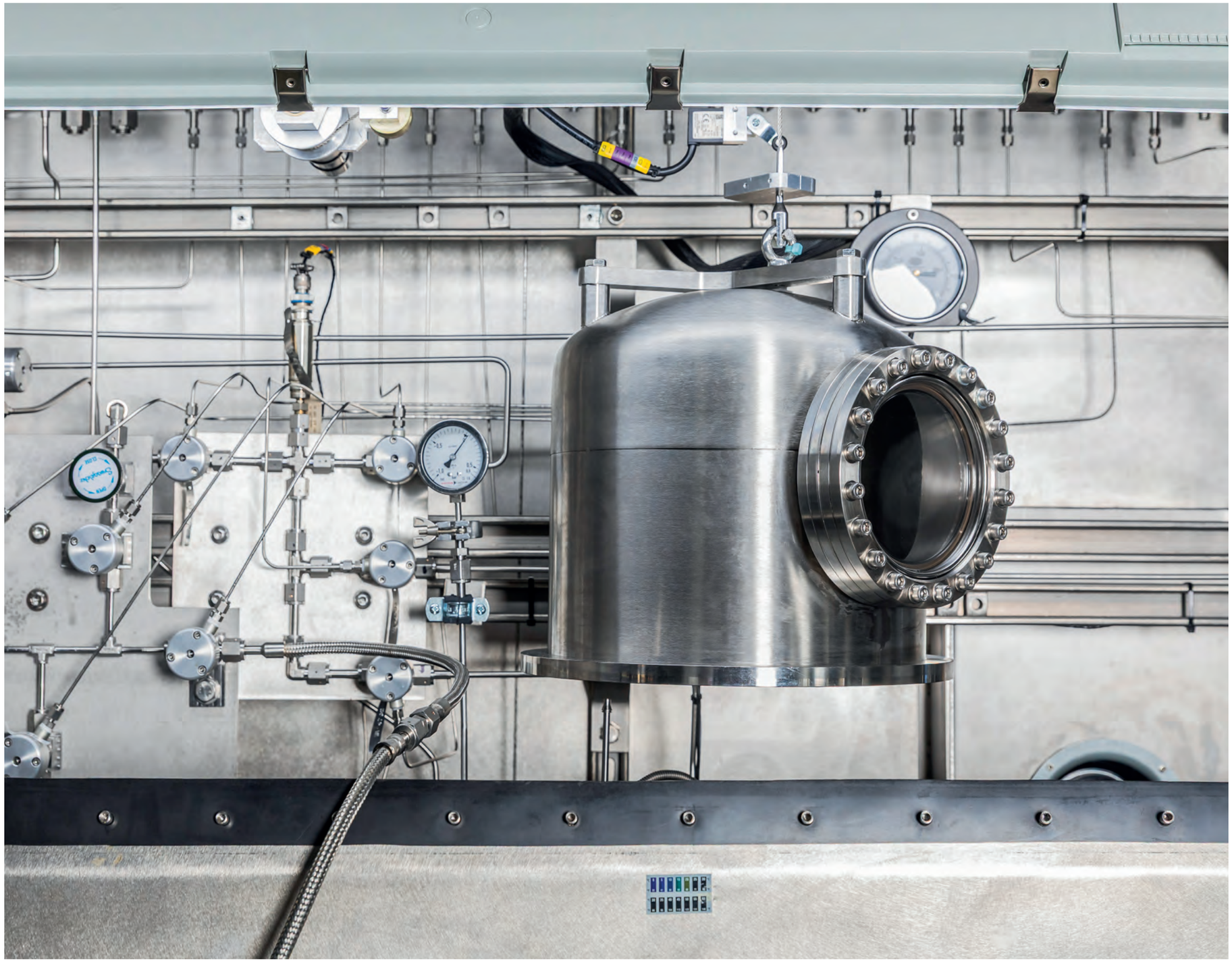
Current Operations

Our specialist facilities at Culham cover the full spectrum of tritium technologies, from tritium analysis and materials testing to waste processing:

- **Beryllium Handling Facility** - Operations include decontaminating items, waste processing, size reduction and maintenance of vessel components and diagnostics
- **Materials Detritiation Facility** - uses thermal treatment to reduce intermediate-level waste to low-level waste
- **Tritium Analysis Laboratory** - Pyrolysis testing of samples informs tritium activity levels, safe handling procedures, and regulatory compliance
- **Plastic Fabrication Workshop** - Makes bespoke containment solutions for use across fusion and adjacent industries
- **Active Gas Handling System** - Ventilating the Joint European Torus (JET) to remove tritium by off-gassing; the system currently contains high levels of tritium from JET's operational history. AGHS also acts as a User Facility, enabling external access to the facility infrastructure
- **Waste processing and storage facilities** - Internal and external waste is received, sorted and either prepared for disposal via approved disposal routes or goes into storage

UKAEA-Eni H3AT Facility

UKAEA and Eni are designing and building the H3AT (Hydrogen-3 Advanced Technology) Facility, a continuous, closed loop tritium fuel cycle providing a platform for the development of fuel cycle technology to meet the operational demands of future fusion power plants. This world-class facility provides industry and academia the opportunity to study how to process, store, and recycle tritium.



Research & Skills

Tritium Research

Our tritium research expertise is recognised globally, and we collaborate with national and international partners to share knowledge and data to accelerate fuel cycle development worldwide. Our research programme draws on — and feeds back into — our facilities and expertise.

Our research covers the full tritium lifecycle — from understanding how tritium interacts with materials, to developing the subsystems and analytics needed to handle it safely and efficiently. We also look at how these elements combine at whole-plant scale, ensuring future power stations can manage their tritium inventory effectively and leave no burden of waste for future generations. Our research programme is focused on the following four themes:

Tritium Interactions with Materials

Understanding how tritium moves through and interacts with different materials, so we can design systems that are safe and efficient. Our current research programme:

- **TDS** (Thermal Desorption Spectrometer) - used to measure outgassing of samples to determine the amount of tritium in them
- **DELPHI** (Device for Exposure to Low-energy Plasma of Hydrogen Isotopes) - plasma-based linear device used to study hydrogen isotope retention in fusion-relevant materials
- **THEIA** - a hydrogen sorption analysis facility that investigates the behaviour of hydrogen isotopes in materials such as zeolites and palladium, operating across a wide range of cryogenic to high temperatures and pressures
- **EUROPA** - a high-temperature tritium permeation setup measuring permeation rates through various materials at temperatures up to 550°C and pressures up to 1 bar(a), while addressing the fusion fuel cycle challenges of containment loss and gas/fluid contamination

Developing Subsystems and Analytical Techniques

We are advancing integrated tritium handling subsystems with robust analytics to ensure that safety, operational and regulatory requirements can be met.

- **THALIA** - testing existing and novel analytical techniques in liquid breeder materials
- **HERA** - real-time tritium gas stream analysis using mass spectrometry and Raman spectroscopy, with capacity for a third instrument

Fuel Cycle Architecture and Modelling

We are using decades of hands-on experience and advanced digital modelling to map how materials and subsystems fit together across the full tritium lifecycle.

- **Virtual Control Room** - a digital twin of the H3AT facility, developed to simulate operations, optimise processes and train the next generation of fusion engineers
- **Tritium Inventory Modelling (TIM)** - multi-physics modelling of tritium lifecycle, with a focus on understanding predicted inventories
- **Palladium Membrane Reactor (PMR)** - tests inactive operational processes within an ITER-relevant design

Visit our website for more examples and information on our operational and experimental facilities.

STEP Programme

TFC's research and facilities directly support UK Fusion Energy's (UKFE) STEP programme, providing the fuel cycle expertise and technology needed to design and deliver the UK's first prototype fusion power plant.

Waste and Decommissioning & Skilled People

Waste and Decommissioning

UKAEA brings decades of operational experience in tritiated waste management, built through some of the world's most significant fusion research programmes. Our work spans the full lifecycle of tritiated materials — from characterisation and safe handling through to treatment, size reduction and disposal — offering genuinely integrated solutions for the fusion sector.

Our approach is guided by three core objectives: reducing waste volume and activity; developing safe, compliant and practical waste handling processes; and ensuring fusion waste does not become a burden on future generations.

Current research is advancing techniques for removing tritium from a range of hard materials (including Inconel, stainless steel, copper, beryllium and tungsten) and soft materials such as PPE and plastics, building the evidence base for cost-effective, compliant waste strategies.

The ongoing decommissioning of JET is providing hands-on experience of dismantling highly activated components in a live environment — one of the most technically complex fusion decommissioning projects in the world. The knowledge developed through this programme is directly transferable to future commercial fusion facilities.

Our facilities include dedicated equipment to support this work:

- **FREYA** - metal melting facility for waste volume reduction, homogenisation and detritiation
- **Low Temperature Permeation Rig (LTPR)** - an experimental rig measuring tritium permeation through materials at near-room temperatures (up to 300°C), generating data to inform packaging and waste storage solutions for long-term tritium containment

Developing Skills for the Future

Fusion's success depends on people as much as technology. That's why we are investing in training and nurturing talent at every level - from apprenticeships to a postgraduate programme and PhD sponsorship for fusion-related research.

Our goal is to build a highly skilled workforce that ensures safe, efficient operations and drives innovation. By developing expertise today, we're securing the capability needed to transition from research to commercialisation tomorrow.

Tritium Learning Opportunities

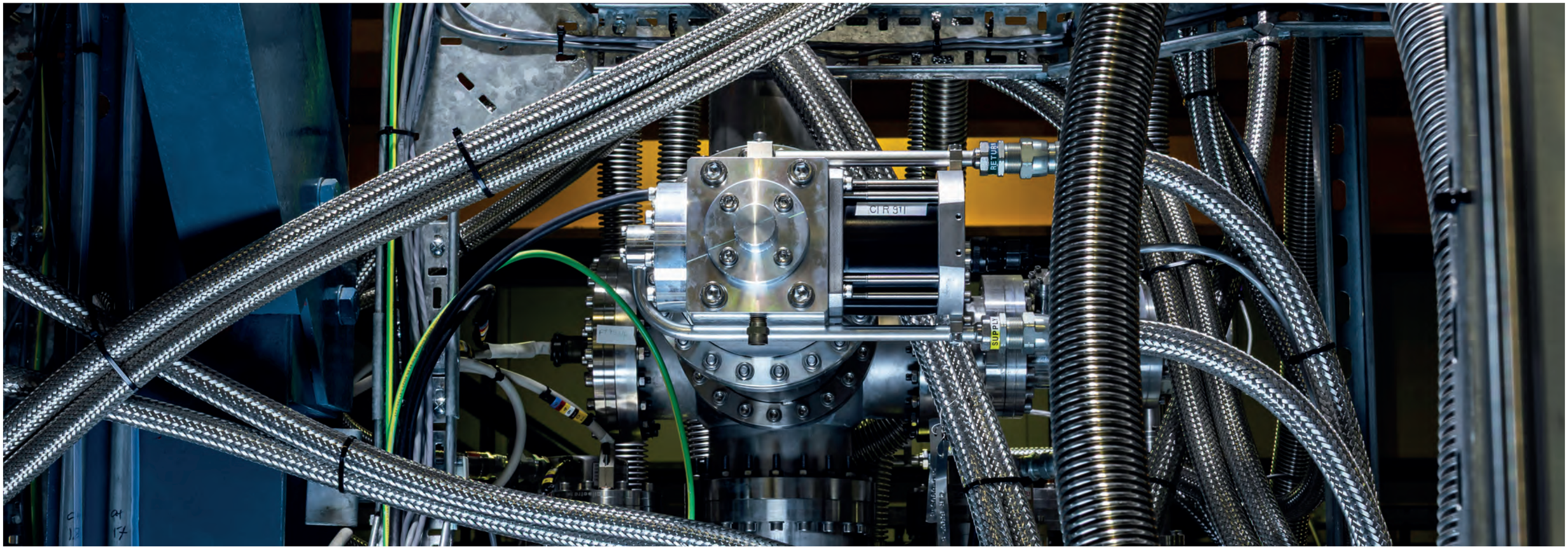
Join our Tritium Training Course to gain the knowledge needed to work confidently with tritium. Whether you are a scientist, engineer or a new starter, our expert team will take you through tritium fundamentals, to future fusion plant concepts and how fuel cycles change.

The course also includes tours of both the Tritium and Waste Treatment Plants.

Applied Tritium Learning Programme

If you have already completed our Tritium Training Course and would like to go further, our Tritium Facilities offer an immersive experience, allowing participants to observe live tritium processing operations in the AGHS.

Key Benefits for Partners

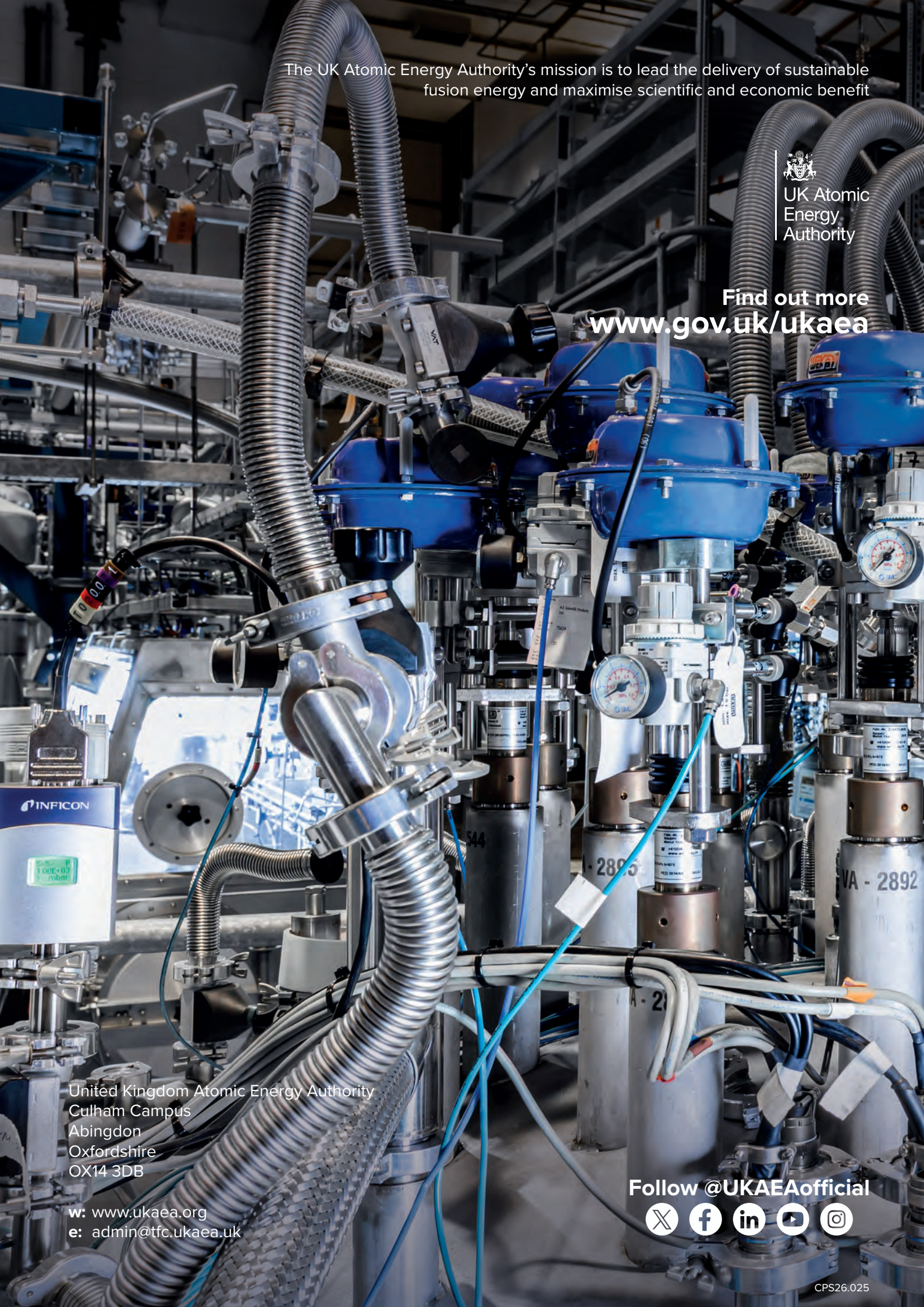


Working with TFC offers access to expertise, infrastructure, and knowledge that cannot be found anywhere else in the world. Whether you are looking to advance your technology, reduce risk, or contribute to the global fusion effort, partnering with us provides:

- Globally unique tritium handling capabilities, from early stage testing through to operational deployment
- Accelerated technology development, de-risked through decades of operational, safety and regulatory experience
- Direct insight from one of the world's most complex fusion decommissioning programmes, with knowledge directly transferable to future facilities
- Access to an internationally connected research network — with established collaborations across Europe, North America, and Asia, and co-authored research opportunities with a globally linked fusion community
- A pathway to commercialising tritium technology, with UKAEA-developed IP available for industry partnership and deployment
- Actively working with UK industry to build tritium fuel cycle capability across the supply chain – helping companies develop the skills and technologies needed to support future fusion power plants
- A trusted partnership environment, focused on shared progress towards sustainable fusion energy

Scan to learn more about the research and capabilities of TFC and for information on the next Tritium Training Course

www.ukaea.org/services/training/#tritium-training-course



The UK Atomic Energy Authority's mission is to lead the delivery of sustainable fusion energy and maximise scientific and economic benefit

UK Atomic Energy Authority

Find out more
www.gov.uk/ukaea

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