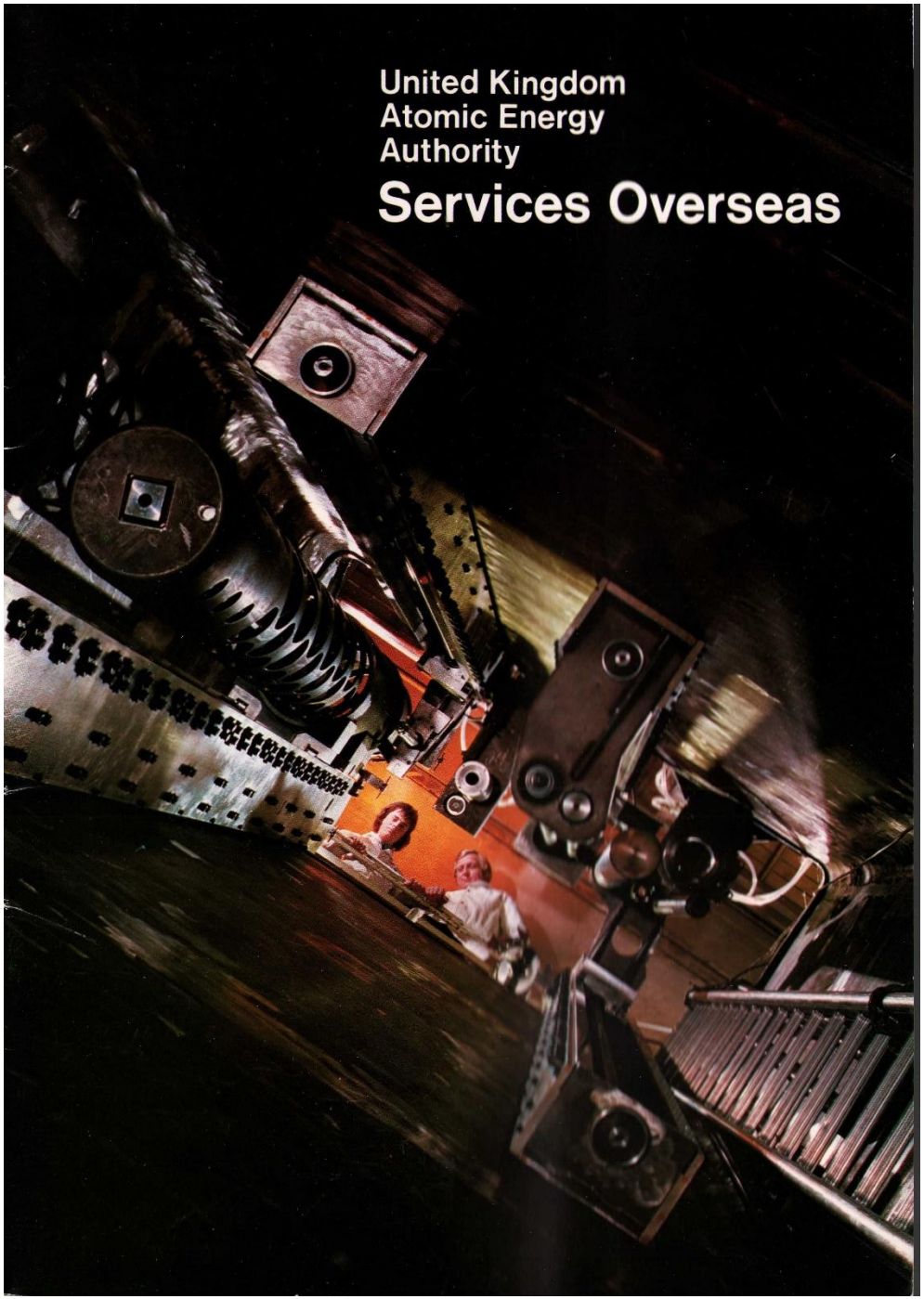

United Kingdom
Atomic Energy
Authority
Services Overseas

Front Cover: Equipment for dismantling fast reactor fuel sub-assemblies in sodium being installed in the post-irradiation examination caves at Dounreay.

The United Kingdom Atomic Energy Authority

Services Overseas

This pamphlet gives a brief description of the services offered by the U K Atomic Energy Authority which might be of interest to overseas organisations engaged in nuclear science and technology. Initial enquiries about the services described should be addressed to the U K Atomic Energy Authority (Overseas Relations Branch), 11 Charles II Street, London SW1Y 4QP (telex 22565 UKATEN London)

The United Kingdom Atomic Energy Authority

The United Kingdom Atomic Energy Authority (UKAEA) is the organisation set up by the British Government under the Atomic Energy Act in 1954 to be responsible for atomic energy research and development in the United Kingdom.

The Authority's principal functions are:

To advise the British Government on all matters relating to the civil applications of atomic energy.

To carry out research and development relating to nuclear reactor systems.

To design, construct and operate prototype reactors and associated fuel cycle plant.

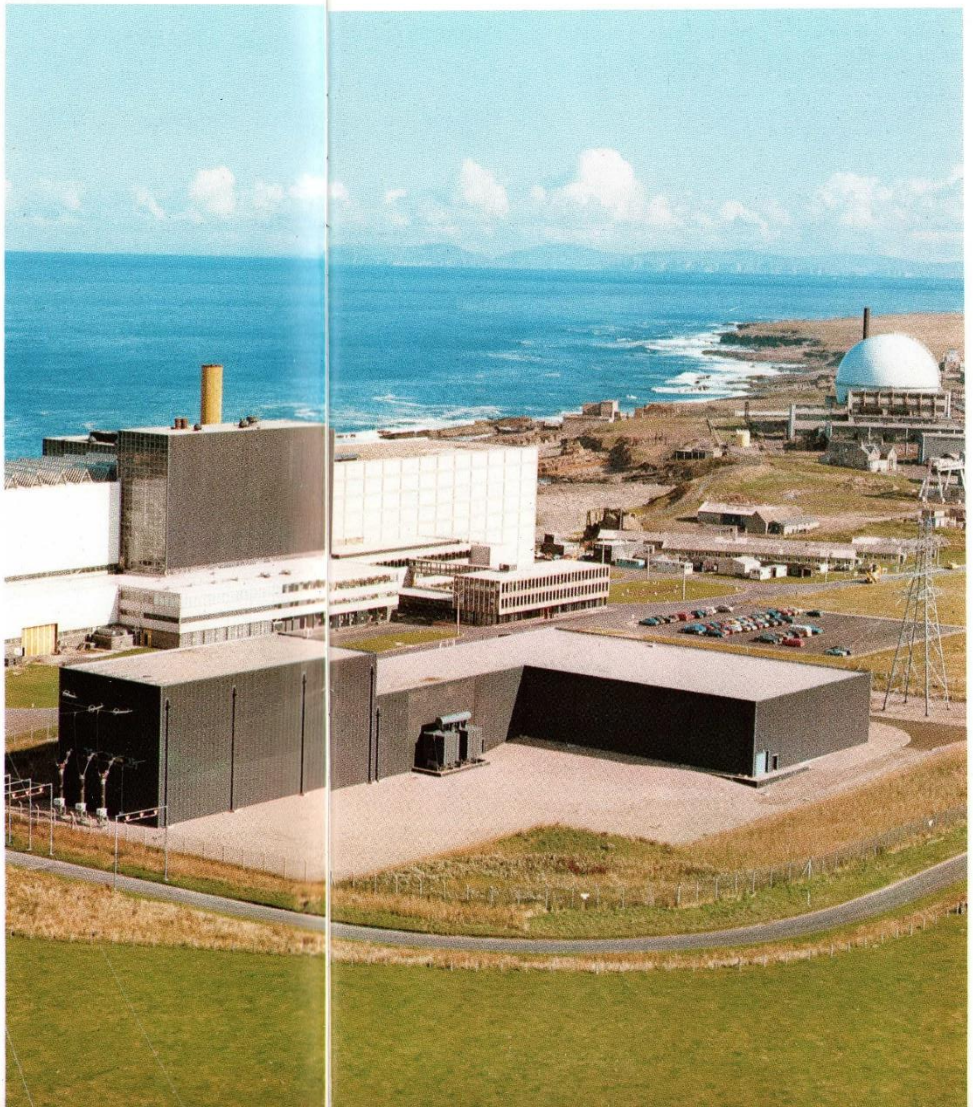
To carry out underlying research relating to atomic energy.

To undertake research into nuclear safety, waste management and associated environmental questions.

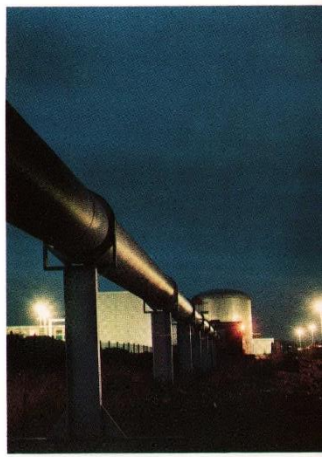
The UKAEA carries out work extending the application of nuclear techniques to the problems of other industries. This work aims at the exploitation of expertise and resources developed for the nuclear power programme, the exploration of new applications of nuclear techniques, and the development of applications with potential or industrial benefit. Most of this work is carried out for clients on a repayment basis or on the basis of shared costs and profits, mainly through licensing agreements.

Since 1965, the UKAEA has been authorised to undertake research and development into projects outside the nuclear field. As a result it is now engaged in such activities as chemical engineering, marine technology, computer systems design and computer applications.

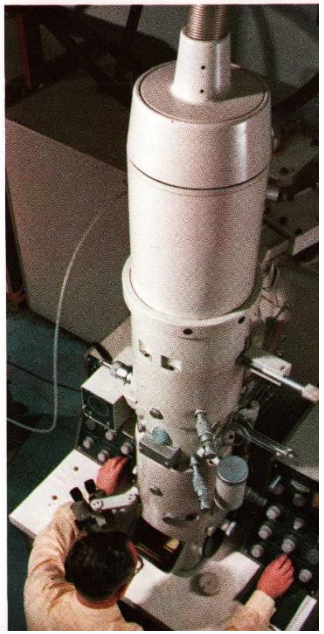
The UKAEA occupies a central position in the British nuclear industry. It is also one of the world's leading nuclear research and development organisations with more than 20 years' experience of nuclear energy. This publication outlines the services offered by the UKAEA on commercial terms.



Aerial view of the Prototype Fast Reactor. On the right is the Dounreay Fast Reactor, which operated from 1959-1977.



The ZEBRA zero energy fast reactor, Winfrith, showing the 200-metre flight tube used for neutron spectrum measurements.



A 200 kV transmission electron microscope at Springfields Nuclear Power Development Laboratories used to study the crystal structure of metals and ceramics for nuclear fuels.

UKAEA Establishments And Laboratories

An aerial view of AERE, Harwell, with (foreground) the TANDEM electrostatic generator.

London Headquarters

The UKAEA Headquarters is responsible for co-ordinating policy decisions and for the Authority's relations with Government departments and other organisations in the UK and abroad. Certain of the Authority's financial, commercial and administrative services are centred here.

The Northern Division

The Authority's Northern Division develops nuclear reactor systems to the prototype stage. The Division provides, on commercial terms, services and assistance in nuclear power development to the nuclear industry in the UK and throughout the world.

The Northern Division consists of:

The Dounreay Nuclear Power Development Establishment, Caithness, Scotland
The principal centre for fast reactor development and the site of the 250 MW Prototype Fast Reactor.

The Risley Nuclear Power Development Establishment, Cheshire
Adminstrative headquarters of the Division, incorporating the Engineering Directorate, Technical Services and Planning Directorate and Central Computer Services.

The Windscale Nuclear Power Development Laboratories, Cumbria
The Windscale laboratories are concerned with the development of plutonium fuels for fast reactors; development work on advanced gas-cooled reactors centred on the Windscale prototype AGR; and the post-irradiation examination of all types of reactor fuels.

The Risley Nuclear Power Development Laboratories, Cheshire
Sited next to the Northern Division Headquarters, the Risley laboratories deal with all stages of reactor component development. The laboratories also incorporate the National Centre of Tribology.

The Springfields Nuclear Power Development Laboratories, Lancashire
Springfields' major function is the development of fuels and fuel element components for thermal and fast nuclear reactors.

Harwell Atomic Energy Research Establishment

The UKAEA's largest research laboratory, Harwell directs about half its effort to problems of reactor development and nuclear power generally, with particular reference to materials research; this is supported by a related programme of underlying research. The rest of the laboratory's effort is divided between work in areas not necessarily related to nuclear energy. A wide range of R & D services, both nuclear and non-nuclear, is provided to industry and public bodies throughout the world.

Culham Laboratory, Oxfordshire

Culham is responsible for research into nuclear fusion and related plasma physics. The fusion research is part of a collaborative programme with other fusion laboratories within the European Economic Community. The Laboratory also designs and supplies specialised equipment for industry and public authorities. Culham has been selected as the site for the new European Communities Tokamak experiment — JET.

Winfrith Atomic Energy Establishment

Winfrith's activities cover the development and assessment of both thermal and fast reactor systems including the important areas of reactor physics, heat transfer and fluid dynamics, reactor safety, reactor control and nucleonic instrumentation. There are extensive experimental facilities for the study of reactor core performance including reactor kinetics, safety and operations. Winfrith is the site of the prototype Steam Generating Heavy Water Reactor.

The Safety and Reliability Directorate, Culcheth
The Directorate, which is jointly managed by the Authority and the UK Health and Safety Executive, is responsible for developing technology to establish the safety and reliability of nuclear and other industrial plants and processes. Advice and services are provided to Government departments, other organisations and industry both in the UK and overseas.

Help With Planning And Developing a Nuclear Power Programme

Planning
A country formulating a nuclear power programme has to decide on:

Assessments to determine when increased capacity is likely to be required.

The integration of nuclear power stations into the existing electricity generating system.

Siting of stations.

A reactor system and supplier.

Safety and regulatory measures.

Fuel cycle requirements.

Programmes of research and development, and of staff training.

Arrangements for the management of wastes.

The UKAEA provide a comprehensive consultancy service on all these aspects of nuclear power.

Data can be presented in a form suitable for use by governments and top management in decision-making.

Computer programs already developed can be used to speed the assessment work, or new programs can be prepared.

Design and Installation of Nuclear Laboratories
A consultancy service is provided for the design, construction and equipment of specialist nuclear laboratories and training centres. It includes advice on the selection and use of:

Nuclear reactors for research, training or radioisotope production.

Associated 'hot' laboratories.

Laboratories for carrying out other work involving radioactive materials.

Particle accelerators.

Advice and assistance in the selection and training of staff and the planning and supervision of programmes of work is also available.

The UKAEA have already helped with the setting up of nuclear centres in Europe (East and West), the Middle and Near East and the Far East.

Safety and Reliability Assessments
Independent safety assessment of proposed nuclear plant is vital to the planning and development of national nuclear power programmes. The Safety and Reliability Directorate (SRD) has become a recognised authority on such assessments.

In addition to expertise in a wide variety of reactor systems and reprocessing plant, the Directorate includes the Systems Reliability Service (SRS). In conjunction with its large and growing data bank, SRS can offer a service for reliability assessment of a wide range of industrial plants.

Consultancy advice is also available from the UKAEA on

International standards for safety and radiological protection.

Quality assurance codes.

Regulations for transport of nuclear materials, both internally and across international boundries.

Setting up national nuclear safety organisations.

The ICL 2980 computer at Risley Nuclear Power Development Establishment.

Test Facilities Available

Removal of a test vessel before a containment modelling experiment at the Reactor Safety Test Compound at AEE, Winfrith.

One of three test channels of the Steam and Water Environmental Test Loop at Springfields. The loop is used for full scale studies on fuel assemblies

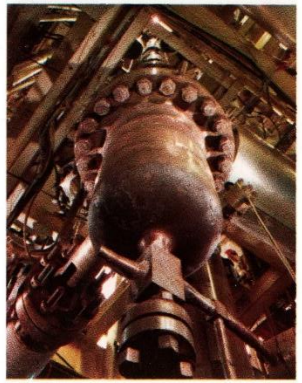
A test section, simulating a helical coil from a boiler, at the Winfrith Heat Transfer Laboratory.

Zero-Energy Reactors — Core evaluation
Zero energy reactor facilities include:

DIMPLE
Used to study the physics of reactor systems moderated by light or heavy water. It allows the use of plutonium-bearing fuels. Core structures can range from large pressure-tube systems to small close-packed systems.

JUNO
A dual purpose assembly used either to study and test a wide range of liquid moderated lattices, or as an exponential system driven by external neutron sources to study pressure-tube type cores.

NESTOR
An annular core structure immersed in water, with graphite filling the centre of the annulus and surrounding it externally. NESTOR provides a source of neutrons for several subcritical assemblies and reactor shielding experiments.



Steam and Water Test Rigs — Component evaluation, including fuel elements
A number of large test rigs simulating LWR conditions are used for testing experimental fuels and components and for thermodynamic tests covering fluid flow, vibration and heat transfer. They include:

6 MW Rig
Provides data on flow resistance, heat transfer and dryout over a wide range of temperature, pressure, flow and heat generation appropriate to both BWRs and PWRs. The tests can provide information on the effect of support grid design and the behaviour of fuel clusters under transient conditions. This rig has been used by a number of overseas customers to test full size models of improved PWR fuel element designs.

SWEL (Steam and Water Environment Loop)
Used to study vibration of plant components in pressurised or boiling water reactors; to measure consequential fretting corrosion and wear; and to investigate pressure drops. The conditions of temperature, pressure, flow and steam content are appropriate to both BWRs and PWRs for the testing of fuel clusters.

SPEL (Springfields Pressurised Water Endurance Test Loop)
Used to study vibration of plant components, and the pressure drops they cause, in flowing pressurised water at elevated temperatures. Conditions include those appropriate for testing PWR fuel clusters.

HTFS rigs
The Heat Transfer and Fluid Flow Service and chemical engineering rigs and loops provide facilities for single or two-phase work on heat exchangers and components, and for studies on convective heat transfer, vibration, corrosion etc. The largest loop has a heat input of 3 MW.

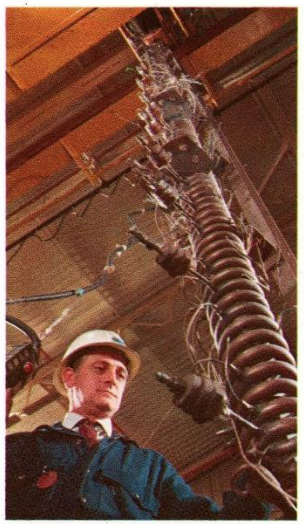
Irradiation Testing in the SGHWR
The Steam-Generating Heavy Water Reactor, a 100 MW power-producing reactor, also provides major facilities for irradiation experiments.

It operates on an annual refuelling scheme, with one shutdown in the Spring.

This schedule, together with individual channel access, extensive instrumentation and the capacity to accommodate full length fuel clusters operating at realistic ratings, make the facility of particular appeal to developers and manufacturers of water reactor fuel.

Associated Technology

Coolant Technology
The UKAEA's operation of power reactors and large rigs for over 20 years has provided a large and continuously growing experience of reactor coolant technology for gas-cooled, water-cooled and sodium-cooled reactors and has led to the establishment of proven design principles for reactor components, and systems for control of coolant composition. Supporting technologies include materials and corrosion sciences and water chemistry.



Reactor Instrumentation
Development of instruments covers radiation measuring and monitoring instruments, nucleonic instruments for power reactors and instruments to measure conventional quantities — temperature, pressure, flow, strain, etc., in the environment of the core and primary circuit of reactors and in chemical plants.

Reactor Equipment Design
Special reactor rigs or loops can be designed, constructed and installed to meet clients' requirements, on new or existing reactors in any part of the world. An example is the large SARA safety test loop now under construction in the UK for the ESSOR reactor at Ispra

Fast Reactor Services
Fast reactors can extract fifty to sixty times more energy from uranium than thermal reactors, thereby promising large-scale savings in uranium consumption.

They are characterised by high concentrations of fissile material in the fuel, the use of plutonium, high neutron flux and high heat rating.

Much experimental work is required to confirm the predictions of theoretical studies and to put materials and components to practical tests.

The UKAEA have nearly 20 years' experience in fast reactor operation and are particularly well equipped to provide experimental facilities, scientific assistance and advice. Special attention is paid to safety questions associated with fast reactors.

Fast Reactor Test Rigs
Test rigs, built to support the development of the Prototype Fast Reactor (PFR) and designs of large (1300 MW(e)) commercial fast reactors, are available for experimental work.

They include the recently commissioned High Temperature Sodium Loop and the Sodium Component Test Rig at Risley, capable of testing full-sized fuel elements and components.

Many of them are designed for continuous operation for long term endurance tests.

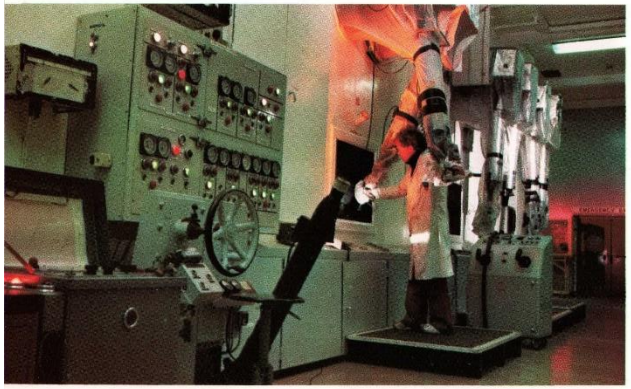
Rig instrumentation covers pressure, temperature, flow and vibration.

X-ray equipment control area at the post-irradiation examination caves at Dounreay.

Handling DFR flasks above the post-irradiation examination caves at Dounreay.

Fuel loading and unloading flask of the PLUTO reactor at Harwell, used for studying the effect of irradiation on fuels and components and for producing radioisotopes.

A Sodium Component Test Rig at Risley used for testing components in sodium at temperatures up to 650° C.



Prototype Fast Reactor (PFR) — Irradiation testing
The 250 MW(e) PFR provides a major facility for carrying out full-scale irradiation experiments.

Special demountable sub-assembly facilities allow for the removal of experiments for non-destructive examination, and their return to the reactor for further irradiation.

Services offered cover design of irradiation rigs (where necessary) and comprehensive post-irradiation examinations and assessments of results.

Sodium Coolant Technology and Instrumentation
In fast reactors it is necessary to maintain impurity levels in the sodium coolant below a few parts per million.

Extensive experience has been accumulated in the purification and instrumentation of sodium, and of its properties in respect of compatibility, thermal performance, flow characteristics and radiation effects.

Rigs include provision for continuous sodium purification, and a small-scale distillation plant is also available to provide encapsulated high purity sodium. A special sodium/water leak rig is available for investigation of sodium/water circuitry problems.

Instrumentation has been developed for measuring the flow, temperature, pressure and level of sodium, and for the detection and measurement of impurities.

Materials Testing and Research Reactors — Fuels, materials and components testing

DIDO and PLUTO
These are 26 MW high-flux research reactors used for accelerated studies of the effects of prolonged in-service irradiation of fuels, cladding, coolant and structural materials, and for research involving neutron diffraction or scattering.

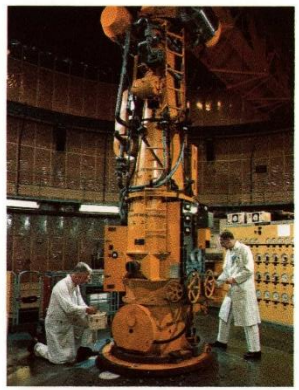
The effects of irradiation, such as creep, swelling, corrosion, water coolant chemistry, etc., can be studied under predetermined conditions. Services available include the design and installation of special equipment, the preparation, irradiation and post-irradiation examination of specimens, and other scientific analysis of experimental results.

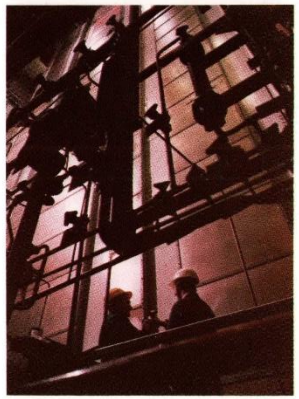
Particle Accelerators
The UKAEA operate a range of charged-ion and electron accelerators which, used in association with materials testing and research reactors, provides a comprehensive irradiation testing service and research facility.

In addition to nuclear power application these facilities can be used for accelerated studies of void formation in fast reactor steels and of the radiolytic decomposition of reactor coolants, and the measurement of nuclear data.

Very high dose rates can be achieved which can simulate in days, or even hours, the effects of many years of fast neutron irradiation.

Comparatively little radioactivity is induced in the specimens.





Post Irradiation Examination
A comprehensive post-irradiation examination service for standard LWR and experimental fuel assemblies is offered to nuclear organisations throughout the world; work has been carried out for customers in Europe, USA and Japan.

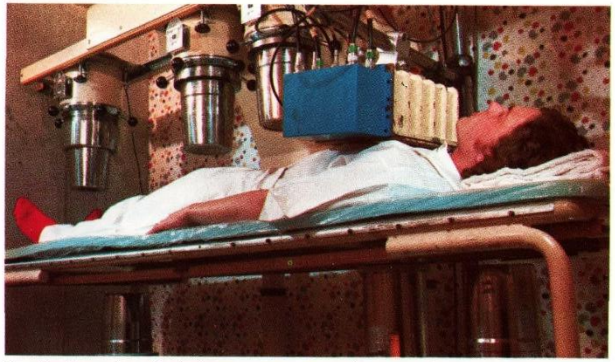
Facilities available include highly developed suites of shielded 'caves' and cells fully equipped for undertaking detailed examination of irradiated specimens of fuels and materials. Precision sampling and testing techniques allow detailed examination of selected areas of specimens right down to the sub-millimetre size range.

Specimens tested may range from complete fast or thermal reactor fuel clusters or other components to small test specimens of fuel or other reactor materials, or single coated-fuel particles.

Transport of radioactive test specimens to and from the UK can be arranged on behalf of clients and suitable transport containers can be provided on loan.

Thermophysical Property Measurements
The UKAEA's laboratories offer a service on measuring thermophysical properties, e.g. specific heat, thermal conductivity, thermal diffusivity and thermal expansion.

Advice On Health And Environmental Questions



Whole body monitor, for estimation of radioactive materials in the lung, in use at the Radiological Protection and Safety Division, AEE, Winfrith.

Radioactive Handling and Transport Equipment
The UKAEA's experience in radioactive handling and transport equipment covers all types of work with radioactive materials, from laboratory scale to full commercial operations. The fields in which assistance and advice can be provided include:

Development of techniques and equipment for radiochemistry and radiation laboratories.

Design and procurement of remote handling, shielding and viewing equipment.

Design and procurement of transport containers and their testing to international safety requirements (including fire and drop tests).

Arrangements for transport of irradiated fuel, etc., locally and across international frontiers.

Design of protective clothing.

Design of decontamination systems and equipment.

Design and procurement of radiation and monitoring instruments.

Radioactive Waste Management
Radioactive wastes range from contaminated scrap and low level liquid effluent to high-level fission product wastes and long-lived actinides. Expert knowledge is required to deal with their management, storage and disposal.

Expertise accumulated over many years can be made available to clients on a consultancy basis.

Practical services include:

Assessment and forecasting of waste problems.

Design of equipment for the storage and transport of active wastes.

Research and development on special techniques for their concentration, fixation and disposal.

Design of protective clothing, decontamination equipment, monitoring systems, etc.

Supervision of international disposal operations, including sea disposal of low-activity wastes.

Radiological Environment Surveys
In assessing the environmental impact of a nuclear installation it is essential to have reliable information on the radiation levels prevailing in the area both before and after operations begin.

Experienced survey teams are available on a contract basis to carry out surveys of existing radiation levels, followed if necessary by repeat surveys to monitor any change in radiation levels resulting from plant operations.

Ad hoc measurements or surveys can be made in respect of releases (or suspected releases) of radioactive materials.

Decommissioning Nuclear Plant
When a reactor or other major nuclear plant has to be decommissioned, the presence of residual radioactivity inevitably imposes special difficulties and dangers.

The UKAEA have accumulated a large fund of theoretical and practical experience in this important field:

Several reactors have already been successfully decommissioned.

A fuel reprocessing plant has been decommissioned, decontaminated and reconstructed for use with advanced fuels.

This experience can be made available to other organisations on a consultancy basis.

Other Technical Services For The Nuclear Industry And Utilities

A waterproof scintillation detector for tracer measurement in use during a coastal pollution study.

Reactor Plant Inspection
Pressure vessels in industrial plants require periodical inspection to ensure their continuing safety. In nuclear plants such inspections have to be carried out remotely because of high levels of radiation.

The UKAEA operate a Reactor Plant Inspection Service to carry out final pre-service and in-service reactor inspections of PWR pressure vessels in the UK or overseas to meet the requirements of the ASME XI code.

The wide experience available in non-destructive testing and in various aspects of pressure vessel technology provides valuable background support to the Service.

Fracture mechanics
Increasing use is being made of fracture mechanics to assess the significance of defects in structures and pressurised components.

Facilities are available for all forms of fracture toughness testing, from laboratory tests to wide plate and crack arrest tests and tests on model vessels.

Acoustic emission techniques are available for application to any of the tests, to characterise emission behaviour of materials or to locate defects in plates and vessels.

Tracer Studies of Material Movements
Detailed knowledge of the movements of water, water-borne wastes and industrial process materials is of vital importance in planning, commissioning and operating nuclear plant. Tracer techniques are useful in providing quantitative data in these fields.

The UKAEA can provide experienced teams to investigate materials movements of almost any kind.

Major nuclear applications fall into the following groups:

Planning and Site Investigations
River-flow measurements, to assess cooling water resources and the capacity for accepting discharges of radioactive or chemical wastes or of waste heat.

Assessment of local underground water resources.

Investigations of connections among underground and surface water-courses that could be important in respect of effluent discharges.

Evaluation of disposal sites for dredged spoil, civil engineering wastes and plant effluents discharged to rivers, estuaries or the sea, or to landfill tips.

Commissioning and Operation of Plant
accurate measurements of water flow, for example in pumps, turbines and pumped-storage hydro-electric schemes.

calibration of flow-measurement equipment against primary standards.

in situ measurements of bulk flow, residence times, mixing efficiency, recycling, carry-over, ventilation rates, etc., under normal or fault conditions.

investigation of leaks, losses and malfunctions.

At Springfields, fuel element cladding materials are tested by simulating changes which occur in reactor operation. This 10-ton machine applies a programmed stress cycle.

The Risley National Centre of Tribology offers a complete consultancy service. In the picture, the operator is 'listening' to the performance of self-lubricating rolling element bearings.

ROMAN — the Remotely Operated Mobile Manipulator developed at Harwell for the Reactor Development Laboratory, Windscale — shown monitoring a radioactive materials container.

Non-Destructive Testing
Non-destructive testing (NDT) — testing an object or material for integrity or fitness for purpose without damaging it in the process — has a vital role to play in nuclear energy.

The UKAEA, through the national NDT Centre at Harwell and the Quality Assurance Service, provide a range of services, including:

Consultancy on engineering quality control and plant reliability, with advice on the choice of test methods and schedules, and on the assessment of results.

On-site investigations of reactor vessels and pipework, chemical plant, machinery, building structures, biological shielding, etc.

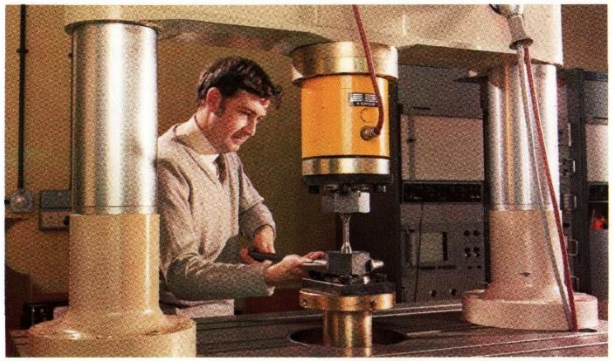
Examination of materials and manufactured parts such as fuel elements, including irradiated fuel elements, which may be sent to the UK for examination.

Design and installation of integrated systems for product quality control, based on modular electronic units assembled to meet the client's requirements.

All established NDT techniques are employed and the Centre maintains a leading position in the development of new methods.

A large computerised data store and an information service are maintained and an NDT manual, including an international directory of goods and services, is published periodically.

Training courses are held at all levels, and include courses specially designed to meet clients' individual requirements.



Tribology
Tribology is the science and technology of friction, lubrication and wear. Tribological studies aim to ensure that the right materials are used in the right places to produce long life, low wear and acceptable levels of friction.

Tribology is especially important in the design of nuclear engineering components which may have to withstand hostile environments for extended periods with little or no maintenance.

The National Centre of Tribology at Risley is operated by the UKAEA and carries out:

Consultancy on all aspects of nuclear tribology, including design and selection of materials.

Research and development.

Testing services based on a comprehensive range of standard and specially designed apparatus for nuclear environments.

Design and construction of special friction and wear test equipment to meet customers' requirements.

Chemical Analysis and Related Services
The nuclear industry faces a very wide range of analytical problems requiring the use of a correspondingly wide spectrum of analytical methods and equipment, much of which has had to be specially developed.

The services of skilled personnel and specialist equipment can be made available to clients in the following major fields:

Nuclear Fuels and Related Materials (prior to irradiation)
Complete analysis and characterisations (including isotopic content) of oxide, carbide and metallic fuels containing uranium and/or plutonium.

Analysis of Zircaloy and other fuel cladding materials, stainless steels and their constituents, structural materials, coolant fluids, etc.

Determination of fissile materials content and distribution in fuel specimens.

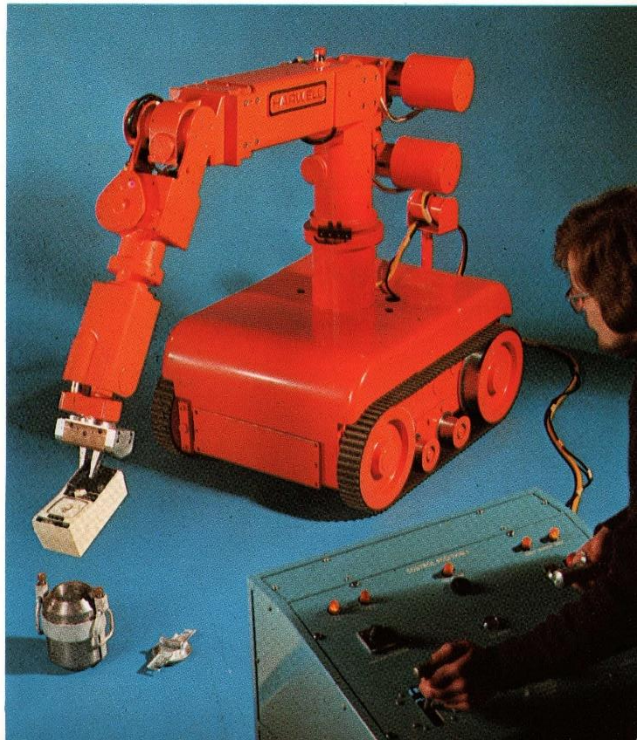
Accurate measurements of oxygen-to-metal ratios in oxide fuels.

Irradiated materials (see also Post-irradiation examination)
Examination of nuclear fuels and other reactor materials after irradiation, to determine their chemical characteristics and the changes due to irradiation.

Determination of the build-up and distribution in the fuel of fission products, plutonium and other actinides, and other products of irradiation.

Analysis of fission products and actinides, etc., in fuel and processing plant solutions, and in wastes and effluents.

For clients wishing to undertake their own analyses, the UKAEA can advise on techniques and equipment including the design of computer-linked systems and of complete laboratories, and on the training of staff.



Special Manufacturing Developments
The production of specialised nuclear components for the UKAEA's own R & D programme calls for the ability to handle a range of unusual materials and manufacturing techniques.

The UKAEA have been directly concerned with many new developments in this field, and are well equipped to advise on the choice of materials and preparatory methods, on component design and on inspection and test criteria. In addition, laboratory and workshop facilities can be made available to meet clients' experimental requirements and to manufacture one-off components needed in R & D work.

The areas covered include unusual materials, production techniques, jointing and surface-coating techniques, production and process evaluation, and special products such as fuel element claddings, spacer grids, thermocouples and sheaths.

Instruments and Instrumentation Systems
Accurate and reliable instrumentation is vital to the development and application of nuclear energy, and to this end the UKAEA have developed a very wide range of instruments, together with the means of handling and using the data that they provide. These include:

Personal radiation dosimeters and associated read-out systems.

Portable health physics monitoring equipment for routine and emergency surveys of radiation and contamination.

Installed equipment for continuous monitoring of radiation levels in working areas, including high radiation alarm systems.

Installed sensing and measuring devices used in the routine operation of nuclear reactors, chemical plant, etc., together with associated data-handling, display and control systems.

Special instrumentation developed for use in association with experimental rigs in nuclear reactors.

Instruments which use nuclear and allied radiations to gain information about non-nuclear systems, e.g. industrial thickness and depth gauges, analytical and mineral-prospecting instruments, etc.

Instrumentation systems in which a range of standardised electronic modules can be linked together in any desired combination.

The UKAEA offer consultancy services and contract R & D on these and other aspects of instrumentation and control, in the nuclear and many other fields.

The UKAEA also offer a service in the design and supply of prototype nuclear instruments to meet the specific requirements of customers.

HTR Technology
The UKAEA offer consultancy services on all aspects of HTR design and undertake contract R & D in this technical field. The UKAEA can also make available information relating to certain materials and processes relevant to HTRs.

Help With The Design And Procurement Of Equipment For Fusion Research

Laboratories carrying out research in plasma physics or controlled thermonuclear fusion, or wishing to use large electrical pulses in association with high magnetic fields, pulsed lasers, etc., may find difficulty in designing and obtaining the specialised equipment that they need.

In such cases the UKAEA's fusion and plasma physics research laboratory at Culham may be able to help by undertaking the specification, design, construction and commissioning, and procurement of such specialised items of equipment as:

Generators, transformers, capacitor banks and switch-gear for handling very large current, high voltage pulses.

Magnetic windings (including superconducting magnets).

Vacuum systems.

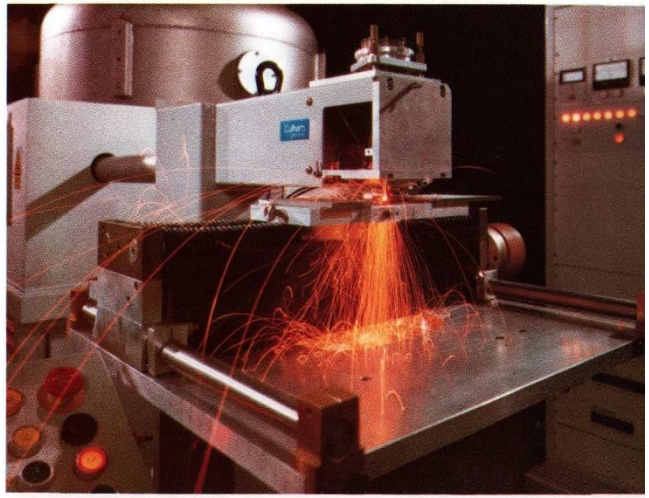
Ion sources and injectors.

Pulsed and continuous wave (CW) lasers.

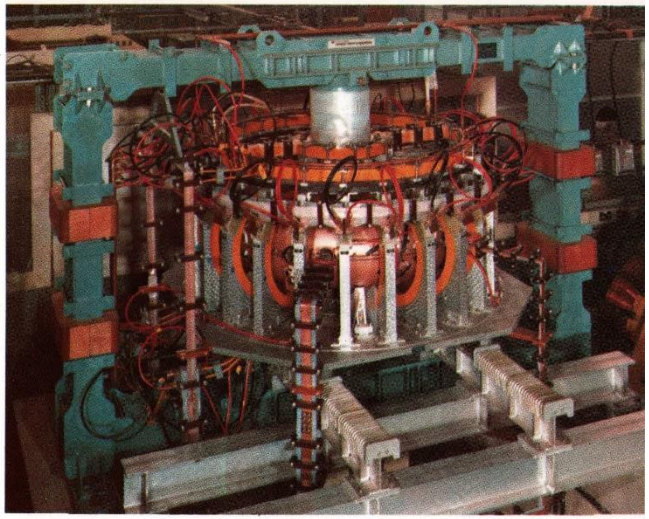
Control and diagnostic instrumentation.

Data-processing systems.

Contracts can be arranged to cover any or all stages of the design, procurement and commissioning of experimental installations based on Tokamak or other magnetic confinement systems, complete with power supplies, control systems and diagnostic instrumentation, etc. The Laboratory works in conjunction with the appropriate industrial concerns.



A 5-kilowatt carbon dioxide laser, CL5, in use at Culham Laboratory (photo courtesy of Ferranti Ltd.)



The THOR tokamak machine developed at Culham for the University of Milan.

Training Services

A young Malaysian vacation student is given guidance on laboratory techniques by a Harwell materials scientist.

The existence of sufficient trained scientists, engineers and technicians is one of the first essentials in setting up and running a nuclear power programme. To help meet the needs of the UK and overseas countries, the UKAEA provide specialised training facilities and maintain close links with universities and other learned institutions.

Training is offered over a wide range of skills, from technician and technical supervisor level to graduate professional engineers and scientists. Courses can often be tailored to suit specific requirements. Emphasis is laid on practical needs and the lecturers are practising scientists and engineers drawn from within and outside the UKAEA.

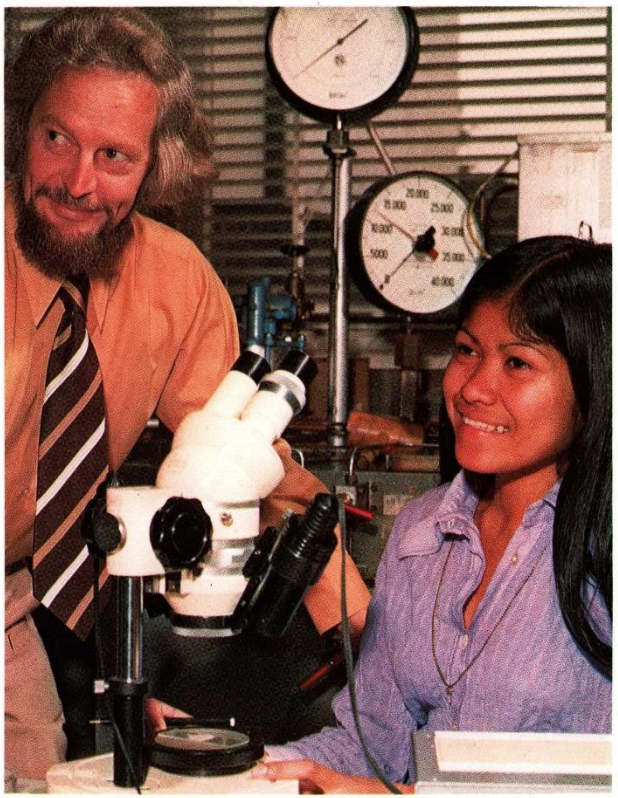
The UKAEA's training centres, all of which are equipped with advanced technical aids, include:

Harwell Education Centre:
Standard courses are held on many different topics, including reactor safety, radiological protection, computing, mathematics, radioisotopes, etc.; and in related specialised fields such as instrumentation, materials science and vacuum technology.

Fast Reactor Training Centre, Dounreay:
The Centre provides training courses in fast reactor technology, also covering essential related techniques and general background information. Specific topics include liquid metal handling, and the maintenance, design safety, siting and economics of fast reactors.

Plasma Physics Summer School, Culham Laboratory:
The annual Summer School provides an introductory course at post-graduate level on the basic physics of natural and laboratory plasmas and on their modern developments and applications, including nuclear fusion research.

Winfrith Training Centre
The Centre provides courses on general reactor technology and water reactor technology and more specific courses covering computing, waste management, heat transfer, reactor physics and a range of management courses for supervisor and professional grades.



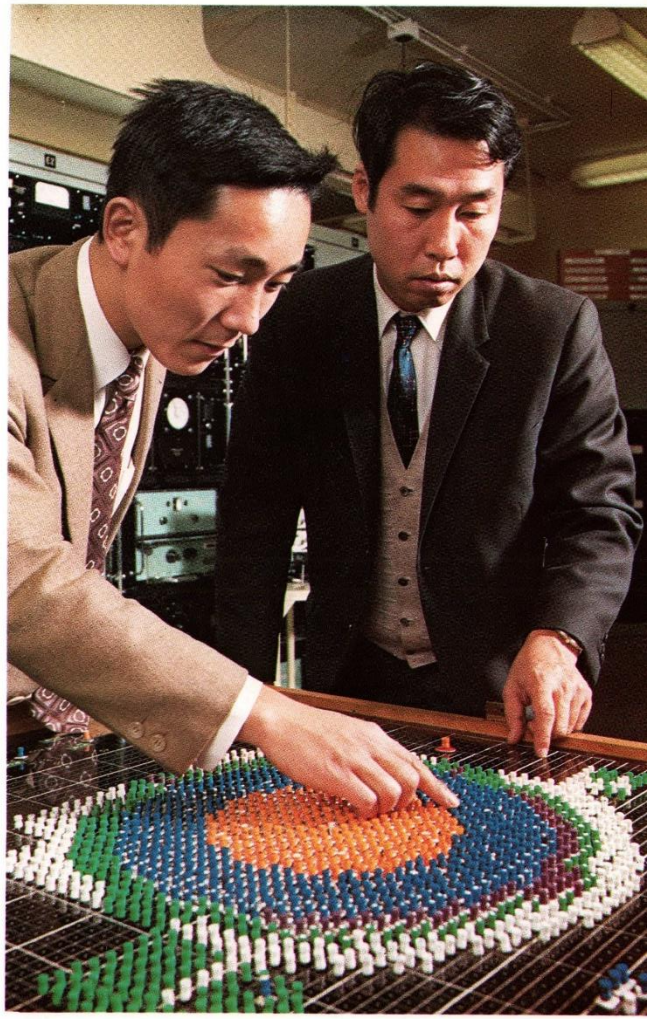
Physicists from Japan who worked at Winfrith in a joint Anglo-Japanese study of reactor physics design data for commercial fast reactors.

Specialist training
Training for specialists in particular aspects of nuclear technology is provided in courses on, for example, systems reliability.

Arrangements can be negotiated for advanced training (which may be in association with a University) of scientists, engineers and technologists to appropriate post-graduate standards.

Consideration may be given to the attachment of specialist personnel for 'on the job' training at appropriate establishments in the UK

Overseas training centres
The UKAEA can also provide a consultancy service relating to the setting up of nuclear training centres in overseas countries.



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