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Just another source of neutrons?

The removal of the Jason reactor at Greenwich

The University of Greenwich have just celebrated the opening of the restored King William Building, a Grade 1 listed building at the old Royal Naval College which has been converted into modern teaching facilities. The Navy had previously used the building for teaching of a rather different kind – it housed a nuclear training reactor. Richard Lockwood and Phil Beeley describe the safe dismantling of a nuclear reactor.

Introduction

'Jason' was a low-power nuclear reactor used to educate and train military and civilian personnel involved in the naval nuclear submarine propulsion programme. It was situated in a reactor hall within King William Building, a Grade 1 listed building within the Old Royal Naval College at Greenwich, which itself is a Scheduled Ancient Monument having World Heritage Site status.

The reactor was first taken critical at the College in November 1962, having been previously operated by the Hawker Siddley Nuclear Power Corporation at Langley from February 1959. The decision to decommission Jason was taken in 1996, following the ministerial decision that the Royal Naval College would pass to non-defence use by the Millennium.

The Ministry of Defence (Navy) removed the Jason reactor between 1996 and late 1999. This was the first time that the MoD(N) had completely decommissioned a shore-based reactor and subsequently handed over the site for civilian occupancy and unrestricted future use. The College now forms part of the University of Greenwich and the King William Building houses lecture theatres and teaching rooms.

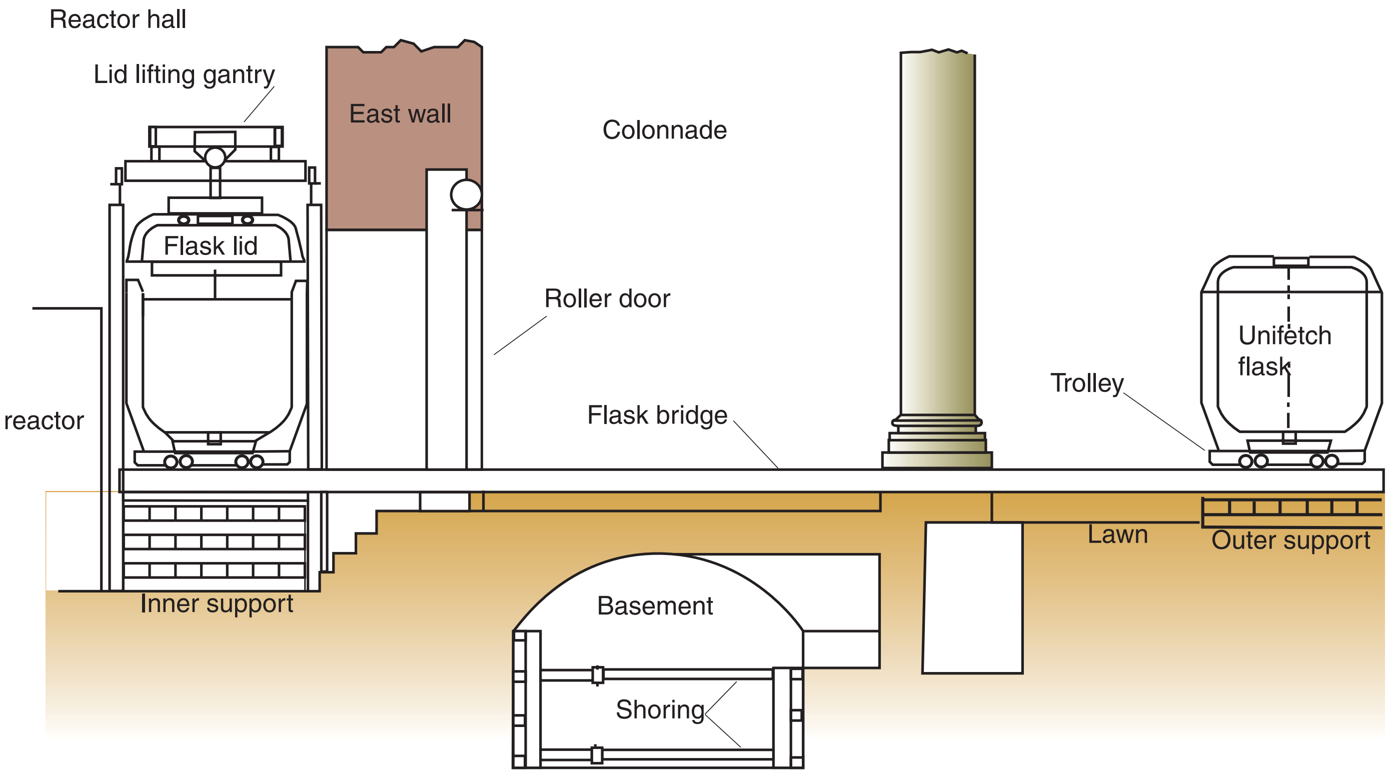
The King William Building during its time as home to the Jason reactor

Decommissioning programme

Following the final reactor shut-down, the decommissioning programme began with the setting up of the management, safety and project teams, obtaining the various heritage and planning approvals for the works and gaining regulatory approval of the nuclear safety cases.

The first physical stage in the programme, called Post-Operational Clear Out, involved disabling the reactor and removing particular operational equipment and was completed by June 1998. The rest of the programme consisted of fuel removal, reactor dismantling, waste removal, site survey and clean up and the final radiological clearance of the site by the Environment Agency, which was achieved on 4 November 1999.

Three civilian contracting firms were appointed to project-manage the overall decommissioning project and programme, the fuel removal phase and the reactor dismantling and waste removal phase.



Route of the fuel transfer flask into the reactor hall

The UKAEA Unifetch fuel transfer flask

Fuel removal

Fuel had not been transferred from the College for about 25 years and fell outside the scope of the operational safety documentation. The overall fuel removal phase consisted of several interrelated off-site and on-site preparatory activities, including the procurement, preparation and modification of a UKAEA-owned 'Unifetch' fuel transfer flask. Modifications were made off-site to interface the flask to the existing fuel removal transfer equipment held at the College. Extensive trials were also carried out using a dummy fuel module to test the modified fuel handling equipment.

The other major off-site activities included the design, manufacture, test and installation of a range of custom-made and proprietary equipment needed to install the Unifetch flask in the reactor hall, transfer the Jason reactor fuel modules, remove the flask and subsequently transport it by road to BNFL, Sellafield. This involved building and commissioning a large steel flask-transfer bridge and a flask lid-removal gantry, which were both proof-load and functionally tested off-site before being dismantled, reassembled and subsequently re-tested on site.

Initial on-site activities included carrying out extensive radiological surveys and the installation of additional decommissioning health physics facilities. A new reactor hall supply-and-extract ventilation system was also fitted, which included a mobile filtration unit, new ducting and fire dampers, filters, monitors and air samplers.

To protect the underground historical artefacts and fabric of the listed buildings, the on-site preparatory works had to be carefully managed. A series of metal interlocking ground protection mats were installed on Upper Grand Square, adjacent to King William Building, to receive the Unifetch flask, lifting crane and removal lorry. The basement areas under the reactor hall were strengthened by a series of wooden braces and shores and the transfer bridge was positioned on railway sleepers in order to clear the historic colonnades and balustrades. Once installed, the transfer bridge was proof-load tested to ensure that the necessary clearances were maintained.

After this equipment had been installed and tested, non-active Unifetch flask commissioning trials were carried out. The internal fuel transfer route was then proven using a dummy fuel element, witnessed as required by the MoD(N) regulator and the Jason Reactor Safety Committee. Final approvals were obtained by 11 September 1998. The fuel was then transferred into the Unifetch over a two-day period and it was subsequently transported by road to BNFL, Sellafield, on 16 September 1998.

Reactor dismantling and waste removal

The next phase of the decommissioning programme consisted of extensive modifications to the internal ground floor of King William Building and the installation and commissioning of reactor dismantling, waste handling, storage, transfer and removal equipment. A large purpose-built clear area was created to process, monitor and package the waste, connected to the adjacent reactor hall through a contained and tented buffer store.

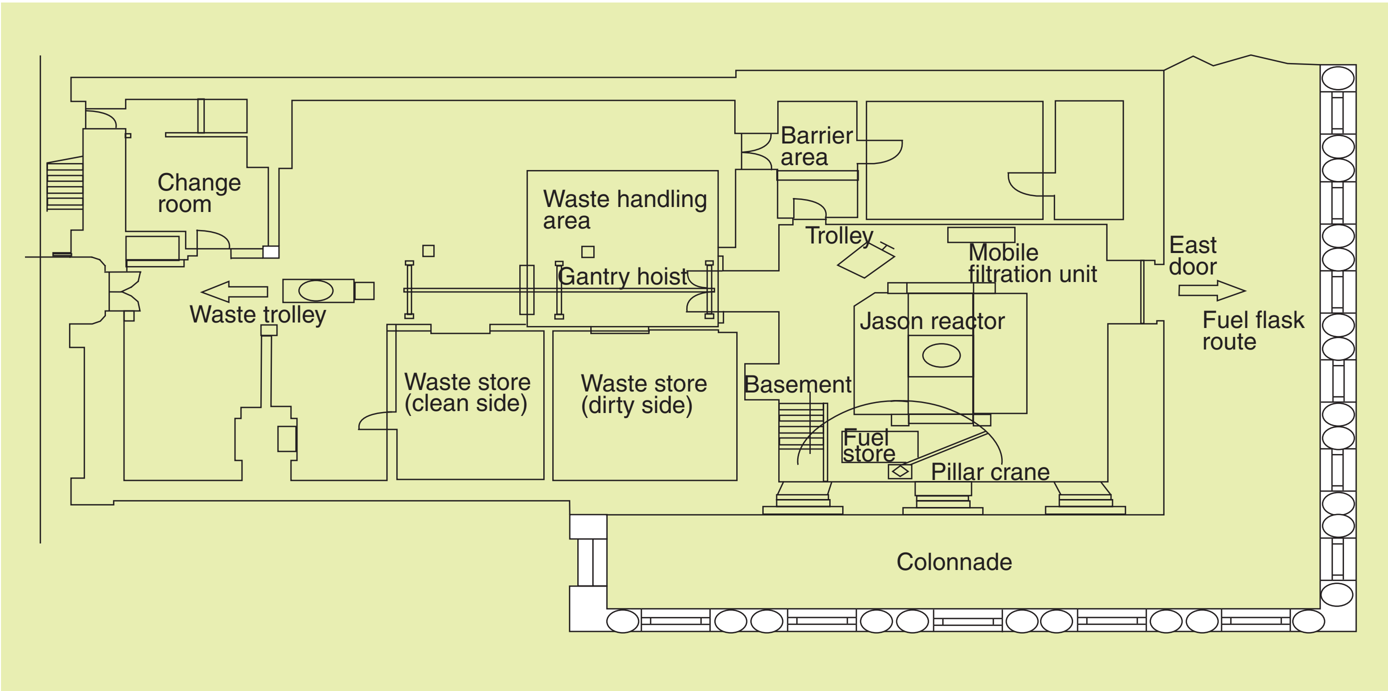
A new overhead gantry and crane was installed to transfer sealed waste from the buffer store out into the general waste storage areas. The sealed and packaged waste and containers were internally transferred through the building by a hand-operated motorised waste transfer trolley running on a purpose-built steel plate transfer route to protect the ground floor of King William Building.

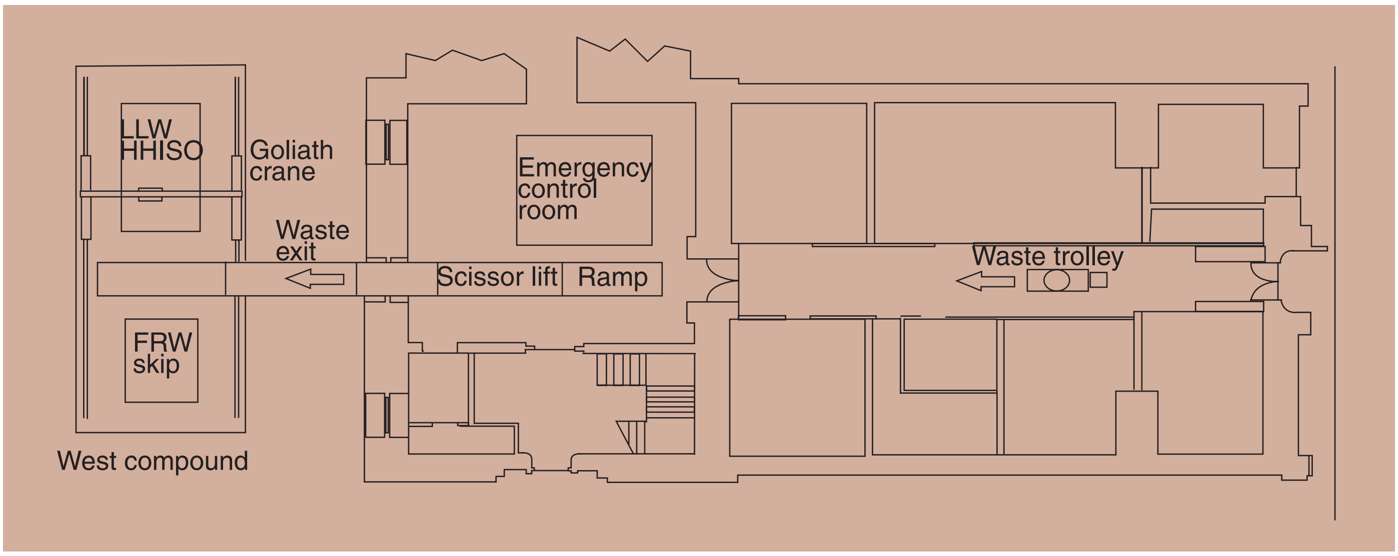
The waste trolley was then raised on a steel ramp and scissor lift from ground level to window height, and transferred out of a window on a steel transfer bridge, which connected with a purpose-built concrete hard standing outside King William Building.

The hard standing provided a level base for positioning standard nuclear waste freight containers and free release waste skips. A gantry and Goliath crane were erected on rails that ran alongside the hard standing; these were used to lift the waste from the trolley and place it in the appropriate waste container. A rail-mounted mobile cover was used to cover all containers as required.

Within the reactor hall two new decommissioning radiation monitoring and alarm systems, new lighting systems, manual fire alarms and fire detection systems were fitted. All drains in the reactor hall and basement areas down which inadvertent discharges of effluent could be made were identified and sealed off. Ventilated containment tents were erected for dismantling activities that could generate airborne contamination.

Access to the inner core areas was gained by removing sequential layers of fixed concrete shield blocks, which were disposed of as free-release or low-level waste as appropriate. Certain internal reactor components, such as the control rods and drive mechanisms and in-core instrumentation systems, were removed and transferred by special courier to the national storage





Route of waste material leaving the reactor hall

Waste trolley being transferred out of a window

facility at Harwell as intermediate-level waste. Most other peripheral fittings (such as the water purification systems and primary pipework) were removed and disposed of as low-level or free-release waste as appropriate.

A large ventilated containment tent was erected over the core area and the in-core graphite blocks and wedges, graphite thermal column, inner and outer reactor tanks and bedplates were removed. Each item removed was monitored, processed and categorised in the buffer store; it was then recorded and stored in the waste storage areas until disposal as free- or low-level waste. An extensive core sampling campaign was then undertaken to determine the extent of activation and contamination of the concrete floor under and adjacent to the removed reactor structures. A free-release waste profile boundary was established and all concrete, rubble and soil was removed to beyond this boundary, leaving a hemispherical hole in the centre of the reactor hall of about 2 m in depth and radius. Following excavation, further check samples were taken and all walls, ceilings, and surfaces were thoroughly decontaminated, cleaned and monitored to meet the free-release criteria.

In total 110 tonnes of free release waste were removed from the reactor hall and surrounding areas during the decommissioning project, mainly consisting of concrete shield blocks and various outer reactor support structures. 160 tonnes of low-level waste was also created, consisting mostly of internal reactor components and activated and contaminated concrete. A very small amount of intermediate-level waste was also produced, consisting of items such as the control rods and neutron detectors.

Waste containers outside the King William building

Radiological clearance

The Jason reactor was not a Licensed Site under the Nuclear Installations Act. It was regulated by the MoD(N) Naval Nuclear Regulatory Panel and also inspected by the Nuclear Installations Inspectorate (under the Ionising Radiations Regulations). The Environment Agency had the final say over the radiological clearance of the site for future unrestricted use.

Prior to decommissioning, protocols were agreed with the Environment Agency covering the conduct of the radiological survey and clearance criteria for both the Jason reactor and all other buildings on the College site. The final Independent Radiological Survey was carried out by the National Radiological Protection Board.

The radiological clearance criteria were very comprehensive and required the removal of all identified contamination resulting from Jason reactor operations. The criteria also required that the levels of artificial contamination remaining in the environment following removal of the reactor would not on average exceed the 'Substances of Low-Level Exemption Order' of 0.4 Bq/g. Any residual levels of external radiation had to be comparable to the natural background environmental measurements from other parts of Greenwich and shown to be equivalent, taking into account local natural variation.

The radiological clearance criteria for the other buildings on the College site required that no loose contamination would remain on the surfaces or in the

Work in progress in the containment tent erected over the core area

drains and that the levels of fixed alpha contamination would not exceed 0.04 Bq/cm^2. They also required that the levels of fixed beta or gamma contamination would not exceed 0.4 Bq/cm^2 and, similarly, that any residual levels of external radiation would not exceed the natural background environmental measurements from other parts of Greenwich.

Following clean up and initial surveys by the decommissioning contractors, the final Independent Radiological Survey was carried out in October 1999. It indicated that the College and reactor site met the necessary radiological release criteria. The radioactive waste approvals were revoked by the Environment Agency on 4 November 1999.

The authors standing in an ancient chimney-shaped structure found under the reactor. Soot deposits are still visible on the inner brick facings.

Handover

The final act in the history of Jason was the approval of the Post-Decommissioning Report, the last safety report produced during any decommissioning project. This report included all necessary details about the final status of the reactor site, dose statistics, compliance with the necessary safety principles and criteria, lessons learnt and confirmation that the whole site met the Environment Agency's radiological free-release criteria.

The report was accepted by the MoD(N) regulator on 1 December 1999. King William Building was fully handed over to the Greenwich Foundation on 9 December and the last MoD(N) employee left the site on 17 December. At the time of handover it was anticipated that the old reactor hall was to be completely refurbished and subsequently used as a lecture theatre by the University of Greenwich.

Conclusion

King William Building and the reactor hall were handed over for future unrestricted use by the Millennium, as had been originally required. The contractual costs of the decommissioning project came in under budget at approximately £6.5 million, compared to the original 1996 forecast of £7.857 million.

The decommissioning and handing over of the Jason reactor at Greenwich to time, cost and quality represented a major milestone in the naval nuclear propulsion programme, particularly as it had been used to educate and train most of the senior military and civilian personnel involved since 1962. Whilst Jason had served the nuclear submarine service well over the years and was not just another source of neutrons, its time had come.

Immediately following decommissioning, live reactor training was carried out at the Imperial College Consort reactor at Ascot. More recently an increased use of simulators and an enhanced use of other laboratory facilities has ensured that the education and training of military and civilian personnel in the naval nuclear propulsion programme has been maintained at the highest level at the Royal Navy's School of Marine and Air Engineering at HMS Sultan, Gosport, Hampshire. ■

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