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A HISTORY OF BUILDING D8550

THE DOUNREAY PLUTONIUM CRITICALITY LABORATORY

SUMMARY

D8550 was the first building at Dounreay to handle kilogram quantities of plutonium bearing materials and it was, by a substantial margin, the first such building to be taken out of operational use.

It was built in the expectation that it would be needed to carry out a major programme of criticality experiments on plutonium-bearing materials lasting at least 10 years (45). In the event, criticality work at Dounreay was terminated before D8550 had been fully commissioned (i.e.: by September 1963).

Although it was then required to be retained as a criticality laboratory on a 'six month availability basis' for almost a further four years, it has been available for full decommissioning since 1967. In fact, an effective programme of decommissioning was not initiated until twenty years later, in 1987.

By 1994 most of the building (though not the test cell) was reported to have been decommissioned "effectively to stage 2" and it is now under care and maintenance in this condition (43).

This paper traces in some detail the history of both the operational and decommissioning phases of D8550's 40-year life.

INTRODUCTION

Construction of an experimental criticality laboratory at Dounreay began early in 1956. It was not part of the original 'site plan' that there should be such a facility on the site, or indeed elsewhere in the UK, and it owes its existence largely to the passing in the USA of the McMahon Act in 1946. This Act virtually destroyed Anglo-American collaboration in nuclear energy, with the result that very little of the vast amount of experimental data on the critical parameters of uranium – and to a lesser extent of plutonium – systems obtained in the US from about 1945 was available in the UK.

This meant that, to ensure the 'criticality safety' of the large-scale production plants for nuclear materials being built in the UK, their designers had since 1948 been almost entirely dependent on calculated estimates of the safe dimensions of process vessels, pipework, storage arrays, etc. They were required to steer a tortuous path between making the plants reasonably efficient and economic and 'safe beyond all possibility of error' - and they had to do this in the knowledge that, in all too many respects, there could be unrecognised uncertainties in their estimates that could be a cause of disaster. It became increasingly apparent during the early 1950s that some more direct confirmation of the safety of these plants must be obtained, as far as possible before they became fully operational.

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Some experimental criticality data had been obtained from the US prior to 1947 and this was augmented by the considerable body of information produced in the Aldermaston criticality laboratory from 1952. But these measurements were almost exclusively on unmoderated (metal) assemblies, with data on plutonium systems being particularly sparse.

Much more relevant to plant criticality problems were experiments which had been started at Harwell in 1952 using the zero energy thermal reactor (ZETR), built primarily for studies in support of the UK's homogeneous aqueous reactor project. By 1955 these experiments had yielded valuable data on the critical conditions of some U_{233} , U_{235} and plutonium solution systems. However, it was all too apparent that the limitations on the scope, accuracy and rate of obtaining results imposed by the Harwell equipment and its location made this ploy quite inadequate for conducting plant safety studies on the scale deemed to be necessary. An Atomic Energy Executive (AEX) decision, made in 1954, to set up a laboratory at Dounreay devoted specifically to this new objective followed from this.

EARLY HISTORY : 1956-60

Since no provision for a criticality laboratory had been made in the basic Dounreay plans it was positioned on the unallocated space at the north-east end of the site, on the east side of the intended eastern perimeter road.

Initially, the laboratory consisted of a single test cell housing one critical assembly rig operated, when criticality measurements were being made, from a remote control room at the edge of an exclusion area of 90 m radius.

Construction of this facility began, to a very tight programme, in February 1956 and the buildings were handed over, ready for equipment installation, by June of that year. The cell, with its adjacent fuel preparation room, became active for the first time in September 1956, when installation began of the (contaminated) ZETR vessels and pipework transferred from Harwell. After a number of sub-critical runs on this rig, criticality was reached for the first time on 13 August 1957, this being the first occasion on which a nuclear chain reaction had been achieved anywhere in Scotland.

This first cell, in building D1249, was intended solely for work with uranium bearing materials and it was, in fact, used almost exclusively for measuring the criticality of U_{235} solutions. It had no installed ventilation system and was uncontained and, whilst it had concrete shielding walls of 45 cm thickness on the three landward sides, its fourth wall and roof were of light construction. Thus, it was quite unsuitable for plutonium criticality studies.

It quickly became apparent, from the early work in cell 1, that criticality data could be obtained rapidly and quite economically by experimental means. This, together with the increasing urgency of acquiring such data and the realisation that – despite much publicised indications to the contrary – American sources were unlikely to furnish it in the degree of detail required by our plant designers, led to the decision in 1968 to construct two further cells for studies on uranium systems and to begin design work on a fourth cell in which plutonium critical assemblies could be safely operated.

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Construction of the plutonium facility, building D8550, started in January 1959 and parts of the building were made available to the operators for commissioning trials on some equipment in July 1960. The whole building, including the containment cell, was completed by March 1961 at a cost of about £500k (1960 prices).

DESCRIPTION

The D8550 building and its facilities

The design, which drew heavily on experience acquired, and still being acquired, in the operation of the three existing cells at Dounreay and that at AWRE, was undertaken by the experimental reactor design office at Risley. Benefit was also derived from liaison, supported by interchange visits, with the designers and future operators of a plutonium criticality laboratory of similar type and purpose being built at Hanford, Washington State, USA to very much the same timescale as the Dounreay one.

The central feature of building D8550 was the critical assembly test cell. This was a typical low-power reactor containment building, consisting of a cylindrical steel pressure vessel concrete shield with a thick concrete roof. In conformity with UK practice of the time, the design basis of the cell shielding was that a criticality excursion yielding 1018 fissions should not deliver a whole body dose (neutrons plus gamma radiation) to the most exposed person, exceeding the then annual limit of 15 rems.

A steel-lined pit was set in the cell floor for housing dump tanks, control mechanisms, etc. A large square door in the steel shell, in line with a removable portion of the concrete shield, allowed large or heavy equipment to be brought into the cell; a wicket door in the cell door and a labyrinth in the concrete were available for personnel access.

The steel pressure vessel was designed to provide a high degree of containment of radioactivity. To preserve the containment, all cables and pipes entered the cell through sealed service plugs, while the two access doors were required to be closed and sealed whenever reactivity was added to an assembly. No air-lock was provided, the intended procedure in the event of a criticality incident being to keep the cell sealed until clean-up action could be taken using pressurised suit techniques. A sub-change room and control point, equipped with radio and CCTV links to the cell, were provided for this purpose close to the cell entrance.

The cell was designed to accommodate two critical assembly rigs, each housed within separate containment boxes having their own re-circulatory ventilation systems. These were intended to minimise the spread of activity and to assist clean-up in the event of a criticality incident or other 'spillage'. It was also hoped that the boxes would prevent the general contamination of the cell unless the incident were unexpectedly severe. The cell itself was equipped with a re-circulatory ventilation system comprising a filter and air heater, which served both for temperature control and for clean-up. The main extract from the cell discharged through a filter to a stack and was operative only when the cell doors were open, the extract duct being sealed by a motor-driven valve during critical experiments.

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Support facilities for the critical experiments were disposed as far as possible around the outside of the cell at two floor levels, with offices and general building services at a greater distance. The active areas were on the side of the cell nearest its entrance and included two fuel processing laboratories, stores for solid and liquid fuel materials, the emergency change room described above and, on the first floor, the extract fan room and fissile material store.

These active areas were separated by a continuous fire-break wall from the non-active part of the building, comprising the control room, an electronics workshop, and a motor-generator plant giving stand-by electrical supplies from batteries. A main change-room, health physics room, input fan room, small engineering workshop and staff accommodation completed the facility.

Provision was made within D8550 for the storage and, to a limited extent, for the preparation of the fuel materials used in the criticality experiments, though not for their purification and recovery. Plutonium nitrate solutions were stored in a fuel preparation room in slab-shaped tanks. These were independently valved, permitting solutions of several concentrations to be held, but were all connected to a common mixing tank in which the solution for a particular critical approach run was prepared. This tank was also connected to a continuous steam-heated titanium evaporator, and to two diluent tanks holding dilute nitric acid and condensate water.

A solution of any desired concentration could thus be prepared in the mixing tank, after which it was transferred to a holding tank which supplied the critical assembly rig, leaving the rest of the solution plant free to carry out further processing. Solution returned from an experiment was passed directly to the mixing tank and thence to one of the stock tanks. Mixing was effected in all tanks by compressed air sparge and all tanks could be independently sampled for analysis. All fuel transfers, other than to and from the critical assembly, were by application of vacuum. Transfer to the criticality rig itself took place in two stages, first through a service plug in the cell wall to a small intermediate tank and then, in an independent operation, to the reactor vessel; both these transfers were by air-operated diaphragm pumps.

Equipment for the preparation of solid fuel tablets of plutonium and moderator was set up in the "active transit area" (ATA) in a glove-box line close to the cell entrance. This included balances and rotary mixers for preparing homogeneous dispersions of plutonium oxide and polyethylene powder, small hydraulic presses, and provisions for packing the pressed tablets in unsealed boxes and for the external decontamination of these boxes. To increase the moderator content of the fuel mixture the tablets were re-fabricated by dilution with additional polythene; this was carried out in a further glove-box equipped with a heated extrusion press, granulator and grinder, for reducing the tablets successively to thin rods, chips and finally powder.

The Critical Assembly Rigs

Of a number of criticality rigs originally envisaged for use in D8550 only two were, in the event, actually designed and built. The first of these, PUMA was a horizontal split-half assembly machine intended primarily for experiments on solid moderated systems of plutonium or highly-enriched uranium. The second was an interchangeable tank apparatus for work with aqueous solutions of plutonium nitrate, with or without a water

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reflector. Between them the two machines were intended to allow the whole range of plutonium concentrations of interest to be studied. Both were designed to be taken to criticality and to operate, if so required, at powers up to a few kilowatts.

1 PUMA (Plutonium Moderated Assembly Machine)

This machine consisted essentially of two flat tables which could be driven towards each other in a precisely controlled manner so that the two, sub-critical, halves of an assembly of fissile material could be brought into contact or, if criticality was reached before contact was made, to some accurately measured separation distance. Ideally, the final configuration of any particular assembly would be that where criticality was achieved exactly at contact.

Each of the two tables was carried on four recirculating ball bushings running on two parallel round bars, an arrangement giving extremely free movement. The bars supporting the 'fixed' table were inclined at an angle. This table was pushed by a pneumatic piston to its normal operating position at the top of the slope, where it was held by an electro-magnet. The other, 'moving', table was driven horizontal towards the 'fixed' table from its maximum separation distance, first at a 'fast' speed and later at one of four pre-selected 'slow' speeds.

Fine adjustment of the table position could also be made by an inching mechanism consisting of a pneumatically driven pawl which engaged a ratchet wheel on the table's lead screw. Two such mechanisms were provided, enabling the table to be either advanced or retracted by 0.025 mm per stroke. The separation of the two tables was indicated directly by a metal scale and vernier, visible on the machine itself and also in the control room over a closed-circuit television (CCTV) link.

Rapid disassembly of PUMA, on receipt of a trip signal, was brought about by the movement of *both* tables. The 'fixed' table, after a magnet release time of about 150 msec from trip initiation, accelerated freely and was subsequently brought smoothly to rest by a hydraulic buffer after travelling to its full separation distance within 6 sec. The reverse movement of the other table was scarcely less reliable, although dependent on electrical supplies; it occurred provided *either* the 240 v AC mains *or* a 24 v DC battery supply to an additional motor was maintained.

2 PANTHER (Plutonium Nitrate Thermal Reactor)

PANTHER consisted essentially of four units: a core tank, interchangeable with others in a comprehensive range of shapes and sizes; a removable cylindrical reflector tank surrounding the core tank; and two dump tanks, one for fuel solutions from the core and one for reflector liquid. The whole apparatus, with the exception of the reflector dump tank, was contained within a transparent secondary containment box equipped with tent flanges to permit core tank changes and general maintenance.

The original range of interchangeable core tanks included ten spheres, three isometric cylinders, and four 'shallow' cylinders, all of which could be used with or without a complete water reflector. There were, in addition, five 'tall' cylinders

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which could be reflected in the radial direction only. The core tanks were all of thick aluminium, protected against attack by the fuel solutions by epoxy resin lacquer.

A vertical pipe at the base of the core tank served as the normal filling and emptying line and also as a fuel dump line through which a portion of the core solution was rapidly discharged to a geometrically safe vessel in the event of a trip; a similar pipe at the top of the vessel served as a pressure balance line.

Plutonium nitrate solution was supplied to PANTHER from the holding tank in the fuel preparation room in two stages. First, a pre-determined volume of solution was pumped quite rapidly through the wall of the cell into an intermediate vessel inside the cell; in a second stage this solution was transferred at a selected rate into the core tank itself. This procedure eliminated the need for any direct connection between an 'unsafe' vessel (the core tank) and a virtually unlimited source of fuel. The return of fuel solution to storage was effected in a single operation.

Water for a reflector, when one was used, was pumped from a dump tank in the pit below the cell floor into a large cylindrical vessel surrounding the core tank. The levels of liquid in the fuel and reflector tanks could be read locally by sight glasses and in the control room over a CCTV link with accuracy. Complete filling of the spherical and closed cylindrical core tanks was also detected by electrical contact probes.

In the absence of a liquid reflector, rapid shut-down of PANTHER was entirely dependent on a single reactivity-reducing process: the removal of fuel solution, both rapidly by dumping under gravity and more slowly by pumping back to a stock tank. To enhance the reliability of the gravity dumping action, two parallel dump lines, each closed by a large diameter, air-operated diaphragm valve controlled by its own trip-responding circuit, were provided. The dump tank was designed to be capable of accepting at least 20% of the volume of the largest core tank and was always arranged, by means of interlocks, to be empty whenever reactivity was added to the system. Additionally, a trip signal initiated the removal of fuel solution by a pump powered by two independent electrical supplies (mains and battery); pumping continued until all solution had been removed.

CRITICAL ASSEMBLY OPERATIONS : 1960 - 1963

Measurements on solid assemblies

By July 1960 construction of D8550 was far enough advanced to allow cell 4 to be prepared for installation of the PUMA machine. Construction of the machine itself was also completed in July, following which it was tested at works and delivered to Dounreay (minus its containment box) on 20 September. Commissioning tests were then carried out on it, culminating in dummy approach to critical runs using neutron sources embedded in non-reactive material.

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Having measured the shut-down characteristics of PUMA, and demonstrated that the loss of reactivity on trip was better than specified, it was possible to complete the safety submission for its use, first in experiments with uranium metal and later with plutonium oxide/polythene compacts.

Enriched uranium systems

As an adequate stock of PuO₂/polythene compacts was not available by the time testing of PUMA was complete - and, furthermore, the containment box for the machine (deemed essential before criticality work with plutonium could start) had still to be delivered - the opportunity was taken in November to carry out a series of critical size measurements on stacks of U₂₃₅ metal billets. Criticality was achieved with these for the first time on 8 November 1960, this being the first criticality in D8550.

In all of these experiments, which could be described as the final commissioning tests of PUMA prior to its use with plutonium assemblies, the machine proved extremely reliable in all aspects of its operation.

Plutonium Systems

Construction of a containment box for PUMA, deemed to be essential for critical assembly work involving plutonium-bearing materials, was completed in February 1961. By April a number of square-section tin-plate boxes containing PuO₂/polythene compacts had been made. These were then used to carry out the first critical size measurements with plutonium at Dounreay.

Measurements on Plutonium Solution Assemblies

Installation of the PANTHER rig and commissioning of its associated solution handling apparatus (storage tanks, evaporator and dilution equipment) took place progressively throughout 1961. Much of this work had to be carried out in parallel with final construction work by contractors' personnel. This was made necessary by a decision by the Reactor Group Board that experimental criticality work at Dounreay should be terminated as soon as possible, ideally by December 1961 - though it was recognised that, because of construction delays, the plutonium solution experiments in D8550 would have to continue well into 1962. The desire was to make as much use as possible of PANTHER before this decision finally took effect.

In the event, the programme of work in D8550 on behalf of the Reactor Group was extended until December 1962. There were, however, further delays in commissioning PANTHER and its ancillary equipment; in particular, the shutdown capability of the fuel dump system was found to be inadequate and required redesign and re-supply. As a result, the only critical mass measurements made in PANTHER were with low irradiation plutonium.

A small further extension in D8550's operational programme was sanctioned to allow a specific experiment devised and funded by the AEA's Research Group to be carried out. This involved the use of PANTHER to measure in detail the spectrum of neutrons produced in the centre of an unreflected homogeneous aqueous plutonium reactor by a time-of-flight (ToF) technique. For this purpose, PANTHER was repositioned in cell 4 so

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as to permit the installation within the cell of a long shielded and evacuated flight tube and a neutron beam chopper rotating at up to 12,000 rev/min. In addition, integral measurements of the neutron spectra at the centre of the reactor were made using foils and fission chambers before the ToF equipment was set up.

Two special cylindrical core tanks made of stainless steel were used for the ToF experiments. Criticality was achieved in these at six different solution concentrations (three each for the integral and ToF measurements).

For the integral measurements, the reactor tank was equipped with a horizontal probe tube to carry the spectral detectors; this tube terminated in an aluminium end window located near the axis of the tank. It was necessary for an extension of this tube to pass through the PANTHER containment box, an arrangement which negated the principle of having a secondary containment for the fuel solution at this point. Although the tube was protected by epoxy resin and had been shown on test to be resistant to attack by fuel solution, rapid and severe corrosion occurred during preparations to traverse fission chambers within the probe tube. This resulted in the leakage of a few litres of plutonium nitrate onto the floor of the cell. Although most of the escaped solution was retrieved the same day, the more general contamination of the cell environment took three weeks to clean up successfully and caused a corresponding delay in the experimental programme.

For the ToF experiments a similar horizontal probe tube, made of stainless steel, served to extract the beam of neutrons for analysis by the chopper assembly. For this work the integrity of PANTHER's secondary containment was preserved by allowing the neutron beam to pass through a quartz window in the containment wall, thus greatly reducing the risk of a general spread of contamination within the cell.

Operational use of D8550 as a criticality facility, and of the Dounreay critical assembly laboratories as a whole, came to an end in September 1963 with the conclusion of the final ToF experiment in PANTHER. The reactor was taken sub-critical for the last time on 26 September, following which the plutonium nitrate fuel solution was returned to the stock tanks in the Fuel Preparation Room and the reactor vessel washed out (the usual operations at the end of a reactor run). This point marked the end-point in the eight-year life of the Dounreay experimental criticality group, all of the remaining staff members being then dispersed to other duties.

THE POST-OPERATIONAL AND DECOMMISSIONING PHASE

'Care-and-maintenance' and initial decontamination : 1963 -1967

Having concluded criticality work Dounreay's immediate objectives for D8550, from October 1963, were:

- (a) to retain all of the operational facilities of the building, including the two critical assembly rigs, in a fully serviceable state of care and maintenance "for a period which was prolonged and indefinite";
- (b) to reduce the level of contamination in the accessible areas of cell 4,

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and elsewhere as necessary, to the point where D8550 could be brought back into use as a criticality facility without undue delay. It was expected that, in so doing, any residual contamination in the active areas would be made unlikely to migrate into 'uncontrolled' areas and so become a hazard.

These objectives were agreed between Dounreay and the AEA's health & safety research committee to meet an AEX requirement that the Authority should continue, for the time being, to have at its disposal a laboratory in which criticality experiments could be resumed if new data were found to be needed; and/or simulation experiments could be set up to aid the investigation of a criticality accident if one were to occur in any of the Authority's plants.

It was stipulated, in a slightly impractical compromise, that the criticality facilities should be available at six months notice, hence the need for early decontamination of cell 4. The AEX requirement did not extend to the non-operational areas of D8550 nor, indeed, did it preclude Dounreay from making use in the meantime of the operational areas provided the availability criterion was not imperilled.

Responsibility for D8550, during the early months of decontamination work, continued to rest with the reactor division and, more specifically, with the DMTR Project. As a first step the neutron probe tube was removed from the PANTHER core tank, thus enabling the integrity of the PANTHER containment box to be restored. Clean-up of the cell walls, girder work, switchgear and the outsides of the rig containment boxes then proceeded apace despite heavy air contamination in the cell. Initially, it was possible to carry out this work in respirators but, from mid-November, when entry was made to the equipment pit below the cell, all decontamination work had to be done using pressurised suits.

In January 1964 it was reported to the Dounreay management committee that the "area decontamination of D8550 had largely been completed" - though later events showed this claim to be more than a little optimistic! Also, the first two containers of plutonium nitrate solution had been transferred from the stock tanks into transit bottles and sent to Windscale for recovery, apparently as a trial of the procedure since no more such transfers were made at this time.

By April it had become possible to cease routine monitoring of the building and to withdraw surveyor cover; and by July there was evidently a hope that surveillance of D8550 might be further reduced since the health & safety division was invited to specify its minimum requirements for the withdrawal of attendance by the HP supervisors. The response was less than encouraging, expressing the view that unless various defined tasks - including the draining of all vessels and pipelines, the removal of all plutonium solutions and the dismantling of PANTHER - "were carried out without delay the plant could deteriorate to a dangerous condition".

In September 1964 responsibility for managing the active areas of D8550, including particularly the duty of despatching to Windscale the substantial quantity of plutonium nitrate fuel still remaining in the stock tanks, was transferred from the reactor division to the chemistry division. There was also something of a new initiative on the decontamination of the cell and further amounts of plutonium nitrate solution were sent to Windscale. The pipework connections to PANTHER were taken away, one panel of the containment box was removed using tenting techniques and about half of the rig was

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dismantled and posted out. Drums of contaminated waste were reported to have been sent to Drigg for storage. An incident involving a split posting bag caused high plutonium-in-air alarms on 22 and 24 October.

During November 1964, various options for the further decontamination of D8550 were considered by the management committee. That selected was, in effect, a "minimum programme", estimated to involve 130 man-days of effort and to take 6-9 months to complete at low priority "as and when labour and supervision were available". The end result to be achieved was "a building safe and free of contamination and readily available for future alpha-active work". The intention was that PANTHER and its containment box would be disposed of, the plutonium storage tanks and evaporator would be emptied and washed out (but not removed), and all glove boxes would be sealed. There was, apparently, no intention to decontaminate cell 4.

This decided, more panels of the PANTHER containment box were removed, though this was probably only a temporary measure, done primarily to permit spray-painting of the interior surfaces of the box. From this point onwards all work on PANTHER - which appears to have progressed very spasmodically - was carried out inside a PVC tent, pressurised suits being worn inside the tent and respirators elsewhere in cell 4.

Further - and more substantial - progress in the export of plutonium nitrate solution from D8550 was made in March and May 1965, effectively completing this task. There were several instances of hand contamination during this operation, attributed to damaged glove-box gloves.

Also during May widespread air and surface contamination was caused throughout the active areas of the building during further dismantling operations on PANTHER. In an incident on 12 May the roadway leading to the loading bay doors was contaminated, as was a tractor and trailer used to convey alpha-waste to D1207. A private motor-cycle parked near the loading bay was also contaminated.

The escape of activity was found on investigation to have been caused by the piercing of a bag containing the waste. By the end of the month "considerable success" was reported in decontaminating the building areas affected; clean-up of the motor-cycle such that it could be restored to its owner seems to have been more difficult! There were also problems in the decontamination of equipment crates, probably containing the unused PANTHER core tanks, stored in the loading bay while awaiting shipment off site.

An incident occurred on 2 June 1965 when an operator engaged on the removal of plutonium-contaminated waste from cell 4 had to be cut free from his pressurised suit. He had not been feeling well prior to starting work and collapsed while in the suit. The incident was not directly related to radioactivity but some skin contamination was caused following the cutting of the suit.

The dismantling of PANTHER and decontamination of the fuel preparation room continued until mid-September - though very irregularly, due to lack of both engineering and process effort - following which it was reported that it would be suspended for three months. In the event it was not resumed until February 1966. In the meantime, health physics surveys of the active areas were reduced to once-weekly with daily air samples

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being taken prior to work starting in the office block of D8550 - which by this time had been brought back into use for purposes unrelated to the decommissioning programme.

The dismantling of PANTHER was resumed in earnest on 21 February and both the rig and its containment box were reported to have been cleared from the cell by the end of April 1966. Hand-sawing of the structural steel work supporting the rig proved to be very slow and was replaced by oxy-acetylene cutting. The cutting operation gave rise to high air contamination within the tent though this was "successfully controlled" and no incidents were reported. It was noted, with evident surprise, that the contamination was produced in large particulate form rather than being vaporised. Checks on the downstream side of the extract plant filters confirmed that they continued to be fully effective - a wise precaution given the somewhat uncertain maintenance history of this plant since 1963. It was also noted that, despite the high levels of surface contamination in the cell and also in the active workshop and transit area, an intensive HP survey of the 'green' areas of the building showed them to be clear of activity except for occasional fairly trivial spots. The whole PANTHER removal operation required about 1000 manhours of effort - not very different from that estimated.

Having disposed of PANTHER the final actions needed to bring D8550 to the "readily usable state" called for by the health & safety research committee were put in hand. Further decontamination was carried out in the cell, with much spraying of paint to 'fix' the remaining surface activity. In the active transit area high contamination in the vicinity of the glove box suite was also removed or contained. By July 1966 the surface decontamination of D8550 was reported to the Dounreay management committee as being "effectively complete" and it was decided to notify AWRE, where responsibility now rested for the Authority's criticality programme, that the Dounreay facilities were now available as specified.

It was recognised that much of the activity in the building had only been sealed in by paint, rather than removed, and regular HP surveys - often followed by decontamination work - were made to ensure that a safe condition was preserved. A need was also perceived for further clean-up of the still heavily contaminated fuel preparation room and this was in progress from August onwards.

In February 1967 the AEX decided that D8550 need no longer be retained on a care and maintenance basis as an Authority resource. Thus, after three and a half years, its status as a critical assembly laboratory available at no more than six months notice, came to an end.

Retention and Surveillance as a 'Redundant Facility' : 1967 - 1987

With D8550 available to Dounreay to use as it wished the Dounreay management committee sought recommendations from Health & Safety Division as to how the building might most economically be kept under safe care and maintenance; in particular, it was hoped to reduce substantially the £4,000 annual cost of running the ventilation plant at full rating. In the response it was noted that much of the building (i.e. the inactive areas) had already been put into use, that PUMA was still in cell 4, and that the plutonium-contaminated glove boxes were still present in the active transit area though they were sealed and reportedly emptied of plutonium. It was considered that "the fuel preparation room presented the biggest problem" but that, despite this, there

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was no real need to maintain a forced extract on either this room or the cell. It was recommended that "access to these two areas should be permanently barred".

It was also noted at this time that to remove all contamination from D8550 such that it would be available "for normal use" would be a major and very costly operation. It could only be undertaken by making a concerted effort; to work in a piecemeal fashion where there was this degree of hazard was to invite a serious incident. In the event, the management committee decided that there was "no incentive for costly decontamination and that the building should be made safe at minimum cost". A permanent, contamination-proof barrier was built at the change-room entrance to the active area. It is not recorded whether recommended changes to the extract filters were made.

From this time until the late 1980s little or no further decontamination was attempted in D8550. The extract ventilation plant was kept in operation, at least for a number of years. It is not clear from the records whether the specified routine testing and maintenance of this plant was sustained throughout the whole of this period; certainly, there are reports extant of fans and fan motors being found in a deteriorated or inoperative condition during the 1970s. Health physics surveys of the boundaries of the 'sealed' area were carried out regularly to confirm that no leakage of activity was occurring and occasional entries were made to the active area to store contaminated equipment from other buildings in the fuel cycle area. Entries were also made on at least two occasions (May 1976 and February 1982) to carry out assessments of the plutonium inventory for the area and to make a photographic record of the state of the various rooms and their contents.

In the late 1970s various assessments were made of the work needed to restart a decommissioning programme should a positive decision be made to embark on one. These culminated, after several reviews of the situation, in a proposal to the AEA northern division directors' meeting in 1982 to "fully decontaminate" D8550 at a cost of £475k over a period of 2-3 years. After further consideration of the work involved and the submission of a revised proposal, a firm decision was taken in mid-1987 to initiate a sustained campaign to decommission the whole of D8550, with the possible exception of cell 4, at least as far as stage 2.

The main decontamination programme : 1987 - 1994

Having made the decision to proceed, a trained and dedicated team was set up. As a first step an entry was made into the 'sealed' area in October 1987 to measure the apparent levels of surface contamination and to prepare a hazards assessment for the project, including an estimate of the radiation dose budget and potential waste arisings. Shortly after this, work was put in hand to license AEA sites under the Nuclear Installations Act and, to meet this new requirement, the D8550 hazards assessment was augmented to comply with Regulations 25 and 26 of the Ionising Radiations Regulations 1985. Also at this time, the building became subject to Dounreay's Authority-to-Operate (ATO) procedure, with the requirement that annual reviews of safety should be prepared for consideration by a safety working party.

Among other preparations for the new decommissioning campaign, D8550's ventilation plant and electrical services were refurbished or renewed and tested and an air sampler was installed in the extract stack. It was also realised that the small sub-change room in

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the active transit area, provided to aid clean-up of the cell in the event of a criticality incident, would be quite inadequate for the major decontamination operation which lay ahead. A new semi-permanent building, D5026, equipped with the necessary change-rooms and other services needed for pressurised suit operations, was therefore built onto the north side of D8550 to serve as the normal means of access to the active area.

The programme was divided into a number of phases, the first of which was to strip out equipment in the solid fuel process area and to decontaminate this and other rooms in the active transit area. This involved the disconnection and removal of a number of glove-boxes, the disposal of redundant pipework stored in the building and the removal of trunking. The entire operation was carried out using air-line suits and required almost 1,000 such entries lasting a total of over 1,750 hours. This phase was completed in just under 12 months, by which time (November 1988) contamination levels generally had been reduced to 0.4 Bq/cm² by swab; in a few places contamination up to 4 Bq/cm² remained and these were covered with a sealant. Thus, entry to this area could be made without respiratory protection.

The second phase of the programme was to remove the plutonium nitrate mixing and storage tanks, titanium evaporator, glove-boxes and other equipment from the fuel preparation room and to decontaminate this whole area. The main problem in this phase was the clean-up, handling and disposal of the very heavy and substantial slab-shaped fuel stock tanks; in all these amounted to 15 te of stainless steel and each tank was surrounded by 15 te of concrete shielding blocks, many of which were contaminated. Other difficulties arose because of uncertainty as to the plutonium inventory of the tanks and pipework, leading to the escape of plutonium liquor during pipework removal, and problems in identifying waste disposal routes for so much contaminated material. This phase of the work was completed in early 1990 and involved over 1,000 airline suit entries lasting almost 2,000 hours.

In a further phase of the work, entry was made to the underground vault containing the effluent tank and pipework. This was found to be full of slightly contaminated water. Although this was readily disposed of to the low active drain, ingress of water from the surrounding rock continued to cause difficulty. Nevertheless, the two tanks in the vault were dismantled using a plasma cutter and the residual activity on the walls and floors greatly reduced by scabbling. Finally, other pipework and equipment was removed and the rest of the effluent drainage system decontaminated.

The final stage of the decommissioning plan was to reduce the internal contamination of cell 4 to the same level as the rest of D8550, i.e. to permit access without a need for respiratory protection. It was recognised that this might involve the removal of most, if not all, of the contents of the cell and would probably necessitate much cutting of steel work. In the event, only limited further decontamination of the cell had been carried out when the decommissioning campaign was brought to a halt in March 1994.

The present status of D8550 is that the whole of the active area, with the exception of the critical assembly cell (cell 4) and the ventilation extract system, has been decommissioned "essentially to stage 2". Cell 4 is still heavily contaminated and serves as a temporary store for dismantled items of plant and other contaminated equipment. The splittable assembly machine, PUMA, continues to reside in the cell within its steel containment box. Although the outside of this box is heavily contaminated the inside is

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not, nor is the PUMA machine itself. Since 1994 D8550 has again been retained under a care and maintenance regime, albeit in a vastly safer state than prior to the recent six-year decommissioning campaign. Nevertheless, studies continue to be carried out of the options available for progressing further with the work, including particularly those relating to the long-term safety of cell 4.

CONCLUSIONS

Construction and operation : 1959 - 1963

During the short time that D8550 was available for operational use some worthwhile criticality data was obtained on solid assemblies of plutonium oxide and polythene, and also on some uranium metal assemblies, in the PUMA reactor. No spread of contamination was caused by this work.

Due to a lack of resources to complete the commissioning of the building very few critical mass results were obtained on plutonium solution systems in the PANTHER rig. The reactor was used, however, to carry out an important nuclear data experiment on behalf of the research group and to this extent the plutonium solution programme was successful.

A 'spillage' incident during the plutonium solution work caused significant contamination of equipment within cell 4. The greater part of this contamination was cleared up within three weeks and it was wholly contained within the cell. No general contamination of the building was caused by the work.

Care-and-maintenance and decommissioning : 1963 - 1997

Due to the dispersal, either before or immediately on conclusion of the operational programme, of all personnel involved in the commissioning and operation of D8550 and its equipment, no one with any familiarity with the plant or with knowledge of the nature and distribution of the active materials in it (or even, it would seem, with adequate expertise in working with plutonium-bearing materials) was available to carry out the stage 1 decommissioning of D8550.

As a result, very little progress was made in removing the plutonium nitrate fuel solution for almost 18 months, dismantling and removal of the PANTHER rig was delayed for a similar period, and when these two tasks were initiated they were carried out in such a way as to cause severe and extensive contamination of virtually the entire operational area of the building;

It is arguable that much difficulty would have been avoided, and both expense and personal dose uptake saved, if the partial decontamination programme begun in the 'availability' period (1963-67) had then been carried forward to its logical conclusion using a dedicated task force. Be that as it may, there can be no doubt that there are lessons of relevance to future decommissioning operations at Dounreay to be learnt from a close study of what has, and what has not, been done in D8550 since 1963.