RADIATION PROTECTION IN THE DECOMMISSIONING OF A POST ACCIDENT REACTOR

Alexander Rankine[1], Jackie L Wilkinson[1] and John Dalton[2]

[1]UKAEA , Windscale, Seascale, Cumbria, CA20 1PF ,UK
[2]W S Atkins (Northern) Wast Water Pavillion, Westlakes Science and Technology Park, Moor Row, Cumbria, CA24 3TZ, UK

ABSTRACT

This paper describes the control and limitation of dose uptake to operators during the early stages of decommissioning of the Windscale Piles. This was achieved by careful planning, the use of inactive trials, thoughtful use of remote handling techniques and review and feedback of information. Built between 1947 and 1950, the Windscale Piles were shut down following the Windscale Incident in 1957. UKAEA Government Division are now undertaking the early stages of decommissioning of these facilities, removing material from the air and water ducts and preparing for subsequent core removal. As part of the overall strategy of UKAEA GD, this work is being carried out using contract staff including the use of a Managing Agency, W S Atkins (Northern).

Decommissi ›ning utilises the same means of dose reduction and control as any other nuclear operation although sometimes in novel ways. In the Windscale Piles, fully remote operations have been used to remove fuel and debris from the environs of the core which was damaged during the 1957 incident. Much use has also been made of training in mock-up facilities allowing manual techniques to be used for some jobs. The implications of using various different contractors rather than an in-house team is also discussed. It is concluded that decommissioning of major facilities can be carried out within acceptable dose uptake criteria by utilising both novel and adaptations of traditional, active handling techniques.

INTRODUCTION

The Windscale Piles were constructed between 1946 and 1950 primarily to produce material for the nuclear weapons programme but also to produce radioisotopes for industrial and medical uses. The first pile went critical in October 1950. The Piles consisted of a graphite moderator block containing 3444 fuel channels running horizontally through the core and cooled by forced draught filtered air which after passing through the core was exhausted via the 125m chimney at the top of which were filters. Fuel cartridges were introduced via a hoist at the charge face and discharged into water ducts at the back of the pile from where they were taken for reprocessing. The reactors operated at a power of 180 MW until 1957.

On 10 October 1957 an accident occurred in Pile 1 during a routine Wigner energy release, involving severe overheating of parts of the core. The emergency, which was to be the most serious for several decades was finally brought under control on 12 October 1957 by shutting down the ventilation blowers and by the application of copious amounts of water to the Pile. Following the fire, both piles were shut down and fuel and isotope cartridges discharged, except for some 10% of the Pile 1 core which could not be moved. Sealing of the pile concrete shells and inlet air ducts was carried out and the associated buildings cleared and put to other uses. The piles were kept under care and until planning for decommissioning was begun.

Recently surveys were carried out and work has begun on the removal of loose fuel and debris from the air ducts and water ducts. This work has involved handling highly radioactive materials in difficult and poorly documented areas. In line with UKAEA policy the work has been carried out by various companies under contract and has been assisted in the project management by a Managing Agency (W S Atkins). This work has shown how standard radiological protection methods can be adapted even in these severe situations and the value of harnessing the experience of the wider contracting community has been shown. Some examples of this are given in this short paper.

AIR INLET DUCTS

The inlet air ducts were the route from the blower buildings either side of each pile for cooling air to enter the reactor cores. Visual and radiological surveys showed that the ducts contained dust and debris and in Pile 1, a quantity of fuel in various conditions. Using the results of these surveys, methods of clearing the ducts were developed. Radiological containment tents with local ventilation were used at points where access was gained to the ducts by cutting through the duct walls. These allowed the deployment of remotely operated vehicles (ROVs). Dose budgets were prepared for each task and dose uptake was monitored using daily issue electronic personal alarming dosimeters.

The Pile 2 air inlet ducts were cleaned and seismically qualified barriers were installed near to the Pile. The barriers consisted of steel formwork and precast, interlocking concrete blocks. They were installed manually using portable lead screens to shield the workers from radiation from the core. Bulkhead doors are now in place and work is complete. The total dose uptake for the installation of the Pile 2 barriers was 9.4 man.mSv with a maximum individual dose of 3.1 mSv.

Because of the fuel in the Pile 1 inlet air ducts, the dose rates were higher than for Pile 2 (700μSv/h cf 120μSv/h). Cost benefit analysis for the clearance work would have resulted in a manual method but a policy decision was taken to use remote techniques. A mock-up facility was used for the testing of the ROV and the training of the operators. The ROV was then used to collect all the fuel and debris in the ducts and put it into specially designed canisters which were then removed by flask. The ducts were then vacuumed remotely. A more remote method had been considered, but on completion of the clearance work the dose rates were sufficiently low (320μSv/h) to allow the same manual construction of the barrier as had been used in Pile 2. Temporary shielding was used and minor modifications to the installation method allowed reduced occupancy times (eg delivery of grout though a hole in the duct roof). The total dose for the installation of the Pile 1 barriers was 15.6 man.mSv with a maximum individual dose of 3.1mSv.

AIR EXHAUST DUCTS

As with the Air inlet ducts, considerable amounts of fuel and debris lay in the air exhaust ducts. It was necessary to collect this material and transfer it to Disposal/storage locations. The obvious access route was via the base of the Pile chimney on the adjacent BNFL Nuclear Licensed site. Installation of equipment through this route would have been dose-intensive and there would have been potential radiation exposure from the packages as they were removed. There were also administrative complications since nuclear materials would be transferred to another site and back again.

An alternative scheme for the exhaust air duct clearance was adopted. This scheme took advantage of the existing shielding of the Pile bioshield. Air dams installed in the duct during an earlier part of the decommissioning could be modified to provide an ROV deployment route which did not require personal significant radiation exposure.

A jib crane was designed for deployment through the existing pile inspection holes. This crane was used to suspend fuel containers in a position where they could be loaded by ROVs. The crane then allowed the containers to be lowered onto the floor of the water duct so that they could be removed along with fuel from the water duct itself (see below).

WATER DUCT

The clearance of the pile water ducts was broken down into a number of tasks: Barrier Installation; Sludge pumping; Fuel/Debris removal; Decontamination; Drainage.

The installation of a seismically qualified barrier was done early in the process to secure containment of the pile should an earthquake or large dropped load breach the duct. Work on two tasks could then take place at the same time, one in the section of duct behind the pile and the other in the external section of the duct. Most work in the ducts was done by ROV.

The flocculent sludge found in the duct had to be cleared from the duct to prevent debris being hidden and allow it to be retrieved by ROV. The method used for this was almost entirely remote using a sludge pipeline from the duct

The flocculent sludge found in the duct had to be cleared from the duct to prevent debris being hidden and allow it to be retrieved by ROV. The method used for this was almost entirely remote using a sludge pipeline from the duct to the Pond. The ROV was then connected to the pipeline and deployed. Dose uptake on the sludge pumping was almost entirely due to the operations to install the pipeline and the deployment/retrieval of the ROV. The ROV was purpose designed for the job and could not practicably be proved to very high levels of reliability before work started. Several retrievals and redeployments of the vehicle were needed before the task could be finished and this had the effect of increasing the dose uptake.

Another purpose designed ROV was used for fuel and debris removal. This vehicle was equipped with a remote manipulator arm, a γ dose rate probe and stowage for fuel and debris containers. The γ probe was used to identify any items such as ^{60}Co pellets which would have a high dose rate when retrieved at the access shaft. Fuel and isotope cartridges were retrieved into shielded containers for transfer to a flask loading facility. Careful assessment of the dose rates from fuel, based on the calculated inventory of the material and dose rate measurements in the air ducts, made it possible to relax the shielding requirements for the fuel transport flask loading facility. It was possible for workers on a platform at the flask top to transfer fuel from the recovery containers underwater within the flask itself using long handled tools.

All work on the water ducts needed careful planning to ensure that an ALARP solution was found. Outline designs were prepared and subjected to a HAZOP study. From this any need to compare options to achieve the optimum dose uptake was identified. The firm design was prepared by the contractor selected for the work and ALARP meetings held to discuss the detailed design where the HAZOP had identified the potential for high dose uptake. Regular progress meeting with the implementation contractor allowed the opportunity to review the dose uptake implications of the work and discuss controls to minimise dose. Contractors were selected with proven experience of nuclear work and, where appropriate, experience of remotely operated technology. Contractors were selected from companies from UK and France.

The total dose uptake predicted for water duct clearance operations to date was 61.1mSv. The total actually accrued is 44.8mSv. No individual received more than 4μSv, well within the dose restraint objective of 8mSv/year. A more detailed breakdown of the dose uptake figures is given in the table below:

Task	Predicted (mSv)	Actual (mSv)
Water Duct Barrier Installation	20.7	11.8
Water Duct Sludge Pumping	15.6	15.3
Water Duct Fuel/Debris Removal	36	15.3 (work continuing)
Exhaust Air Duct Clearance	6.8	2.4

CONCLUSION

At UKAEA Windscale experience is being gained in the decommissioning of facilities which present a much greater challenge than power reactors will. This experience has indicated that in terms of radiological protection the operations involved, even in the extreme example of the Windscale Piles, are little different from those encountered in everyday operations of a nuclear establishment. By careful planning, inactive trials and training use of remote handling equipment and by using techniques common in other industries, dose uptakes can be kept ALARP.

ACKNOWLEDGEMENT

The Windscale Piles project is funded by the UK Department of Trade and Industry and the Ministry of Defence.