DECOMMISSIONING OF SHIELDED FACILITIES AT WINFRITH USED FOR POST IRRADIATION EXAMINATION OF NUCLEAR FUELS & OTHER ACTIVE ITEMS

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ABSTRACT

This paper describes the approaches used in the clearing, cleaning, decontamination and decommissioning of a very large suite of seven concrete shielded caves and other facilities used by UKAEA at Winfrith Technology Centre, England over a period of about 30 years for the post-irradiation examination (PIE) of a wide range of nuclear fuels and other very active components.

The basic construction of the facilities will first be described, setting the scene for the major challenges that 1970s’ thinking posed for decommissioning engineers. The tendency then to use large and heavy items of equipment supported upon massive steel bench structures produced a series of major problems that had to be overcome. The means of solving these problems by utilisation of relatively simple and inexpensive equipment will be described.

Later, a further set of challenges was experienced to decontaminate the interior surfaces to allow man entries to be undertaken at acceptable dose rates. The paper will describe the types of tooling used and the range of complementary techniques that were employed to steadily reduce the dose rates down to acceptable levels. Some explanations will also be given for the creation of realistic dose budgets and the methods of recording and continuously assessing the progress against these budgets throughout the project.

Some final considerations are given to the commercial approaches to be adopted throughout this major project by the decommissioning engineers. Particular emphasis will be given to the selection of equipment and techniques that are effective so that the whole process can be carried out in a cost-effective and timely manner.

The paper also provides brief complementary information obtained during the decommissioning of a plutonium-contaminated facility used for a range of semi-experimental purposes in the late 1970s. The main objective here was to remove the alpha contamination in such a manner that the volume of Plutonium Contaminated Materials (PCM) was minimised and to clean the whole facility to a free-breathing state such that it would be available for other work or subsequent demolition.

INTRODUCTION

In the mid 1950’s, new facilities for nuclear research studies were constructed at Winfrith Heath in Dorset by the United Kingdom Atomic Energy Authority, (UKAEA). Building A59 was constructed as a major Active Handling Facility to carry out studies on irradiated nuclear fuel materials from the site's SGHWR and DRAGON reactors. Amongst these facilities there were two large concrete shielded suites of facilities, usually referred to as 'caves', that were used to carry out Post Irradiation Examination (PIE) on all types of gas-cooled and water reactor fuels and other activated components. Additional facilities constructed within this building including a Pressurised Suit Area (PSA), where highly contaminated items were routinely handled and inspected together with the sorting and disposal over many years of a range of other wastes. A diagram of the layout of all the facilities in Building A59 as they existed in January 2000 is shown for reference in Figure 1.

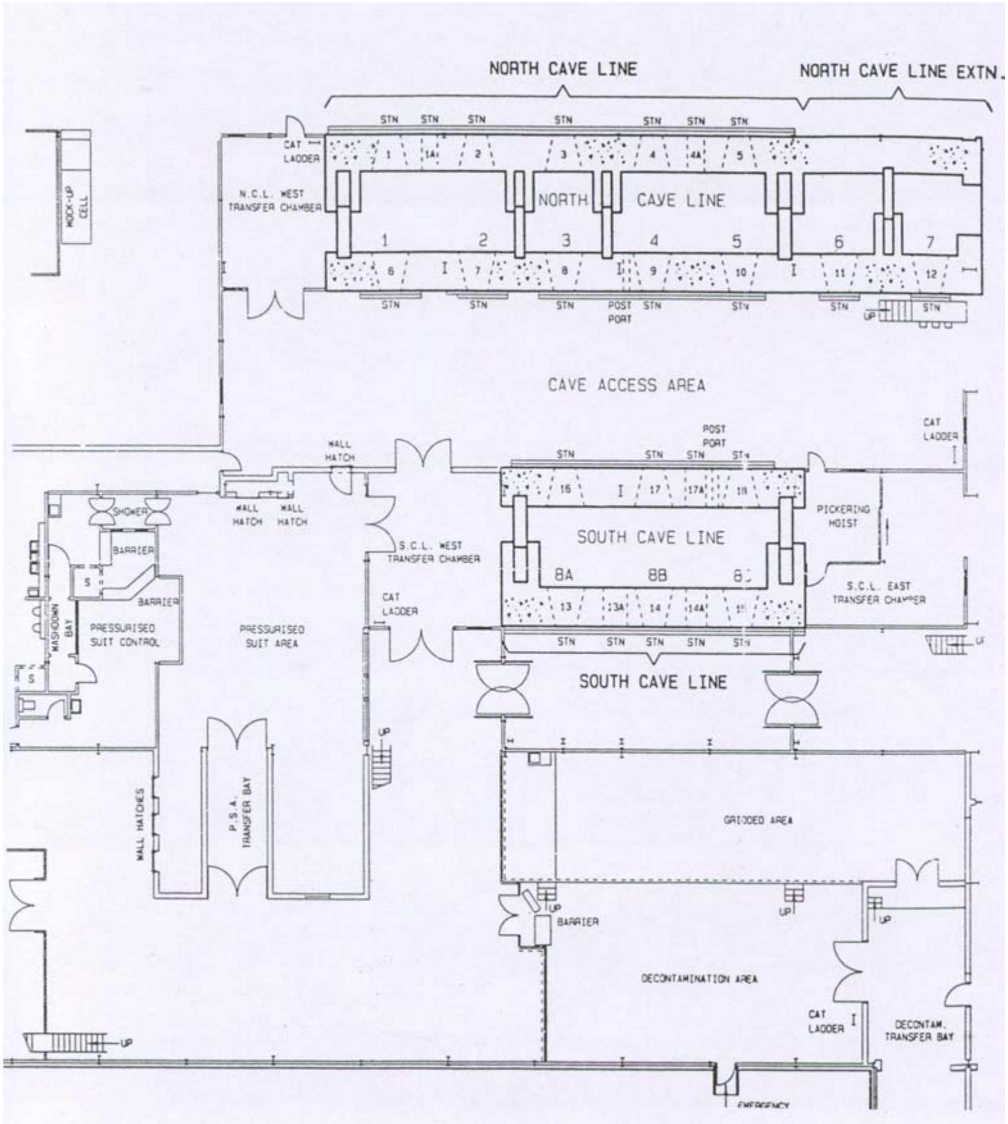

Fig. 1. Diagram of the layout of shielded facilities in Building A59 at Winfrith

At the time these facilities were declared redundant in the late 1990’s, all internal surfaces of the caves were extremely contaminated, as were those in the Pressurised Suit Area (PSA). In 2000, RWE-NUKEM was awarded the contract by UKAEA to decontaminate, decommission and demolish the whole building in its entirety. This was in support of UKAEA's mission, which is to carry out environmental restoration of its nuclear sites and to put them to alternative uses wherever possible.

The principal objectives of the contract are to carry out the above tasks to time and budget in a cost-effective and efficient manner. Close attention will also be required to constraining the amounts of LLW and ILW generated throughout the task to meet incentives in the contract from UKAEA. A total dose budget of ~210mSvs has also been declared for the project and it will be important throughout the work to monitor the doses to operators and constrain them wherever possible.

DECOMMISSIONING PROGRESS ON THE NORTH CAVE LINE

The North Cave Line (NCL) comprises a suite of seven caves, Figure 2, and this facility has currently reached a fairly advanced stage of decommissioning. A second smaller suite of caves (SCL) constructed in an almost identical way is located adjacent to the NCL and is in the process of being decontaminated and decommissioned in a similar manner.

Fig. 2. View of South Face of North Cave Line at Building A59

The basic construction of the facilities and their subsequent modification to support the examination of nuclear fuels for a commercial client presented a major challenge for the decommissioning engineers due to the ideas and designs that were current when they were refurbished in the 1970’s. The tendency then was to use large and heavy items of equipment supported upon massive steel bench structures and this in particular presented a series of major problems that had to be overcome. The means of solving these problems by utilisation of relatively simple and inexpensive equipment is now described.

The RWE-NUKEM team in Building A59 has already undertaken a programme of Post Operational Clean-Out (POCO) during which all redundant equipment and services have been cleaned, size-reduced, packaged and removed for disposal as LLW. This in itself was a major undertaking, but the presence of the in-cave benching allowed these tasks to be undertaken remotely using the installed master slave manipulators. Equipment was dismantled where possible and then vacuum cleaned and/or swabbed to remove loose contamination. Relatively simple monitoring equipment was used in-cave to establish local dose rates on these items, a low dose-rate area being established early on to support this operation. Once levels lay well below 1mSv/h at contact, the items were removed from the caves for disposal as LLW using the electric overhead hoists.

Once the individual caves had been cleared of equipment and other loose items, the heavy in-cave bench and support structure could then be remotely dismantled using relatively simple techniques and size reduced to facilitate removal for disposal. The bench top comprised 6mm thick steel plates and these were secured to the underlying steel support structure with cap head screws. These screws were removed using a pneumatically-operated impact screwdriver held down by a master-slave manipulator. This worked well and the tip of the tool was guided into position on the screw heads using a remotely operated in-cave TV camera, which was used to support all the work. The camera had an auto-focus zoom lens, enabling both close-up and long distance images to be readily viewed out-of-cave. The availability and flexibility of this camera system made a great difference to the ease of carrying out many of the subsequent tasks. Any screws that could not be removed had their heads ground away using a simple air-operated grinding disc, but the process was slower than the unscrewing operation. Once freed from the securing screws, the bench top was cut into smaller sections using an electrically operated slitting wheel supplied with hardened tips to cut steel or stainless steel as appropriate. The NCL had a mild steel bench top and the SCL a stainless steel unit. Blade exchanges were required occasionally and these were carried out in a dedicated glovebox located at waist height on the cave roof, Figure 3.

Fig. 3. Glovebox on Roof of NCL used for Tooling Maintenance

This facility had originally been provided to support the introduction of small consumable items into the caves during its long period of work on fuel-based PIE operations. Once the decommissioning operations started, the facility was used to support the maintenance of many items of in-cave tooling on both cave lines. As such, the facility was invaluable since it provided close control of contamination yet allowed manual access to the tools to provide a quick and easy means of maintenance.

The removal of the bench top provided access to the heavy support structure. Here the securing bolts were removed by use of pneumatically operated impact wrench units supported from the in-cave hoist hook by a wire cord. The wire cord was used to allow the recovery of the tools when, as inevitably happened, they slipped out of the manipulator jaws holding them. The end fitting on the tool was pinned so that it could not drop away and was also pivoted to provide local movement to assist with locating upon the nuts.The TV camera was used to help the operators guide the tools to all positions and in almost all cases, with much operator skill and perseverence, the bolts were remotely removed. This enabled the steel support girders to be dismantled sequentially and then removed from the cave for final disposal as LLW using slings supported from the in-cave hoist. It had been intended to attempt to decontaminate some of these steel items, but small amounts of residual contamination were such a problem that this plan had to be dropped and the materials were wrapped in PVC and placed into an ISO container for disposal at the UK's LLW facility at Drigg.

The next stage of the work involved the remote decontamination of the internal surfaces of the caves to a sufficiently low level to allow the man entry manual decontamination to be undertaken. Agreement was reached with the client for man entries to commence when a mean dose rate of ~250μSv/h was reached in the centre of the cave. In order to achieve this level, all accessible surfaces were first vacuum cleaned using standard tools held in the long-reach VNE-80 manipulators. These manipulators are ideal for the purpose as with the electric arm extensions the jaws can reach the cave floor and almost the full depth of the cave, since manipulators are installed on both sides of the ~3m internal width of the facility. However, the really difficult surfaces to reach were those above head height. Vacuum cleaning heads were developed to use suspended from the in-cave hoist but it proved very difficult to deploy them remotely. However, further ingenuity by the operators led to the development of an alternative means of cleaning contamination from some of the high level surfaces. The in-cave hoists were powered by a cable fed from a shielded service area at one end of the cave, Figure 1. At the high-level access position for the cable there was a small opening that allowed a specially made vacuum brushing head with long attached suction pipe to be introduced. The suction pipe from this unit was connected to the in-cave vacuum cleaner using the manipulators and the head was then moved along the hoist rails using a set of steel connecting rods. This allowed ~10m lengths of hoist rails and adjacent surfaces to be vacuum cleaned quite effectively in an almost fully remote manner. Significant levels of contamination were collected in the vacuum cleaner as a result of this work, demonstrating that it had been effective. The key feature of this work had been to capture the enthusiasm and ideas of the operators and assist them in the development of simple but effective tooling to overcome what first appeared to be an impossible task.

At this stage of the remote decontamination of the caves, it was necessary to monitor progress towards reaching the 250μSv/h dose rate in the cave centres. A small cylindrical gamma dose rate monitor was used for this task, connected to a coaxial cable supplying the power and output to a Harwell 6000 series rate meter. These simple monitoring heads are calibrated in

the laboratory before use and provide a robust means of monitoring dose rate throughout the facilities. Hotspots of activity were thus identified and then abraded using mainly air-operated grinding tools held in the manipulator jaws. The abraded areas were then vacuum cleaned to recover the loosened active debris. The main active areas were located on the cave floor but in a few cases hotspots were also located in crevices around the shielding windows. These latter positions were very difficult to reduce in activity to the extent planned but vacuum cleaning and scraping with thin manipulator-held tools did effect some local activity level reductions.

Once the target dose rate had been achieved for man entries, the process of manual decontamination of the caves could commence. The first major operation was the removal of the installed VNE-80 manipulators, involving recovery of the slave arm using the in-cave hoist and then the removal of the master arm and through tube. For the NCL the first stage of the manual decontamination process has already been completed on all seven caves, Figure 1, and the local dose rates in the cave centre have been reduced to levels in the range 20-100μSv/h. Entries were initially made through the east end of the line at Cave 7, taking care to maintain depression in the caves provided by the installed hazard extract fans. Later, entry positions were taken forwards progressively, from Cave 6, Cave 5 and then Cave 3 as work was completed. The operators wore suitable personal and respiratory protective equipment as appropriate at the time. Initially the operators wore full airline fed suits with disposable crash suits on top; later, as contamination levels reduced, half-suits were used and finally 'Breatheasy' units, a type of powered respirator.

One of the first in-cave operations once the general levels of loose contamination had been reduced was to cut away the in-cave hoist rails located in recesses in the external walls about 3.5m above the floor. The rails, together with the supporting steel I-beams upon which they were mounted, were progressively cut away in short sections using an oxy-acetylene unit. However, due to concerns over operator safety and the ever-attendant risk of fire, a compact electric circular sawing unit was subsequently used to cut the hoist rails and a reciprocating saw for the 15cm x 7.5cm support beams. The operators carried out these tasks whilst working from small pneumatic or hydraulic safety platforms. Space does not permit further discussion here but these units were vital to the overall manual decontamination process since they allowed all in-cave surfaces to be accessed to allow stripping of their overlaid protective paint and contamination. It should however be noted that on the south face of the caves, the hoist rails ran along the walls at about the same height as the encast hazard extract ventilation ducting. During the hoist rail cutting operations, local shielding in the form of sheets of steel were placed behind the rails to reduce doses to the operators. This was quite effective in cutting down operator exposure and partly influenced the change in cutting procedure referred to above.

Having now removed the hoist rails, all in-cave surfaces were vacuum cleaned again, particularly the levels above 2.5m high around the manipulator ports and the hoist rail recesses in the external walls. Next, decontamination gels were applied with paint rollers over the whole cave surface and left in situ for about 2-4 hours to digest and loosen the surface contamination. The surfaces were then washed with a hot water spray and the effluent recovered using a standard wet-vac system. Significant activity was recovered by these means and the recovered effluents were disposed of via the site-based active effluent plant. As might be expected, the principal isotopes identified in the effluents were Co^{60} and Cs^{137}. The process of application of gel and removal with water was sometimes repeated when necessary, depending upon the levels of surface contamination in the particular cave.

Once the cleaned surfaces were dry, they were then abraded using a range of suitable tooling that had been found effective for the purpose. The cave surfaces were both painted steel and concrete and 'Trelawny' units were used with suitable inserts to abrade them. These tools, Figure 4, comprise a series of hardened steel inserts connected to a central rotatable spindle by narrow leather strips.

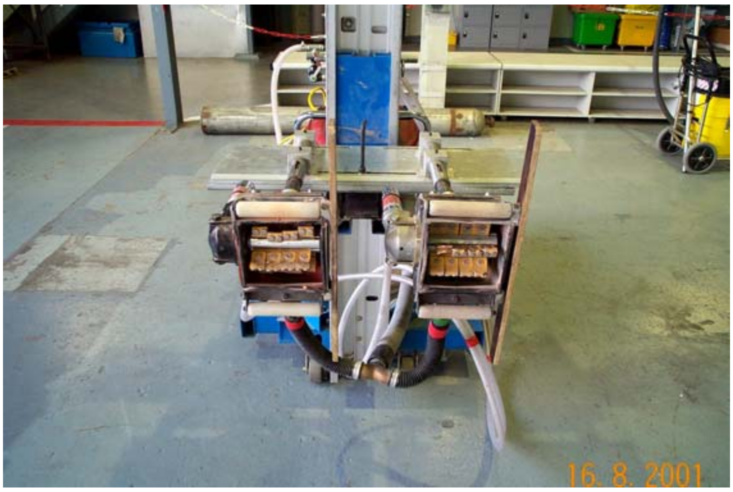

Fig. 4. View of Trelawny Surface Scabbling Unit used in PSA Facility

The units are located inside a semi-circular housing from which a vaccum cleaner draws the air, dust and contamination freed by the abrasive action of the inserts. They can be operated either electrically and pneumatically but the operators developed a preference for the electrically driven units, which tended to be more powerful. In each cave, the removal of all the paint from the walls, floor and ceiling led to a significant reduction in activity levels with dose rate reduced to around 20µSv/h in caves 4-7 and around 100µSv/h in Caves 1-3. At this point the surfaces were resealed with various paints to protect them into the next stage of the cave decontamination and decommissioning process. This allowed the cave windows to be drained of their zinc bromide and then removed from the structure. The means of carrying out this routine task lies outside of the scope of the paper, but it should be noted that each window comprised three items, a concrete framed tank holding ~920 litres of zinc bromide, a 100mm thick lead glass attenuator block and finally a 30mm thick piece of lead glass to seal the internal face of the cave.

NEXT STAGES OF DECOMMISSIONING THE NORTH CAVE LINE

At this point, all seven caves of the NCL have been manually decontaminated down to relatively low levels of activity and the caves now have had all services, windows and other items removed. The next steps are to remove contamination from two final sections of the cave structure, the encast hazard ventilation extract ducting and the interspace between the in-cave shield doors and their associated wing walls, Figure 1. It is the contamination associated particularly with the hazard ventilation ducts that accounts for the residual activity levels, particularly in the case of caves 1-3. This work is currently at an early stage but the means of carrying them out have both been established.

The inter-cave doors are hydraulically operated and a horizontal cylinder moves the ~26Te structure on rollers backwards and forwards in an interspace between two slimmer ~20Te wing walls set into the inner faces of the outer wall structure, Figure 1. Above the walls and door there are a pair of hydraulically operated wing-flaps that seal each cave off at high level but when raised allowed the electric hoist units to traverse the whole length of the facility. These wing-flaps have already been cleaned and stripped of paints so are relatively clean. However, the internal surfaces associated with the shield doors are still contaminated since they cannot yet be exposed.

Briefly, an external wall concrete shield plug will be freed and then removed into a ventilated enclosure constructed around the outer cave wall such that the interspace between the two wing walls can then be exposed. It should be noted that the interspace between the wing walls is only ~0.5m wide so man access is not possible at this position. The access will nevertheless permit the vacuum cleaning of the interspace and the fixing of residual contamination using a sprayed water-soluble adhesive once levels have been reduced by use of long-handled tools to allow the walls to be physically removed. This latter process will be carried out using a large, powerful fork-lift truck capable of lifting up to 40Te. The wing walls, which each weigh ~20Te each, will then be removed from the caveline, laid into the horizontal plane and decontaminated using a series of mechanical processes similar to those already described. The cave door units, of which there are five sets each weighing up to 26Te, will be recovered and processed in a similar manner. Most of the materials resulting from this decontamination will end up available for free-release disposal, saving valuable LLW disposal volume at Drigg for more difficult materials.

The final steps will concern the decontamination of the hazard ventilation ducting. This facility is a good example of the 1950's design where there was no consideration given about final decommissioning of the caves. The steel-lined ducts are about 45cm x 15cm in section and >20m long, largely located inside the cast structure of the outer 2m thick cave walls and below the building floor. However, there are open extract ports at high level in the cave, and it is planned to vacuum clean from these positions along the steel ducts to reduce activity levels down from the high tens of mSv/h to more manageable 1mSv/h dose rates. Some surface abrasion may be required but if the levels do not reduce as required, the ducts will probably be grouted to seal them and the steel sections recovered later when the facility is demolished.

MINIMISATION OF WASTE VOLUMES

Throughout the decontamination stages of the NCL, close attention has been given to minimising the amounts of LLW generated. The target for the building as a whole is 750 cubic metres of LLW and currently the quantities generated lie somewhat below this target for the stage of the project that has been reached. This has been achieved by close attention to dismantling and size reduction of items before disposal. Where possible materials have been size reduced such that they can be placed into 200 litre IP2 drums, which can subsequently be supercompacted to further reduce volumes. Larger steel items such as the bench plates and support girders have been wrapped and placed into ISO containers for disposal. The packing has been carefully controlled to ensure maximum volumes are contained in the ISO. Very little ILW has been generated during the decontamination and the target is <0.5 cubic metres. This has been achieved by removal of contamination from items and vacuum recovery wherever possible to minimise the volumes. To this end, a cyclone-based vacuum system has been utilised for some time to recover active particulate, allowing the waste bin to be directly

emptied without any accompanying filter. This type of system is commended to other groups carrying out similar tasks.

MINIMISATION & CONTROL OF OPERATOR DOSE UPTAKE

Finally, all operator exposure to radiation dose has been carefully monitored throughout this project. Before man entries are undertaken into a cave, a dose budget is drawn up against a series of tasks that are to be carried out. Experience has shown that these dose budgets have been reasonably accurate and to date about 150man-mSv of the total dose estimate of 210man-mSv has been utilised. The most difficult stage of the project has been reached with individual dose restraint targets for the year, 8mSv, being challenged by the overlapping of man entries in 2002 and for those planned for 2003. However, given reasonable operator flexibility, this challenge can be met and overcome.

One issue that is worth commenting upon concerns the types of instrumentation used to record dose and the wearing of the 'Legal Dosemeter'. When the project started, all operators wore film badges, which were processed monthly for the legal dose to be recorded, together with a personal indicating dosimeter (PID) when carrying out special operations. Later, the legal dosemeter was changed within RWE-NUKEM to an OSL (Optically Stimulated Luminescence) type and early results have shown significant discrepancies between doses recorded in-cave from these dosemeters, the PID's and film badges. In many cases, the newer OSL units are recording larger doses than the PID's. The variations in doses appear to lie between a factor 1-2 for reasons that may be due to the presence of significant amounts of beta radiation in-cave that is more readily recorded by the OSL units than the PID's or the film badges. Work is continuing to study these effects in more detail.

ADDITIONAL DATA FROM PSA DECOMMISSIONING

The tasks described above will be progressively utilised within Building A59 to decontaminate and finally decommission the two large concrete shielded cave lines. However, some further experience has been gained during the decommissioning of another facility, the Pressurised Suit Area, (PSA), that is worth recording.

As constructed, the PSA comprised a large open working area roughly 9.4m x 18m with an associated control room on the west side and an exit shower cubicle, Figure 1. It was designed for operation with radioactive items that were mainly alpha contaminated with associated but relatively medium-level beta/gamma activities. The starting point for the decommissioning of the PSA facility was to establish the extent of alpha and beta/gamma contamination on all surfaces and to use this information to determine whether the wastes would be LLW (low level waste) or PCM (Plutonium contaminated materials). Wet and dry swab samples, together with paint scrapings were taken from a wide range of surfaces to establish the pre-existing contamination levels. Samples were also taken from the below ground drains for the same purpose. The swab samples were then analysed for all the major alpha and beta/gamma emitting isotopes from which it was shown that despite earlier concerns to the contrary, the wastes could all be consigned to the LLW category. This was a major advance, since the client had fully expected that much of the PSA wastes would fall into the more expensive PCM category. Additionally, the analytical results enabled a standard 'Fingerprint' to be established for the PSA waste stream, used to provide the data for all isotopes required to enable them to be taken to the UK's LLW disposal facility.

The experiences with the decontamination of the PSA have highlighted a number of issues concerning techniques and equipment that are worth sharing. In this instance, operator dose from direct radiation was never likely to be a concern but inhalation of alpha-bearing dusts was a major concern. Thus, for a significant period of time, the operators were required to wear full airline-fed suits for personal protection during the decommissioning work. Later, when the whole facility had been cleared, and the surface stripping and decontamination phase commenced, the airborne activity levels were sufficiently low to enable the operators to wear 'Breatheasy' units instead, which are a powered respirator with high efficiency filters built into a PVC hood. The advantage here was that the operators were less encumbered, could move freely around the facility without the attached airline and generally found the items comfortable to wear. The downside was that these units were not provided with an intercom system and thus operators had to be properly briefed about their work before commencing operations. All operators are required to attend a whole body monitoring session twice per year and to date there has been no sign of any change in body burden as a result of the work carried out in Building A59. We can thus conclude that the RPE equipment has performed well and has been fully satisfactory.

The equipment used was mainly electrically operated and great care was taken to minimise the harmful effects of vibration from tooling on the operators' hands and arms. Tooling selected for use generally had low vibration factors and was only used in a continuous manner for the recommended timescale. Generally, these items operated reasonably reliably, and few motor failures occurred. The Trelawny units in particular were very successful, and the ability to swop the steel inserts to suit steel or concrete surfaces was especially valuable. A variety of other tools were purchased, including a rotating diamond abrasive cleaning head, but this was not so successful on the walls and the unit had to be supported from a Genie unit due to its greater weight.

The Blastrac equipment worked very well and almost all the painted floor was stripped using this tool. This unit stripped surfaces by a shot blasting technique but the key features that were so useful were the simplicity of operation and the design of the cyclone debris recovery system. This powerful cyclone unit allowed the active materials removed by the blasting to be directed to and then retained in a drum that could then be recovered and emptied directly. No associated filter medium was involved and this greatly aided the minimisation of waste volumes. This system, although moderately expensive relative to standard vacuum cleaner units, is thoroughly recommended to other operators carrying out a similar task.

CONCLUSIONS

The full decommissioning of the cave lines in Building A59 is progressing according to schedule, with completion due by November 2006. A combination of good forward planning, the harnessing of operator enthusiasm and skill, the use of simple and adaptable tooling together with the support and confidence of the client are leading steadily towards a successful outcome.

As a result of the operations carried out during the decommissioning of the pressurised suit area (PSA) a number of additional lessons were learnt including the provision of tooling with a low hand/arm vibration factor to maximise the duration of their use. Many of the procedures utilised here should easily be replicated in operations of a similar nature required as further redundant nuclear facilities in Europe and the USA are identified for decommissioning.