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DISMANTLING OF A CONCRETE SHIELDED FACILITY

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ABSTRACT

Decommissioning processes have been developed for a small but heavily contaminated, concrete-shielded remote handling cave as a precursor to operations on two much larger facilities within one building at the United Kingdom Atomic Energy Authority's (UKAEA) Winfrith Technology Centre. Techniques have been developed to maximise the amounts of contaminated materials that can be removed from the cave remotely in order to minimise operator dose uptake. This has been achieved using both shielded flasks and other semi-shielded containers together with setting of maximum dose-rates on removed items. Man entries with well established cleaning techniques have been used to reduce the contamination levels such that the whole structure can be dismantled. Particular attention has been paid to provision of a safe lifting arrangement for five 40Te concrete shielding blocks, which form a major part of the structure. Additionally, methods are being developed to demolish 36 cubic metres of steel-reinforced concrete in a simple and cost-effective manner. Finally, a protocol has been developed for the removal of paints and contamination from the large concrete blocks and many other items with the objective of achieving free-release disposal, thereby saving considerable sums of money for the contractor and ultimately the client. A commercially based shot blasting technique will be utilised here to achieve the required levels of cleanliness demanded by the appropriate regulatory authorities.

INTRODUCTION

Cave 9 is actually the newest of the three cave facilities in the UKAEA's Winfrith Active handling Building A59, having been planned and constructed over the period 1972-1976. The structure, described later, provided a small single concrete-shielded cave that was used for a variety of tasks up to 1996, when arrangements commenced to take it out of use prior to decontamination and dismantling.

NUKEM Nuclear Ltd (NUKEM) was entrusted with developing processes and safety cases to allow firstly the clearance of the cave, followed by decontamination and finally, total dismantling to allow disposal of the debris. NUKEM was further incentivised by the commercial arrangements to establish a means of maximising the free-release of the facility structure. This applied mainly to the five 40Te shielding blocks embodied in its construction, 13 further 2.5Te shielding blocks and 36 cubic metres of site-poured steel-reinforced concrete.

This paper sets out to describe the details of the approaches adopted that were believed to show the greatest potential for a successful outcome, not the least with an eye to the commercial aspects. There is a clear timeframe for completion of the task by mid-April 1999 and so the concept of availability of unlimited time and resources on this project was entirely inappropriate.

Finally, the nuclear industry constantly strives to improve safety and drive down operator doses, particularly in decommissioning older plants and facilities not necessarily constructed to modern standards. This report makes reference to the means of striving to achieve these twin objectives in the context of a commercially focussed project.

DESCRIPTION OF THE FACILITY

The cave structure, which is a free-standing facility, was conceived mainly on the basis of the availability of five large 40Te shielding blocks displaced by modifications from one of Building A59's other cavelines. Externally the cave is about 8.2m wide and 4.8m deep, the 1.5m thick shielding walls thus leading to internal cave dimensions of about 5.2m by 1.8m. Due to details of its construction, (Figure 1), the facility has two different roof levels. One is about 4m above the ground in which is provided a large diameter posting port for use with shielded flasks. The other is at 5.6m height and contains a smaller port over which is mounted a glovebox and posting facility for introduction of consumable and other small items. The facility has two operating stations on its western face, one containing an unsealed full-size zinc bromide window and the other a similar half-size window. Each station is provided with two unshielded Mark 9 master slave manipulator units introduced through penetrations above each window block. The cave internals are illuminated by three large 'Solarcolour' vapour lamps conventionally mounted between the pairs of manipulators.

As noted above, the facility embodied five 40Te shielding blocks, each about 2.7m wide, 1.5m deep and 3.7m high. Two of the blocks contained a 250mm diameter full-depth posting port located below the centreline of the main face whilst all contained two smaller diameter service line penetrations at the sides of this face about 1m above the ground. Two of the blocks formed the main roof shielding at the south end of the facility whilst the other three formed parts of the north, east and south walls, Figure 1.

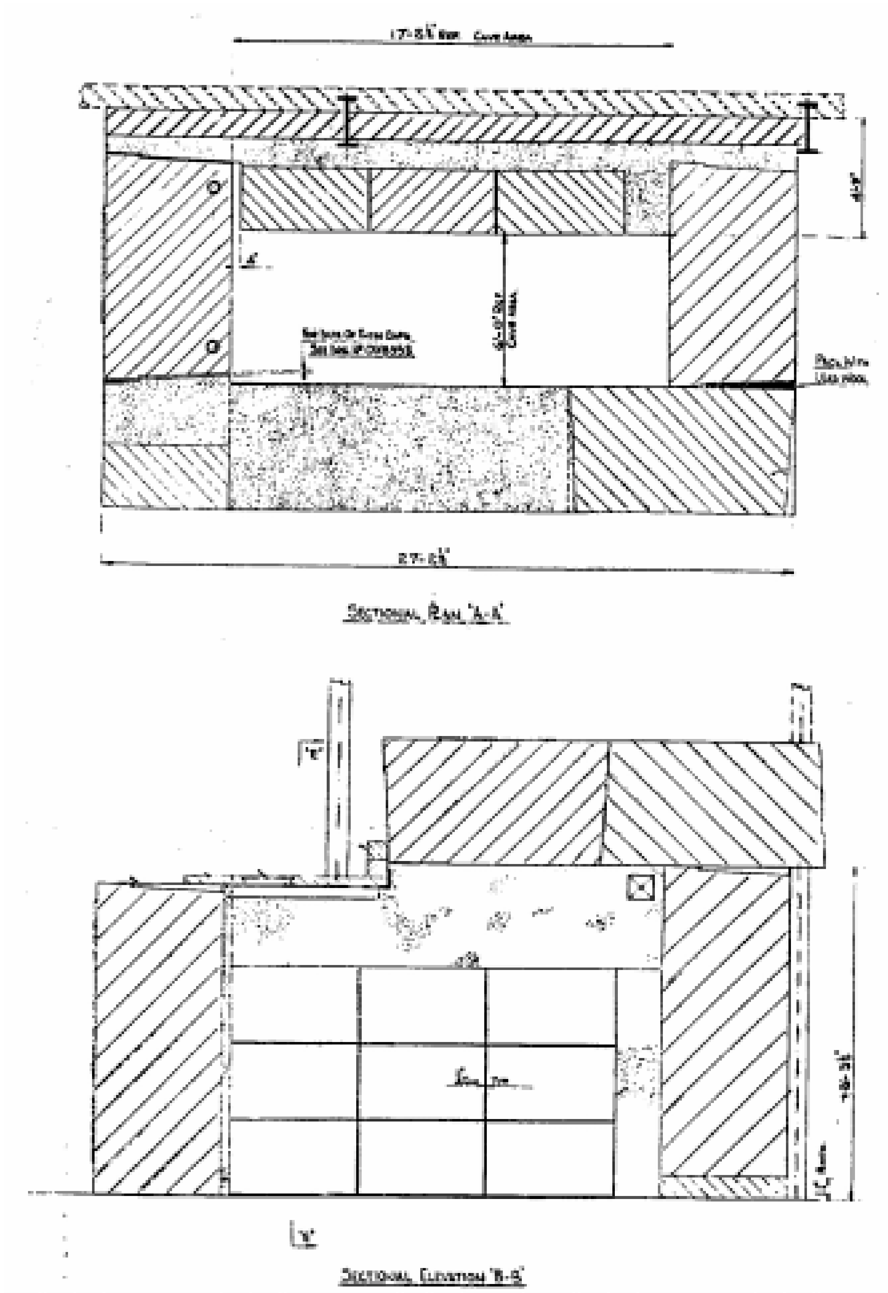

Figure 1: Diagram of Structure of Cave 9

The structure also utilised a total of thirteen additional smaller concrete blocks, nine providing greater shielding internally and four built into the cast section of the north wall. The remainder of the facility was completed with steel-reinforced concrete, using about 36 cubic metres of new material in all. Most of the internal surfaces of the facility are clad with painted mild steel sheeting to minimise contamination of the structure, particularly of the in-situ poured concrete. This includes the floor area and the walls up to full height but not the facility roof area. All inter-plate joints were metal sprayed for effective sealing of the finished structure which was finally painted to provide a clean and light-reflecting surface.

At the north end of the cave a large roof-posting facility for flasks was provided utilising a 200mm thick steel plate about 2.4m square with a plugged penetration about 610mm in diameter at its centre. This plate was supported on three sides by the concrete structure and on the fourth side by a cast-in steel girder spanning the facility There was no provision of any transfer chamber to allow removal or maintenance of in-cave equipment. The ventilation arrangements are provided within the higher roof area of the cave, the extract being located towards the south east corner. There is only one extract fan, shared with another building facility, and at the roof area there is a single set of unshielded spark arrest and absolute filters.

The stainless steel bench, which covers the whole area inside the cave, is supported on a painted mild steel framework, bolted together and supported just under 1m above the floor. There is an 0.5Te electric hoist spanning most of the bench top, supported from two steel rails running along the cave axis at the roof height. As well as the total of four master-slave manipulators, the cave is supplied with basic electric, pneumatic and hydraulic services, introduced through the service ports via stepped, spiral-shaped shield plugs.

STARTING CONDITION OF THE CAVE

Over the intervening years since construction, Cave 9 has been used for the inspection and dismantling of a wide variety of mainly non-fissile materials. However, the last main task in this facility concerned an experimental programme of coated-particle fuel burning, with the objective of achievement of a significant volume reduction of this unique fissile material. However, some of the ~1mm diameter coated particles that had been successfully recovered from the larger compacts were spilt onto the cave floor during decanting operations. The precise amount is not known with certainty but the construction of the cave made its recovery from the floor impossible except during final decommissioning. Local dose rates of >100mSv/h are recorded at certain areas of the floor as a result. The recovery of this fissile material is one of the major tasks involved with the decommissioning process.

The cave is also host to a 90Te hydraulic press that is used to compact all the ILW materials produced throughout the cavelines in the building. Before anything else can be done, this unit will have to be decontaminated, dismantled and moved to a new location in one of the other cavelines to continue to provide this essential service for all current and future work programmes. Dose rates from this item are currently about 50mSv/h in places and very substantial reductions will be required to effect its relocation in a safe and acceptable manner.

The cave currently contains some 'pucks' of compressed ILW arisings, numerous hand tools and other waste from past programmes as well as several LLW cans that are used to hold contaminated swabs and other low-active waste items. The bench top is provided with five penetrations that were used in the past to hold/store various cans of materials from the test programmes. The penetrations vary in diameter ranging from 100mm to around 300mm. Most are fitted with closed-end stainless steel inserts of varying size/design to ensure that items/debris do not fall to the floor and thus become inaccessible, as was the case for the coated particle fuel referred to above. Activity levels due to contamination are not immediately available due to the accumulated ILW but it will be another major objective to establish the starting position once the main ILW sources have been removed.

The cave rear wall in front of the larger window is fitted with two sets of heat exchanger pipes left from the earlier fuel burning experiments. Their starting condition is very dirty and it will be necessary to either remove them remotely, if possible, or clean them down sufficiently for manual removal at a later stage. The fact that the mountings penetrate the protective steel cladding on the cave interior will need to be taken into account when planning their removal. Additionally, the whole cave rear wall contains an internal shelf about 250mm wide at the top of the nine internal shield blocks, Figure 1. This shelf, and other horizontal surfaces at elevated heights within the cave, will present a particularly challenging task to monitor and clean during the process of the facility decommissioning.

The visibility of the above-bench areas of the cave is reasonably good, but the view towards the south end is restricted by the half-width window with some areas completely invisible directly. On the basis of an initial visual inspection, the walls of the cave are in a reasonable state and the paint is still adhering to the cladding. Plans will be made to further inspect the south end of the cave and the below bench condition using a miniature TV camera and light lowered through one of the unlined bench penetrations in front of the larger window. This will be another main objective for the programme.

All the installed cave services are available at present with no major concerns. In particular the electric hoist operates in a satisfactory manner and great care will be taken not to hazard this unit during decommissioning as it provides the only useable lifting capability within the cave. Failure of this hoist would present difficulties with future decommissioning activities due to the absence of any shielded maintenance facility.

DEVELOPED PLAN FOR DECOMMISSIONING & SAFETY CASE PRODUCTION

This is the first significant facility to be decommissioned involving a concrete-shielded cave on the Winfrith site or indeed anywhere else within UKAEA. There are other redundant facilities within UKAEA's area of responsibility but this is the first that will be taken past established first and second stages of decommissioning, the latter often referred to as post-operative clean-out (POCO). The clear objective for Cave 9 is to fully dismantle the facility by mid April 1999.

In broad terms, these operations can be grouped into eight steps: -

- Preparation of safety cases to allow the decommissioning operations to be carried out
- Relocation of the ILW press.
- Cleaning and clearing of items from the cave.

- Preparation for man entries and physical cleaning of the cave.
- Removal of large roof shielding blocks and in-cave crane
- Removal of small internal shielding blocks and cladding
- Demolition of cave walls and recovery of two remaining large shielding blocks
- Removal of paints and contamination from concrete blocks to allow free- release disposal.

OPERATIONAL PROGRESS TO DATE

Initially, considerable effort was expended just clearing loose items from the cave bench. All the accumulated ‘pucks’ of crushed ILW were placed into a suitable stainless steel container that was lidded and then removed via the cave roof port into a shielded flask mounted upon a circular gamma gate assembly. Then the bench top was swept to pick up loose debris and a number of low level waste (LLW) cans were packed with unwanted items and scrap to clear a working space in front of the main window.

The next step involved the introduction of three simple but crucial items of equipment, a circular vacuum cleaner and hoses, a cartridge type gamma monitor and lead and finally a miniature self-focussing, low-light TV camera and lead. The cabling from all these items was introduced through standard service ‘bullets’ located in the front cave wall. These simple items were then used to good effect to identify, measure dose rates and then to recover dirt and dust from around the cave.

At this point a full gamma dose-rate survey was made of the in-cave bench and walls where these could be reached using the manipulators or the in-cave hoist. The starting dose rates in the cave were thus established as lying in the 1-50mSv/h range, giving a clear indication of the scale of the work to reduce these levels to a target of ~200μSv/h in the cave centreline before man-entries would become possible. Removal of a bench cover plate also revealed that there were dose rates of up to >100mSv/h over the floor due to the spilt fuel kernels. Swabs were also taken from the bench and walls to establish the nature of the surface contaminant and to support the production of the two main safety cases associated with the ILW press relocation and the full decommissioning of the cave.

Having worked out the processes required to allow the decommissioning of Cave 9 to proceed, the next step was to prepare the safety case to allow the relocation of the ILW 90Te press. Originally it was thought that this unit would have to be dismantled to reduce activity levels sufficiently but an in-cave activity survey suggested another approach. Most of the dose was coming from a region below the main press body (Figure 2) where debris and squeezed fluids had accumulated over a period of time. By making a set of small hand scrapers and similar items, the vast bulk of this activity was removed such that local dose rates were substantially reduced to allow removal in one piece. This proved the value of simple dose-rate reduction techniques in achieving cost-effective equipment relocation rather than the more labour intensive and dose absorbing alternative of total dismantling and re-assembly.

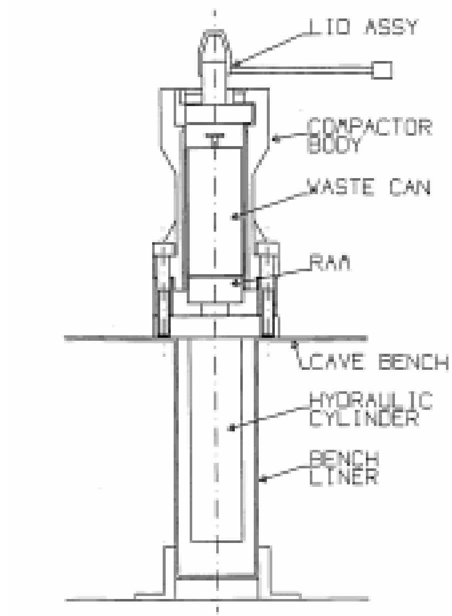

Figure 2: 90 Tonne Press

The final approved safety case allowed the cleaned but whole unit to be raised out from the facility roof via a large entry port using an overhead crane. The top was enclosed in a PVC bag to contain contamination and the base was lowered into a steel liner that was subsequently used in the new location to support the press in a large framework. A fork-lift truck effected the movement of the enclosed press to the transfer chamber of the North Cave Line (NCL) where later the unit was craned into the cave and placed into a prepared support framework and surrounding tray to allow continued use. Man absorbed doses arising from the transfer were very low, minimised by careful contamination control and maximising staff distances from the relocated items wherever possible.

The safety case for decommissioning the whole facility was then prepared and approval subsequently achieved. The basis of the safety case relied upon the maximisation of remote cleaning and clearing of the cave, with continued operation of the installed ventilation system. As noted above, large reductions in dose rates were required in-cave before direct intervention by staff. The objective set was completely strip the cave interior such that only contaminated walls, roof and floor remained if at all possible. Bearing in mind that parts of the cave could not be directly viewed or even reached by manipulator, this was a difficult target to achieve from the outset.

The next stage centred on the long process of clearing and remote cleaning of the redundant facility, an operation that occupied a period of about 6 months. The highlight here was the ability to capture the skills and enthusiasm of the small team carrying out the work and to be ready to listen to their ideas and suggestions along the way. Remote dismantling of large items in-cave in a controlled manner is a difficult task but here the use of air operated slitting wheels held in the manipulators proved highly effective. This allowed the cave benching to be slowly recovered and size reduced to allow removal in sections by overhead crane through the posting port in the roof. The in-cave crane was also used to pull the immediately inaccessible sections of benching towards to main operating window to effect the recovery operations. This combination of ad-hoc techniques proved very effective and ultimately all the bench structure and its steel support framework were removed, largely as LLW. Processes rejected here were plasma torch cutting and hydraulic nibbling; the reasons for rejection largely centred upon the very small cave volume and the need to use small lightweight tools in most cases.

Mention was made earlier that there was a quantity of fissile material spilt on the cave floor from a previous operation. The in-cave monitor confirmed high activity levels (>100mSv/h) in many positions in the area below the main operating station, (Figure 1). Use of a simple vacuum cleaner, guided to locations by the TV camera, allowed almost all of this fuel to be recovered within a few weeks. The cleaner bags were carefully placed into metal transfer containers and posted out from the facility roof port with a shielded flask. The use of standard metal extension tubes attached to the cleaner body allowed the floor to be reached in a situation where the installed manipulators could not.

General cleaning of the whole of the cave floor produced another piece of ingenuity, a small wheeled vacuum cleaner unit being made and installed, the ‘vehicle’ being pushed into inaccessible areas using adapted ‘drain-rods’ held with manipulators. The unit also carried a simple gamma monitor to allow an immediate assessment of progress, a valuable tool under any circumstances. An additional tool used almost throughout this stage of operations comprised the cheap low-light TV camera. This proved invaluable in the process of inspection of the bench and support structure and to guide the air operated saw to the appropriate bolts for cutting.

During all the 20 or so posting out operations not involving the use of flasks, man-absorbed doses were carefully minimised. A limit of 2mSv/h was set on any removed item, and the use of the in-cave monitor was crucial in limiting the false starts that can often occur with these operations. During these postings the total dose absorbed by about six staff was around 750μSv, a relatively low figure under the circumstances. In a couple of cases, cans of higher dose rate up to 10mSv/h were removed and quickly lowered into a concrete shielded drum (termed a bertha) to reduce local dose-rates. Such a process is well developed at Winfrith and can be commended as a valuable and cost-effective tool in circumstances where low levels of contamination but higher levels of radiation are expected.

During the posting-out operations staff noticed that the open hole (~1m diameter) provided an excellent view of the upper levels of the cave. In particular, the higher heat exchanger pipes could be seen and a section of the 300mm wide shelf running along the rear wall and the crane rails. The opportunity was taken using long rods with swabs attached to clean contamination off all these surfaces. The process was very simple and effective with dose rates reduced to a 200-400 μSv/h. The operators also took the opportunity to use a set of extension rods to swabs the clear floor from this position once the benching had been removed. This process was also beneficial in further reducing dose rates at the floor which in general lie in the 300-1000μSv/h range. Man absorbed doses during these unusual operations were minimal due to the large distances involved. This is another example of operators’ ingenuity being harnessed to good effect.

In order to make man entries into the cave a target dose rate in the middle of the cave of 200μSv/h was set by the client's responsible officer. The remote cleaning process has achieved this target over almost the whole cave, with a maximum level of <300μSv/h in just a few positions with levels around 150μSv/h in others.

To sum up the fully remote decommissioning operations, great use has been made of simple and reliable tools in order to facilitate the almost complete removal of items from the cave and to achieve the required dose rate target. A major contribution to achieving this objective has been the ingenuity, skill and enthusiasm of the operators, coupled with a modicum of good fortune. The only items remaining in-cave at the end of this stage are the two sets of heat-exchanger pipes attached to the rear cave wall. The dose rates on these items lie in the 200μSv/h range and will be readily removed during the early stages of man entry.

Mention must be made at this stage about details of the approval of the overall safety case that finally permitted the full decommissioning and demolition of the cave structure. The approval identified a number of hold points along the path to demolition where it was prudent to provide a review of progress to date and confirmation of the continued applicability of the safety case. This allows the client to have confidence during a long and complex task that operations carried out to date have not compromised the safety case. This provides a valuable check, which enables safety to be maximised throughout the project, and a regular comparison made between actual and predicted man absorbed doses.

NEXT STAGE OF OPERATIONS

Once man entries occur, use will be made of a range of standard processes to reduce local contamination levels quickly. Operations will commence from the north wall, where a 2.44m x 2.44m steel plate weighing 9Te and a 40Te concrete shielding block will first have been removed into a tented enclosure, (Figure 3). Use will be made of long monitoring probes to locate and confirm the major sources of direct radiation in the cave. Current assessments show that these are located in the area immediately adjacent to the access position. Consideration was given to location of an alternative access point but for other operational reasons this could not be achieved. Use will be made of long handled tools and swabbing devices to slowly enter the cave from relatively low dose rate positions, working forwards with one operator at a time, supported by another held back until appropriate to exchange them. The heat exchanger pipes will be quickly cut away using a hacksaw, the weight being supported by the in-cave hoist. Cleaning and size reduction of these low dose items will take place at a suitable position within the tented enclosure, away from the higher activity levels of the cave. The cave extends in height to about 3.7m and the contamination will be removed from higher levels using a small battery powered hydraulic platform. This has the advantage of simple controls allowing movement and elevation within the 1.8m wide cave. There are safety rails surrounding an operating platform of about 2m x 1m, allowing simple access to both side walls and the roof of the facility, whilst keeping back from the contaminated surfaces throughout. This is expected to deliver significantly reduced operator body and extremity doses during the vital first stages of cleaning whilst providing a very safe means of reaching the high levels that often gives rise to problems under normal circumstances.

Figure 3: Lifting of Square Steel Support Plate from Cave 9 Roof

Further activity level reductions will also be obtained by the use of a water-based strippable paint. Results on a glovebox have shown these materials can be used very effectively to further reduce fixed contamination levels often experienced towards the end of manual cleaning operations. Once removed the surfaces will be re-monitored to locate ‘hotspots’ that will require further attention. A final application will be made to act as a tie-down coat for any residual contamination when the next phase of disturbance of the cave structure commences.

The next stage will involve the removal of two further 40Te shielding blocks that are located at the roof level, (Figure 1). There are no real innovations to report with these operations that mainly concern the need for care when lifting large heavy items such as these blocks. Use is to be made of modern epoxy-resin securing arrangements to attach lifting features to each block at appropriate positions. These must be capable of both supporting the direct loads during block lifting as well as those incurred during subsequent block turning operations. Removal will then allow the recovery and disposal of the in-cave hoist that will no longer be needed at this stage of the decommissioning. In order to maintain a small depression on the facility, the open roof will be enclosed using PVC wrapped scaffolding planks. Additionally, an air mover system will be installed in the wooden roof area to replace the larger capacity system originally installed into the structure. This can be justified at this stage of decommissioning due to the much-reduced levels of activity and contamination present.

The final stage in the progress to decontamination of the facility will be achieved by removal of the steel cover sheeting that was placed over the internal surfaces prior to cave operations commencing. The sheets were screwed to the concrete walls and the joints were metal sprayed to provide a seal against contamination. Work will commence at the south end of the facility farthest away from the entry position and progress steadily towards this location. As plates are removed the exposed wall will be sprayed with strippable paint to seal the clean surface against possible fresh contamination. When completed, the sheeting will be disposed of as LLW and the cave interior should now be clean and capable of free-breathing operations. This will naturally need to be confirmed by monitoring.

Operations should now move to the final phase that involves the recovery of nine 2.5Te shielding blocks from the inside of the cave and then the cutting and demolition of 36m3 of reinforced concrete sections of the walls. It is planned to cut the walls using a diamond impregnated rope system, as this is very efficient for cutting steel and concrete structures with minimal use of water as a lubricant. This will then allow the attachment of lifting points and the recovery of the final two 40Te concrete shielding blocks that form the part of the cave structure. The site will then be completely cleared by the removal of all active and non-active debris, the latter materials being passed into a free-release disposal route.

FREE-RELEASE OF CONCRETE BLOCKS & OTHER MATERIALS

There is one further set of operations that NUKEM must carry out in order to achieve the free-release of the concrete recovered from the facility for which it has accepted responsibility. A detailed protocol has been developed with the assistance of the UK Environment Agency to cover the means of cleaning and proving the state of the recovered materials. This will involve the removal of layers of epoxy paint and associated contamination from all the concrete blocks and the recovery of cored samples from agreed locations for testing to prove that the materials really are uncontaminated and non-activated due to neutron bombardment.

The cleaning of the paint and contamination from the blocks will be achieved using commercially available shot blasting equipment called ‘BLASTRAC’. This process provides for the energetic impact of 1mm diameter steel balls onto exposed surfaces and the subsequent recovery and recycling of these steel balls. A powerful vacuum system evacuates the area being bombarded and provides for the recovered materials to be collected in a cyclone unit above a steel collection drum. The exhausted air is discharged to atmosphere through a high efficiency HEPA filter assembly. Tests with this equipment carried out by NUKEM in Germany have shown that it operates very well on dry concrete and steel and quickly enables contaminated paint and even thin layers of concrete to be removed. Steel surfaces are left with a dull matt surface ideal for monitoring to confirm its condition. Continuous monitoring will enable the cleanliness of newly exposed surfaces to be established leading quickly to an ability to free-release these large blocks. The monitoring of the internal surfaces will present a more difficult problem for establishing the absence of contamination but work is currently being carried out to overcome this issue.

Handling of the large bocks will present a few problems but a means of safely lifting and turning the blocks has been developed by a competent engineer and will be employed to good effect. The turning of the blocks is required to enable all surfaces to be cleaned prior to final monitoring and disposal. By these means it is predicted that the vast bulk of the recovered concrete and steel blocks will be made available for free-release.

CONCLUSIONS

A detailed plan has been produced to allow the full decommissioning and demolition of Cave 9 at UKAEA Winfrith Technology Centre. Work is advancing in accordance with programme and has just reached the man access position. Considerable ingenuity has already been used to clear an ILW press and all other items of equipment and benching from the structure. The next steps are thus to manually reduce contamination levels and press relentlessly towards structure dismantling. Operator doses have been restrained to a satisfactory level to date and all necessary steps will be taken to minimise doses during the crucial early stages of man access.

It is confidently predicted that the plan will successfully lead to the complete removal of the facility within time and budget. Arrangements are well advanced to clean the recovered concrete blocks using a commercially available shot blasting process that is confidently predicted will allow free-release disposal rather than adding to LLW streams.

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