DEVELOPMENT OF DECOMMISSIONING TECHNIQUES ON A MAJOR NUCLEAR FACILITY AT UKAEA WINFRITH

K. D. Miller, G. Tizzard, S. J. Parkinson, R. M. Cornell
RWE NUKEM Limited
Winfrith Technology Centre, Dorchester, Dorset, United Kingdom

A. T. Staples
United Kingdom Atomic Energy Authority (UKAEA)
Winfrith Technology Centre, Dorchester, Dorset, United Kingdom

ABSTRACT

Building A59 at Winfrith contains two heavily shielded suites of caves originally used to carry out remote examination of irradiated nuclear fuel elements from the UK based nuclear power stations and other experimental reactors. These heavily contaminated facilities were declared redundant around 1996 and after competitive tender a full decommissioning contract was awarded to RWE NUKEM by the site owners and nuclear site licence holders, UKAEA, commencing in July 2000.

Decommissioning operations have steadily advanced to such an extent that both suites of caves have been fully cleared of equipment, benching and services and substantially decontaminated so that the next stage of major structural dismantling could be undertaken. This paper briefly summarises the major tasks achieved during the decommissioning over the past year and describes how the process used to clean the heavily contaminated, encast ventilation ducts used to provide in-cave depression was developed and deployed. This was particularly important since the ducts contained the last major source of intermediate level waste that had to be removed from the structure. The essential challenge was to achieve this objective in a cost-effective manner without incurring exposure of staff to high levels of radiation and contamination.

The achievement of the duct cleaning provided the opportunity to initiate the removal of large and heavy internal shield walls and doors in the facility by a novel method involving the use of a heavy lift stack truck. Details will be given of the nature and magnitude of the problems that had to be overcome and the lessons learnt during the process which led to the removal of 12 heavy structures weighing 16-33Te by this technique. The means of further decontamination and disposal of these items using a variety of equipment items, largely as free release materials, will also be described.

Recovery, and disposal of the zinc bromide used in the shielding windows of both facilities will also be described, including useful data on the methods for disposal of both lightly and heavily tritium-contaminated solutions.

The report will fully explain how the achievement of cost-effective and safe solutions to all these problems has been greatly assisted by the employment of a non-adversarial team-working approach between client and contractor throughout the programme. The fact that the whole

programme is ahead of schedule and has been achieved in a safe and efficient manner emphasises the benefits of this approach, which facilitates good project management practice.

INTRODUCTION

One of the main aspects of nuclear research studies carried out at Winfrith Heath in Dorset by the United Kingdom Atomic Energy Authority, (UKAEA) from the late 1960's was post irradiation examination of nuclear fuel elements. The main thrust of these studies initially centred on fuel newly discharged from the 100MW(e) prototype Steam Generating Heavy Water Reactor, which had been constructed on-site and commenced operations in 1968.

In order to support the planned fuel examination programmes, UKAEA had constructed an Active Handling Building A59, which contained two large concrete shielded suites of facilities, usually referred to as 'caves'. The building also contained other supporting facilities such as an equipment decontamination bay and active workshop so that the in-cave items could always be developed and maintained as required. These caves were used to study initially SGHWR and DRAGON HTR fuels, the latter discharged from another prototype reactor constructed on the Winfrith site. Additionally, for a period of about 21 years commencing in 1971, one of the two cave lines was used to carry out complementary studies under contract, mainly but not exclusively on Commercial Advanced Gas-cooled Reactor (CAGR) fuels for the Central Electricity Generating Board (CEGB)

At the time these facilities were declared redundant in the late 1990's, as a consequence of the shrinkage of the UK's nuclear power research programmes, all internal surfaces of the caves were extremely contaminated. In 2000, RWE NUKEM was awarded the contract by UKAEA to clear, 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 for RWE NUKEM 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 financial incentives in the contract from UKAEA.

DECOMMISSIONING PROGRESS ON THE NORTH CAVE LINE

The North Cave Line (NCL) comprises a suite of seven caves 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. The basic construction of the facilities presented a major challenge for the decommissioning engineers due to the ideas and designs that were current when they were constructed and later refurbished in the 1970's. The tendency then was to construct facilities without any consideration for their later decommissioning and at the outset of the contract several technical problems remained to be solved.

In an earlier paper, (1), the clearing, remote and manual decontamination of the NCL was described, together with details about the techniques and equipment utilised to achieve these objectives. At this point, roughly 12 months ago, all seven caves of the NCL had been manually decontaminated down to moderately low levels of activity and the caves had all services, windows and other major items removed. The next stage of the decommissioning process was to carry out the following tasks:

- Removal of Cave 7 shield doors and associated upper shielding blocks
- Decontamination of the interspace between wing walls and shield doors (5 sets)
- Decontamination of the encast ventilation ducts (5 sets)
- Removal of roof flaps (4 sets)
- Removal of wing walls and associated shield doors (5 sets)
- Further decontamination of internal surfaces to de-minimus levels
- Disposal of the zinc bromide recovered from the cave windows

Significant progress has been made with all of these tasks over the past year and indeed some have been completed. In the next sections, the main aspects of the decontamination and removal processes used with each major task will be set out, together with a commentary where appropriate on the lessons learnt during these operations.

REMOVAL OF CAVE 7 DOORS & UPPER SHIELDING BLOCKS

The Cave 7 outer shield doors were added in 1971 when the original cave line was refurbished and extended from five to seven units. This cave was provided with a pair of fabricated steel doors that were operated in a horizontal plane using a pair of hydraulic rams. The doors, which each weighed about 15Te and ran on solid wheels upon a steel floor plate, were designed as a steel skin and basic support structure to be filled with layers of cast iron blocks. This enabled the doors to be fabricated off site and then installed prior to filling with the iron blocks in-situ.

The removal of the two external shield doors followed the full decontamination of this and several adjacent caves. The external steel cover plates were removed and the doors basically disassembled in the reverse manner to their construction. Once empied of the iron blocks, which were all monitored and then disposed of as saleable scrap, each door's internal steel skin had two rectangular holes cut in it using a hand-held circular saw with a tipped blade suitable for this material. This allowed a fork truck to lift the empty structures, each now weighing around 1Te, from off the steel floor plate such that they could then be lifted free supported by soft slings from an adjacent electric travelling overhead crane. The door frames were subsequently laid down, size reduced, decontaminated and also disposed of as saleable scrap.

Once the two doors had been removed, attention turned to recovery and disposal of the set of eight pre-cast concrete lintels located above the doors at this position. These lintels, which were each shaped to interlock in a vertical plane to avoid radiation shine paths, were about 3.5m long, 0.6m deep and owing to height variations weighed from 1.8 to 3.4Te. In order to recover these lintels from a high level, initially ~4m above the floor, the lead packing located around the edges of the assembled structure was removed and two lead-shot filled boxes, located at the top to in-fill the slinging positions with which they were originally hoisted into position, were emptied using a cyclone vacuum cleaner.

Fig. 1. Trucks Removing Cave 7 Shielding Lintels in Tandem.

In order to remove these heavy lintels in a safe manner, two high-lift gas-powered fork trucks were hired and operated in tandem using soft slings to gently raise and then withdraw the units in sequence, Figure 1. By careful operation of the two trucks, each lintel was removed safely and lowered to the floor, the trucks being driven backwards at slow speed once each lintel had been freed from those supporting it below. Subsequently, the eight pre-cast lintels were disposed of as clean waste for other civil engineering projects. Very little decontamination was required to achieve this objective, following the cave cleaning operations which took place before this dismantling occurred.

DECONTAMINATION OF WING WALLS INTERSPACE

The inter-cave doors were hydraulically operated and a horizontal cylinder moved the ~26Te structure on rollers backwards and forwards in an interspace between two slimmer ~16Te wing walls set into the inner faces of the outer wall structure. Above the walls and door were a pair of hydraulically operated steel plates (called flaps) that sealed across each cave at high level against the top of each wall but when raised allowed the in-cave electric hoist units to traverse the full length of the facility. The flaps and all adjacent external surfaces of the wing walls and door had largely been cleaned and stripped of paints at an earlier stage to remove contamination, but the internal surfaces and a short section of the shield door lying inside the wing walls remained contaminated since they had not yet been exposed.

Fig. 2. Removal of Concrete Shield Plug from Wing Wall Interspace.

In order to expose these surfaces, the external concrete shield plug (~1.25 x 0.6 x 1.5m) in the external cave wall was freed by removal of lead sheets around its perimeter and then removed into a ventilated enclosure constructed at this position to control contamination. The concrete plug was provided with two sturdy threaded holes close to its base which allowed the attachment of pulling cables mounted on a window block recovery frame. By operating the two winch units on the frame in tandem, the ~1.5Te block was readily pulled out of the wall recess to expose the interspace between the two wing walls, the rear of the door and the hydraulic operating ram, Figure 2. This interspace is only ~0.6m wide so man access is not really possible at this position.

However, the access was sufficient to permit the vacuum cleaning of the internal surfaces of the wing walls and the rear of the door using long handled tools and the fixing of residual contamination by spraying surfaces with a water-soluble adhesive. The external opening was then sealed using a thin steel sheet and a suitable mastic adhesive, allowing the tented enclosure to be cleaned, removed and resited at another location. This whole process went very well and as a result all the NCL openings have been cleaned to allow the next stages of decommissioning involving the removal of the wing walls and doors to proceed.

DECONTAMINATION OF THE ENCAST VENTILATION DUCTS

Before the roof flaps could be removed, it was necessary to decontaminate the encast hazard ventilation ducts. These ducts are a good example of the 1960s design, with no consideration given to their cleaning or final decommissioning at the end of life of the caves. The steel-lined ducts are about 45cm x 15cm in section, >12m long and the duct runs are largely located inside the cast structure of the 1.5m thick outer cave walls and down into filter pits ~2m below the building floor. Each extract duct was connected to the building hazard extract plant and could be isolated at a damper fitted adjacent to but downstream from the filter pit. There are open extract ports about 0.5m square located at high level in the cave and this allowed some access to vacuum clean from these positions, initially only horizontally, to reduce activity levels from the high tens of mSv/h to more manageable 1-5mSv/h dose rates. Along this ~3m section of the duct, the front steel face was exposed on the in-cave face, although at the buttress position the duct turned vertically downwards where there was substantial coverage by concrete. At the ~2m below floor level, the ducts turned into a horizontal plane and were directed into a pair of brick lined pits located in the cave access area outside of the line, in one of which was a spark-arrest and HEPA filter assembly. It was thus decided to clean these ducts in three sections, the short ~3m horizontal in-cave section, the ~10m vertical section inside the cave buttress wall and finally the ~2.5m long horizontal section running into the external filter pits. Each duct was isolated from the main extract system before commencing the cleaning operations.

The operators, wearing disposable PVC oversuits and airline fed half-suits, were raised to the high level in-cave position using a small battery operated hydraulic platform suitable for two men. This machine was extremely manoeuverable inside the cave and allowed the operators to access the heavily contaminated extract duct openings from a reasonable 1-2m working distance. As in the previous report, (1), a cyclone-based vacuum cleaner, located on the floor, was used to recover loose activity from inside and around the duct opening. Then the duct opening was enlarged in a horizontal plane by cutting away the complete steel front plate with a circular slitting saw. This was quite a dirty operation but when completed, a significant section of duct was exposed and accessible for cleaning. Further, it allowed access to the long, ~10m section running to below the floor of the cave so that it too could subsequently be cleaned. Quantities of loose dust were recovered from each duct in turn, commencing at Cave 5 at the eastern end and progressing steadilty to Cave 1 at the western end of the NCL.

Activity levels were quite high in Caves 3, 2 and 1, where the majority of the destructive operations had been carried out on fuel pins/rods over the lifetime of the facilities. Contact dose rates of up to 100mSv/h were recorded here and the cleaning operations were challenging. However, by use of long handled tools and vacuum hoses, the task was successfully completed and once opened up, the duct internal surfaces were further decontaminated with liquid based cleaning agents, which were successful if further reducing the local activity levels.

Having cleaned the first duct sections, attention turned to determining the activity levels in the vertical duct sections buried in the buttres wall and viewing the internal surfaces. To achieve these objectives, a miniature, self-focussing, low light camera about 3cm in diameter was lowered down the duct together with a small festoon lamp and a cylindrical gamma monitoring probe. The power and signal cables, connected to suitable monitoring units located out-of-cave, were bound together and wrapped in PVC sheaths to keep them clean. The assembly was then carefully lowered down each duct to determine the variations in dose rate inside the ducts and to establish their general condition. Local dose rates were generally lower than in the horizontal duct sections, ranging from 20-50mSv/h. Dust deposits could be seen on the duct surfaces and these tended to become disturbed by the movements of the wrapped cables. Care had to be taken at this stage as the hazard extract ventilation system was still available and there was a risk that the HEPA filters would subsequently become blocked with ILW dust once the connection was remade, leading to problems with their subsequent disposal. At this point the decision was taken to clean these duct sections using a pressure washing system rather than vacuum cleaning owing to the relatively restricted access in-cave. Additionally, at the base of the vertical section of each duct the TV camera revealed that there was a flow divider installed which would obstruct the cleaning head that it had been planned to use. Interestingly, this flow divider was not shown on any of the archive duct drawings.

In order to clean the ducts, a complete system had to be assembled and tested using a range of pressure washing heads and cleaning fluids. The system eventually adopted was developed from one designed to clean ducts contaminated with edible fats and other similar items of cooking/catering equipment. Two different fluids were employed, one to act as a degreasing agent and the other a general decontaminant. The former was utilised with warm water and the second with cold water, the degreasing liquid being first applied and allowed to digest the contamination before being rinsed away with warm water. The principal feature of the pressure washing head was its small size and its ability to rotate in the horizontal plane to provide an all round cleaning action for the rectangular duct section.

To effect the cleaning, the ventilation to the duct was first isolated downstream of the HEPA filter assembly, allowing this latter unit to be removed using the standard maintenance procedure. The whole area around the filter pit was then enclosed in a ModuCon modular containment using fibreglass panels, backed up with a powerful, filtered air mover system to control airborne contamination. The floor was completely covered with PVC sheeting for the same reasons. Next, the low density concrete at the base of the filter pit was drilled/cut away to allow a deep metal tray to be inserted there so that the contaminated liquid produced during the pressure washing and emanating from the duct outlet could be collected here and pumped away to a large plastic tank located on the cave access area floor. The duct was then cleaned from the top downwards by introduction of the pressure wash head, gaining access in cave at the top of the buttress wall from the battery powered elevating platform. This allowed the low pressure application of the decontamination fluids from the top downwards and later the high pressure rinsing of the released contamination under the action of gravity. The whole process worked well and after two complete runs, new measurements with the gamma probe showed that the levels had reduced down to <2mSv/h throughout, with many sections below 1mSv/h.

The liquid effluent recovered from the filter pits was taken to the building decontamination bay, where they were sampled for activity and identification of the principal isotopes. They were subsequently discharged to the site active drainage system without further treatment. By these combined means the five hazard ventilation ducts were effectively cleaned and prepared for the next stage of decommissioning. The intention now is to spray the inside of the ducts with a water based adhesive to tie down any residual contamination. They will then be filled with a hard expanding foam to stabilise them and then to break them out during the demolition procedure for further attention and disposal as LLW material.

REMOVAL OF THE ROOF FLAPS

Now that the major sources of contamination in the hazard ventilation ducts had been removed, it became appropriate to remove the four double sets of roof flaps referred to earlier as a precursor to removal of the wing walls and shield doors. Each roof flap was 4.2m wide, 0.5m high and 0.07m thick, constructed of steel and weighing around 1.1Te. The flaps were raised and lowered using a hydraulic ram arrangement located externally to the cave line, working from a long central spindle located at one end of each unit and passing through the cave wall. The spindle on the opposite end was supported within a bearing set into the cave wall and merely provided support to allow rotation of the flap.

The technique adopted for flap removal followed very closely that employed for their installation. In the cave structure immediately above the centre of each roof flap there is a 40cm diameter penetration through which a soft sling and shackle could be passed to provide support for each item. This enabled the operators, working in-cave from the elevating platform, to drill and tap a hole into the flap above its vertical centreline into which a suitable eyebolt could be introduced. The sling and shackle were then attached to the eyebolt and raised using a 2Te A-frame and chain block assembly such that the weight of the roof flap was supported. The operators then unbolted the two roof flap side plates and drove out the three supporting dowels to disconnect the flap from the rotational system. The flap was then slightly rotated about a vertical axis to free it and then lowered using the chain block onto a wheeled trolley placed below it on the cave floor. This procedure was adopted throughout the recovery process and proved very effective in the removal of all eight flaps from the NCL.

Once freed from the cave structure, each flap was wrapped in PVC and then taken to the decontamination bay, where it was immersed in a bath of decontamination liquids. This procedure effectively reduced the loose contamination on these items, allowing each to then be cut with a powered hacksaw into three roughly equal pieces to assist with subsequent handling. The sectioned items were then taken into a vented enclosure, where the paint and surface activity was removed using a 'Blastrac' shot blasting system. This mobile system is backed up with a powerful cyclone based vacuum system, which retains the recovered activity and debris in a sealed container. The process, supported by a small amount of local grinding of 'hotspots' with hand tools, reduced activity levels sufficiently for the steel sections to be directed to the site-based shot blasting plant, where the residual activity was completely removed from the external surfaces. The only remaining operation now required was to overdrill all the pre-existing bolt/dowel holes through the flaps such that no contamination remained on these heavy steel sections. After rigorous monitoring, all these steel items were disposed of as scrap metal though the free release route, some 8.5Te in all.

REMOVAL OF THE WING WALLS AND CAVE DOORS

The basic layout of the cave line shows that each cave or pair of caves is separated from each other by a pair of wing walls and a shield door. The heavy shield door runs on rollers from the wing wall recess to close into a shallow recess in the opposite wall. The external wing walls and doors are a little thicker than those used internally to reduce external background radiation levels. Each wing wall is roughly 3.3m high, 2m wide and either 30 or 38cm thick, depending upon location. These items were fabricated off-site with a substantial steel framework and external skin. They were then moved into the cave and installed into position in a prepared recess in the inner surface of the external shield wall. They were then filled in-situ with iron shot concrete to provide the main shielding. Consequently, the masses of these items have had to be calculated and are shown to range from about 16 to 20Te. The shield doors are of similar physical dimensions but are 62 to 75cm thick and weigh from 26 to 33 Te each, again depending upon location. The external shield doors also contained a lead lined horizontal posting port originally used with shielded containers to introduce or remove ‘hotter’ items to/from the cave line.

The major progress that had been made with decontamination of the NCL now made it possible to remove the internal partitions in sequence, working from east to west along the axis of the cave line. Once completed, this would leave a totally empty cave line ready for final decontamination down to a clean state prior to controlled demolition. RWE NUKEM was faced with a major challenge to be able to free and then recover these massive items. In total, within the NCL, there were eight wing walls and four shield doors to remove with the over-riding objective that the majority of the structures, weighing a total of ~260Te, could be disposed of via a free release route.

A range of methods for the recovery and removal of the wing walls and doors were explored but the break-through came when it was discovered that there was available locally an American manufactured fork lift truck capable of handling the loads required of up to ~35Te. The basis of the removal plan was then developed around this Versa-lift 40/60 truck, but the key challenge was to design and manufacture a special lifting bracket for the walls and doors that could be used with this vehicle. Additionally, as there were so many units involved, it was important that the lifting bracket was re-useable. The details of the development of this bracket lie outside the scope of this paper but the plan developed was based on attaching it to a door or wing wall using Hilti HSL heavy duty M24 anchors. In this case the stress calculations showed that the wing walls could be lifted using only 4/5 anchors and the doors 6/7 anchors, each anchor being carefully torqued up to 250Nm. Welding the bracket onto the steel faces of the door or wall was never going to be an acceptable commercial option. At this point in the programme, after a thorough review of options and independent checks on the stress calculations, a positive decision was made to proceed with the plan. The contractor was also required to confirm that the Versalift truck was fully capable of lifting the heaviest item, an ~33Te external shield door.

The manufactured lifting bracket is a reasonably compact unit about 0.6 x 0.4m and 2.5cm thick, with the central section dominated by the curved support feature. The profile of the underside of the support feature was matched precisely to that at the front of the Versalift 40/60 truck when its own fork assembly had been removed. The removal of the fork assembly also enabled the truck to get very close to the door/wall and greatly increased its lifting capability, which was further raised by the controlled extension of the counterweighted rear axle assembly.

The lifting bracket was attached to the centre of each wall or door to be removed at a position roughly two-thirds of its height above the base. The attachment required the wall or door to be drilled with up to eight holes, each 32mm diameter and not less than 180mm deep to accept the Hilti M24 anchors. The drilling needed to be carried out accurately so a steel guide plate was manufactured together with the lifting bracket to assist with this objective. The drilling plate was lifted to the pre-marked position with a fork lift truck and tack welded into position. Then the outer 6mm thick steel skin of the wall or door was drilled at each selected hole using a flat-bottomed tool held in a magnetic base electric drill. The magnetic base drilling unit was then removed to allow use of a hand-held power drill supplied with special Hilti masonry drills for the shot-filled concrete. The key objective here was to ensure that the holes were straight and the openings did not become ovalised. The drilling system achieved both these objectives extremely well and once completed, the tack welds were ground away allowing the drilling template to be removed. The steel surfaces were then dressed to enable the bolted plate to be attached as required; this was achieved without significant difficulty.

As the shield door units were mobile they could be centrally positioned for the lift by the hydraulic ram when required. However, as the wing walls were grouted into the inner surface of the cave shield wall, these had first to be freed and moved into cave to allow them to be lifted at a central position. This was doubly difficult since the external surfaces at the base of each wing wall had been welded to the steel cave floor during installation and needed to be ground away first before the walls could be freed from the inner cave wall. Additionally, since the internal edges of the walls had not been welded, the base of each wall had attracted loose contamination and this activity had to be recovered and prevented from spreading during the relocation operations.

The first operation, replicated at each set of wing walls and door, was to remove the grouting from around the outer edge of the outer wing wall. Then the welded joint at floor level was ground away around the external periphery using an electrical angle grinder. This process was backed up by vacuum cleaning the debris as it was generated to minimise any potential spreading of contamination from this area. Next, the wing wall was moved out of its position in the cave wall using a 60Ton hydraulic jack placed at a position close to its top edge. This was possible because behind the top of each wall was a rectangular recess through which the wheels of the in-cave hoist originally ran upon steel rails. The hydraulic jack was placed between the outer shield wall surface and the centre of the edge of the wall at a position close to its top surface. The operation of the jack led to the freeing of the wall by instigating initially a tilting movement which caused the wall to break free at the top edge and then the whole to move outwards. By alternately pushing at the top of the wall and then allowing it to settle under its own weight, the unit was removed to a position about 10cm away from the fixed position. In order to ensure that the wall could not fall over during these operations, an L-shaped steel brace about 2m high was welded to the front edge of the wall with the horizontal portion level with the cave floor. This brace was usually left in position until just before the wall was lifted and cut away shortly afterwards when the wall had been secured to the truck. As noted earlier, some fresh contamination was experienced during the relocation of the wall, which was removed using standard decontamination techniques to allow the Versalift truck to be safely deployed into the cave line. From this point onwards the process became deceptively simple as the truck’s lifting feature was carefully aligned with the base of the wall bracket. Once completed, the truck’s lift mechanism was operated to first take the weight of the wall, lift it clear of the ground and then tilt it backwards slightly for maximum stability. The truck was then very carefully reversed out of the cave so that the wall could be set down in a vertical plane upon wooden sleepers to allow it to be slung from the overhead 30Te crane using steel chains, Figure 3.

This allowed the wall to be lifted away from the truck and subsequently laid down in a safe horizontal orientation upon more wooden sleepers. Some preparation work had to be carried out in-cave to allow the loads to traverse a number of floor storage holes and other below-floor features that were present relating to the earlier use of the caves. The details of this work lie outside the scope of this report.

By these means the first wing wall was removed, followed in similar fashion by the shield door. Once the shield door had been removed, the inner surface of the second wing wall had to be cleaned thoroughly as some new areas were again exposed with contamination present. In many cases after cleaning, the surfaces were sealed with paint or a water-based adhesive to prevent any spread of residual contamination onto the lifting equipment. Additionally, before lifting the second wall, two steel support frames were welded on either side to prevent it tilting over during the relocation operations. These features were again removed before the final lifting process occurred.

Fig. 3. Removal of Wing Wall with Versalift Truck showing Rear Extension.

In this manner, the four sets of wing walls and doors in the NCL were progressively removed to leave a large open cave line ready for the next stage of decommissioning. This included the final removal of areas of fixed contamination on all inner surfaces and the pressure wash cleaning of the several hundreds of through-wall steel penetrations in the outer walls and roof structure.

DECONTAMINATION OF WING WALLS, DOORS & IN-CAVE SURFACES

The recovery of the wing walls and doors from the cave line lead to an urgent need to decontaminate these bulky items, which were placed on top of one another in the storage area of the building within reach of the two overhead 30Ton and 40Ton capacity electric travelling cranes. Two dedicated cleaning areas were set up for this purpose, the first being a ventilated area largely surrounded by clear Perspex panels adjacent to the storage area. As noted earlier, this area is served by a low wheeled trolley capable of supporting a 40Te load that can be pushed into or pulled out of this area with an electric truck. The area is roughly 5.5m wide and 8.5m long with a sloping roof falling from around 3.5m to 2.5m at the most distant end. The access from the storage area is via a pair of full height plastic doors.

Once a wing wall is located inside this facility, laid flat upon the trolley, operators set about the task of decontamination wearing disposable plastic suits over ordinary coveralls and 'Breatheasy' respiratory protection. The initial plan was to vacuum clean the surfaces and then remove the paint using a chemical stripper before attempting to monitor and then abrade the surfaces where necessary with a hand held electrical grinder to remove identified 'hotspots'. The initial processes were effective in removing much of the contamination but the steel surface appeared to retain contamination that proved extremely difficult to completely remove as required. The steel skin of the wall was then cut away in large sections using an electric angle grinder, using knowledge of the design to locate and cut away the internal anchors used to secure the plates to the structure. The recovered steel plates were generally disposed of to a LLW route, mostly into an ISO container. The exposed surfaces of the now mostly iron shot concrete structure were further vacuum cleaned and locally abraded down to a clean condition, after which they were removed from the building for free release disposal. During the latter stages of their dismantling, parts of the structure became unstable and fractured at planes of weakness associated with junctions in the iron shot concrete, which during construction had been poured in three discrete stages. These fractured sections of ~3Te in weight were recovered using a fork lift truck and were actually rather easier to handle than the initial 16-20 Ton item. Further, the newly fractured surfaces could be monitored for activity and when none was discovered it supported the assertion that these materials were clean and capable of free release disposal.

In order to start the decontamination of the larger shield doors, a second enclosure of rather smaller dimensions was constructed in the storage area using ModuCon panels to include a sealed roof. The internal walls were sprayed with strippable paint to ensure there was a proper control of contamination and the structure was fully ventilated with a portable unit located at one corner. The area was entered by operatives through an airlock arrangement and the facility made provision for the introduction of a shield door laid down upon a second heavy duty trolley by removal of a short section of panels on one side. Once pushed into the facility, this side wall was replaced and bolted back into position. Similar cleaning operations to those above were carried out here, largely removing the gross contamination and paints with stripper and also removing the wheels from the bottom of the doors. Once the local radiation and contamination levels had been substantially reduced, the doors were taken into the first area for completion of the decontamination operations using similar techniques to those already described.

In the cave line the removal of the wing walls and doors exposed a few previously unchecked surfaces where traces of contamination were present. These areas were quickly cleaned using standard techniques and in many areas these surfaces were sealed by paint. Upon completion of the major task, the whole cave line had then to be completely stripped of all paint back to the bare concrete and steel materials used in the construction. Work recently commenced at Cave 7 at the east end of the line and is at an early stage. The surfaces are being stripped using a combination of tooling, including a 'Trelawny' flail abrasion machine and a 'Blastrac' shot blasting system. Both units are supported by a high powered cyclone vacuum system to remove the abraded materials freed from the surfaces. Any residual 'hotspots' of activity are then removed by local chiselling using an air operated tool. Considerable health physics surveillance effort is involved with the monitoring of the subsequent surfaces to ensure that they are clean. To assist, the surfaces are indelibly marked into areas of $1m^2$, which are then monitored for radiation and contamination. This enables a clear record to be maintained of the progress being made towards the completion of this important task.

ZINC BROMIDE DISPOSAL

The two cave lines in A59 were constructed with zinc bromide shielding windows and at an earlier stage of the decommissioning operations, all these windows had the zinc bromide liquid drained from them into 200 litre polythene-lined steel drums. Before the windows were drained, however, a small sample was recovered from each to enable a radiochemical analysis to be carried out. Results showed that some batches of zinc bromide were contaminated with tritium ranging from the limit of detection of ~0.1 to 21.5Bq/g, with one small batch at a maximum of about 600Bq/g. The origin of the tritium is obscure but may have come from the occasional storage of these liquids in stainless steel drums previously used to store heavy water from the SGHWR reactor on-site. As a result of these analyses, 12,000 litres of clean zinc bromide was transferred into 115 litre drums and disposed of to a chemical processing company for a small consideration. This left about 23.5Te of contaminated zinc bromide for which a disposal solution was required.

In order to effect the disposal of the contaminated zinc bromide it was necessary to convert it into a solid as, under current UK legislation, only clean zinc bromide solutions can be transported as a liquid. Further, if the solid material could be reduced in activity to <0.4Bq/g, then this same legislation permitted it to be disposed of as an exempt material. However, since it was likely that the zinc bromide would require special treatment before final disposal, outside the immediate capabilities of the Winfrith site, the solidification of the zinc bromide into grout or any cement-based material was not an acceptable option. After discussions with the UK Environment Agency (EA), and a waste processing contractor, a procedure leading to the disposal of a substantial quantity of the tritium-contaminated zinc bromide was derived. A careful study of the amounts of zinc bromide that might be capable of disposal via this route was found to be about 5,200 litres or ~13Te, the initial levels of contamination lying in the 0.1 to 2.0Bq/g range. All the remaining zinc bromide, of which there were about 4,200 litres or 10.5Te, was judged too active to be capable of meeting the EA's requirements and an alternative disposal route was sought.

The basis of the disposal of the lightly contaminated zinc bromide solutions relied firstly on an ability to convert it into a solid for transporting it to a waste treatment centre. Here the plan was to carry out further treatment to convert this material into a stable solid using further water, pulverised fly ash (PFA) and ordinary Portland cement (OPC). Additionally, the EA required the final product to be very resistant to the leeching out of zinc ions, since the ultimate disposal was land burial of the resultant solid blocks produced at the waste processing plant in an authorised landfill site. This necessitated the waste contractor carrying out small scale processing and leeching tests on samples of solidified zinc bromide supplied from Winfrith to demonstrate compliance with the EA's requirements before the whole process could be approved for use.

Since the solidification of the zinc bromide solutions in cement or grout was not acceptable, other absorbent materials were investigated. One of the more promising options concerned the use of sodium polyacrylate granules. These materials form one of the main absorbents used in disposable nappies and are acceptable in the context of their environmental impact after disposal. A number of different suppliers of these materials were identified and samples sourced for small scale tests to check their effectiveness in absorbing ~77% aqueous solutions of clean zinc bromide. Early tests showed that the starting solutions of zinc bromide were difficult to solidify in any significant amounts but the absorbing characteristics of the granules were much improved by further dilution of the zinc bromide with water. This approach was quickly developed and ultimately reliable results were obtained using sodium polyacrylate granules supplied from Arcus Absorbents Inc. of Canada. Several major benefits were derived from this process in that the addition of water reduced the tritium concentration of the solutions and the resulting solid material did not set hard but formed a friable material capable of recovery for further processing as was required. Additionally, and unexpectedly, the resulting solid was almost completely neutral chemically, such that it was capable of transport as an exempt material and not as dangerous goods.

The detailed means of carrying out the physical solidification of the zinc bromide lies outside the scope of this paper. Briefly, an electric stirrer was purchased for use with standard 200 litre HDPE (high density polyethylene) drums in which the zinc bromide was first diluted with water to approach the target of 0.4Bq/g and then solidified with the sodium polyacrylate granules. The stirrer was operated carefully as the granules were added until the mixture just became solid, Figure 4. The operator skill lay in judging just when the point of solidification was reached and by this means the 5,200 litres of zinc bromide were subsequently successfully solidified into 197 HDPE drums.

These drums were then processed as already described at the waste treatment plant and land burial followed without incident. Subsequent tests carried out by the EA showed that the disposal met all the criteria set out at the start of these operations.

The remaining zinc bromide solutions are to be disposed of by incineration, following the completion of a small scale trial by a competent contractor using solidified material supplied from Winfrith. As a result of the success of these trials, the EA has granted a licence to a waste incineration contractor for the destruction of all the remaining contaminated zinc bromide from the Winfrith site. The relatively small amounts of tritium present in the zinc bromide were not seen as a major problem by the EA but the destruction of all zinc bearing materials has to be carried out with care and in small batches. The same method of solidification was employed for these solutions but smaller 125 litre HDPE drums were used with a maximum payload per drum of 150kg. A total of 286 drums were used to hold the 4,200 litres of zinc bromide in this category and all are expected to be processed by spring 2004.

Fig. 4. Adding Granules to HDPE Drum to Solidify Zinc Bromide.

CONCLUSION

The full decommissioning of the cave lines in Building A59 has continued to make steady progress consistent with the required schedule, with completion due by November 2006. The use of a heavy duty forklift truck to effect the removal of a number of large and heavy structural items from the North Cave Line (NCL) has been a major factor in maintaining the decommissioning momentum. Decontamination of the recovered items and the internal cave surfaces is progressiong steadily using a range of established techniques. The successful decontamination of the NCL encast hazard ventilation ducts completes one of the remaining challenges facing the decommissioning engineers. The disposal of all the zinc bromide from the cave windows has also secured a major milestone for the project using a mixture of processes agreed with the UK Environment Agency.

Once again, a combination of good forward planning, the harnessing of operator enthusiasm and skill, the use of simple and adaptable tooling together with the vital support and confidence of the client are leading steadily towards a successful conclusion to the decontamination and demolition of Building A59.

REFERENCES

[1] Miller K D, Parkinson S J, Cornell R M and Staples A T, Decommissioning of shielded facilities at Winfrith used for PIE of nuclear fuels and other active items. International Conference WM'03, Tucson AZ, February 23-27, 2003.