THE DECOMMISSIONING OF BERKELEY – II

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Introduction and Background

BNFL Environmental Services is the new name for BNFL's nuclear decommissioning and clean-up business group. It has an unparalleled track record of achievement in nuclear decommissioning and remediation, including a reactor decommissioning portfolio of Magnox stations, WAGR, research reactors and the Big Rock Point and Fort St Vrain decommissioning projects in the USA.

The BNFL Environmental Services project portfolio also includes remediation projects such as the Idaho Advanced Mixed Waste Treatment Project and the Oak Ridge East Tennessee Technology Park Gas Diffusion plant decommissioning project, both for the US Department of Energy.

This paper describes the decommissioning progress at the Magnox site at Berkeley in Gloucestershire. The last article on the decommissioning of Berkeley appeared in The Nuclear Engineer in summer of 1992 (Volume 33 No. 3). It concluded with the last dispatch of fuel from site in March 1992 and much has happened since. Berkeley has continued to lead the way on reactor decommissioning in the UK and to make a significant contribution to setting world standards.

Description

Berkeley Power Station Decommissioning Site is on the eastern bank of the River Severn in Gloucestershire, and is approximately 17 hectares in size. It was a twin Magnox Reactor 276MW Station with a total of 16 steam raising units (boilers) and used gaseous carbon dioxide as the heat transference medium. The site divides into 3 approximately equal areas, the Reactor Controlled Area, a conventional plant area including Turbine Hall, transformers, reservoir, office accommodation etc, and a greenfield area. (*Fig 1*)

Approach to Decommissioning

Throughout the work at Berkeley the emphasis has been on conducting decommissioning safely. This has been reflected in the progress of decommissioning starting with removal of the fuel from site and thus much greater than 99% of the radioactive inventory. The major radioactive hazard therefore remaining has been the Intermediate Level Waste in the form of fuel element debris (graphite struts and extraneous magnox components removed to increase the packing density of fuel elements in flasks going to Sellafield), miscellaneous activated components, sludges and resins. Approximately 1500m^3 of such material exists and is stored in underground waste vaults on site. Work is underway to recover and encapsulate the waste in cement so rendering it "passively safe" meeting both Company and NII objectives. (*Fig 2*)

All work on site is, and has been, covered by a nuclear safety case acceptable to the site's independent safety assessors, its Nuclear Safety and Decommissioning Committee (which includes external members) and the NII. The case has a key objective of minimising the radiological exposures that could accrue to workers from site decommissioning and reflecting this an early decision was taken to leave work on the Reactor Pressure Vessels themselves for several decades. This will allow significant radioactive decay and permit simpler hands-on work rather than necessitate use of remotely operated machinery, so reducing individual and collective doses overall. This "Safestore Strategy" is set out in the recent BNFL Magnox Quinquennial Review submission to the NII and will mean the site will enter a period of "Care and Maintenance" during which it will consist solely of its 2 reactor buildings and associated blowerhalls, one of which has been converted to an ILW store.

Also important in protection of the workforce has been control of asbestos. In common with many other power stations of its period world wide, Berkeley used several hundred tonnes. As the site has aged, sheet and lagging fixings have deteriorated, and binding agents have degraded. Much material has been removed with redundant plant and equipment, but a programme of remediation in line with government legislation has been required to ensure personnel safety throughout the decommissioning period and into Care and Maintenance. This programme has revealed the extent to which industry used asbestos in addition to insulation e.g. to cover electrical cables, as building panels, and as reinforcing filler in paints.

In addition to health and safety matters the site's approach to environmental issues has been consistent. Formally such standards as ISO 14001 have been adhered to and the appropriate certification maintained. At a working level the principles of reduce, reuse and recycle have been inculcated.

General Programme

The site's approach to decommissioning has been clearly reflected in the work programme. In summary (and amplified below) it has been, removal of fuel; disposal of operational wastes except ILW; stabilisation e.g. cleaning of cooling ponds; upgrading of waste treatment facilities; isolation of reactor pressure vessels; removal of external gas ducts and boilers; disposal of redundant plant (e.g. CO_2 tanks), equipment (e.g. charge face machinery), and buildings (e.g. new fuel store and Turbine Hall); installation of a new site electrical system; demolition of cooling ponds complex and active drainage systems.

Decommissioning of the Grid Sub-Station (now complete) was delayed until this year when the Company decided to foreclose the option to repower the site by using the station's cooling water systems which had already been cleaned as a prelude to either repowering or to demolition. The C W systems are to be decommissioned this year.

The critical path project is the removal and processing of ILW. New facilities have been constructed over the underground vaults containing the waste, and adjacent to them. These are shielded structures with remote handling equipment which will permit safe recovery and remote processing of the waste. This comprises the fuel element debris already mentioned and material generated by the fuel irradiation examination programme conducted at Berkeley Centre over the years. This lack of homogeneity in waste streams will be challenging. Notably in the development of suitable radiological assay equipment.

The remaining programme will be necessarily sequential in nature viz. completion of ILW passive storage, demolition of the plant used to handle and encapsulate sludges and other "mobile" waste, demolition of the Active Effluent Treatment Plant, removal of the Low Level Waste complex and any temporary effluent plant used in the interim, then demolition of the Main Change Unit and office accommodation. This phase of the programme is expected to take 3 years.

Stabilisation

Elsewhere in decommissioning circles this phase is frequently referred to as Post Operational Clean Out (POCO). Stabilisation is a better term at Berkeley because in many cases decommissioning work has encompassed POCO, and in other cases POCO, as such, has not been possible.

Early in the programme the reactor pressure vessels were extensively air purged through a filter pipe and monitoring equipment. The aim being to reduce moisture levels in the vessels and discharges to atmosphere to an absolute minimum. This has been successful in both cases. Measured corrosion rates are low; externally less than 1 micron/year, internally less still and both lower than 10 microns/year which was a predicted maximum. All this suggests the storage regime is one which is effective in protecting the vessels from marine aerosols and other corrosion promoters.

Traditional POCO was seen in activities such as high pressure water jetting to clean the surfaces inside the ponds and their building, and in removal of hydraulic fluids and lubricants from redundant plant prior to disposal later in the programme. The aim throughout was to reduce the need for maintenance to a minimum and to minimise the possibility of accidental release to the environment through degradation occurring in the long decommissioning period.

Given that Berkeley was the first of its kind it was inevitable that the transition between the strict controls appropriate to an operating station and those relevant to a decommissioning site required to be managed. It proved difficult to ensure that pace of change on site in this phase was matched by that in regulatory control. However, through close liaison with the regulators this was largely achieved.

Charge Face Machinery

This, the most obviously redundant equipment on site, was not easy to remove. Machines were of the order of 100 tonnes each and could not easily be relocated at ground level. Dismantling therefore took place on the pilecap. The potential for them to contain high dose-rate debris not easily discerned by even comprehensive pre-dismantling surveys was realised. Nonetheless, through the use of detailed drawings and a carefully planned approach, the work was successfully concluded. Many of the constituent parts proved to be completely decontaminable. (*Fig 3*)

Gas Circuit, Steam Raising Units (SRU's) and Turbine Hall

The approach to much of this work was similar in nature and took place between 1995 and 1996. As a prelude thousands of bags of asbestos lagging were removed by specialist contractors, exercising particular care where contamination could have occurred e.g. around man accessways into SRU's (Boilers). It was this potential for contamination which differentiated the work in the Reactor Controlled Area (RCA) from elsewhere. However by exercising radiological protection protocols which were well thought out and communicated to workers they were able to proceed, for the most part, as if the plant in the RCA was conventional in nature.

Top gas ducts complete with their supporting gantries were lifted down by a craneage contractor used to handling loads in the hundred tonne range. (*Fig 4*) Vertical ducts were similarly removed and welded steel blanks fitted to the pressure vessel. The winds occurring on a coastal site had to be catered for in this work and in two aspects of removal of the 16 boiler houses. Firstly in removal of the thousands of panes of glass by a glazing sub-contractor, and again in lifting down the structural steelwork section by section for dismantling at ground level, and sorting into categories of activation and/or contamination. (*Fig 5*) The boilers weighing 300 tonnes each were then lifted from their vertical position and laid horizontally onto specially designed cradles on 8 new purpose built foundation pads at ground level. (*Fig 6*)

Most of the faces of the reactor buildings were glazed like the boiler houses. This glass was removed also and the top 15 metres of building demolished to reduce the visual impact of the buildings whilst in the Safestore phase, and to reduce ongoing maintenance costs. (*Fig 7*) Each building was then reclad in high performance, low maintenance materials fit for several decades.

Feed and steam ranges were removed in the same period and the Turbine Hall demolished. Many conventional safety challenges presented. Large numbers of rigging operations were required, electrical isolations performed, and unforeseen issues encountered, such as lead fume from oxy-propane cutting of the lead painted turbines. Huge quantities of concrete were size reduced on site (following monitoring if in the Reactor Controlled Area) and clean material brought in e.g. to infill the Turbine Hall basement. (*Fig 8*)

All this work was in the public eye. The Site has always enjoyed a good relationship with the people of Berkeley, and has played a full part in the community. Therefore it was normal for local individuals and for the Local Community Liaison Council (LCLC) to be kept informed by visits and meetings. Many records of the work and its final status physically, radiologically, and environmentally were produced to enable future disposal of the site if required. The advent of the Construction, Design and Management Regulations in this period and therefore the requirement for Health and Safety Files has been a useful adjunct as contractors now working on-site have become familiar with producing such documentation at Berkeley and elsewhere.

One of the sub-projects associated with this plant took place 2 years later. It was the experimental dismantling and decontamination of Boiler 10. This was carried out inside a temporary steel building erected over the Boiler whilst in its horizontal position. It was more challenging than first hoped due to the diversity of materials encountered, their complex geometry and the variation in thickness and type, of oxide deposits created by the different operating conditions which had pertained at different levels. A range of decontamination techniques had to be employed from high-pressure water jetting or grinding of plate to acid based cleaning of plain tubes or use of proprietary decontamination fluids on finned tubes. In all 80-85% of the steel was decontaminated and sent for free release as scrap metal, the remainder being consigned to the national low level waste disposal site at Drigg in Cumbria.

A lot was learnt by all as the work was conducted with NII and EA overview. Detritiation of both boiler steel and that gas circuit ductwork which had been decontaminated was achieved after development of a suitable technique by the author and the decommissioning team collaborating with support staff from adjacent nuclear laboratories at Berkeley Centre.

<u>Cooling Ponds and Active Drains</u>

Throughout the decommissioning the role played by the regulators (NII and EA) has been crucial. Much of the existing UK legislation was not enacted with decommissioning in mind. NII and EA have worked in conjunction to help frame and guide the site in its work. Nowhere was this more useful than in decontamination and demolition of the Cooling Ponds and active drainage systems. The site was able to define a suitable radiological end point with the regulators early in the project. This was based upon the widely recognised “de minimus” levels for solids of 0.4 Bq/g total specific activity, and total surface activity of 4 Bq/cm^2 beta and 0.4 Bq/cm^2 alpha. In all the Ponds project took nearly 7 years to complete in 3 phases so had there been indecision on the radiological endpoint the time scale and costs involved would have been greatly extended.

The two main ponds situated at the north end of the $350m^2$ cruciform shaped building (in plan) were 8m deep and the size of an olympic swimming pool. The building itself had a reinforced and piled ground slab and a precast concrete roof. Walls were brick infill to the building’s steel frame. Also in the building were other ponds and resin tanks and associated craneage, as well as a road transport flask dispatch bay and active effluent treatment tanks and pipework.

During the operational phase radio-caesium in a highly soluble and readily mobilised form had leached from the stored fuel into the water and entered the concrete walls and floors of the pond despite protection offered by paint coatings. The substructure of the building was thus contaminated and splashes of pondwater had also lightly contaminated the superstructure.

Work began with a Phase 1 contract in 1994 lasting 2 years in which redundant plant and equipment were removed, as well as loose and near surface contamination to a depth of 2mm from building and ponds. This reduced background doserates to an extent that made good radiometric survey possible and allowed proper scoping of Phase II.

Phase II, involved concrete planing and scabbling to remove several tens of millimetres of pond surfaces and, in the case of the central pumphouse, wholesale concrete removal. (*Fig 9*)

In this and in Phase III keeping the area dry was a priority to facilitate radiological monitoring. In Phase II extreme care had to be taken not to puncture the ponds' groundwater barriers bridging construction joints lest water flood in. Similarly in Phase III the building was demolished beneath a weatherproof scaffolded structure, (at that time the largest in the UK.) (*Fig 10*) Completion of the project in March 2001 was another UK first for Berkeley.

Coincident with Ponds Phases II and III the redundant gravity active drains were removed and latterly the pumped active drainage system, except for those sections required to the end of this decommissioning period. The primary pipework of the gravity system was removed to Drigg. All manholes and secondary pipework sections were decontaminated and a comprehensive video and monitoring survey carried out, and inspected by NII. A few sections with persistent contamination were totally removed to Drigg.

The stainless steel pipework and tanks of the pumped system proved readily decontaminable with care.

In all 2 ¼ miles of pipework were successfully decontaminated and removed.

Safety on Site

As expertise has grown during the period safety has improved to a very high level; sufficient that the site has been regularly recognised by RoSPA and last year gained its 3rd Gold Medal.

All workers on site are viewed as the Berkeley Team, treated as such, and are represented by their donor organisations on the combined Safety Health and Environment Committee. Its approach to safety improvement has been demonstrably successful, and has included such routines as combined plant safety tours, joint safety training and participation in BNFL's Behavioural Safety Improvement Programme.

With the advent of BNFL Environmental Services and its parent groups within BNFL learning from experience is promoted at all of its sites including Hunterston 'A', Trawsfynydd, Capenhurst, Aldermaston and parts of Sellafield. Best practice is therefore shared.

Collective dose for the whole period (approximately 1 man.Sv) has not exceeded that for any year of generation and the highest annual individual dose has been 7 mSv with the average well below 0.5 mSv.

The Future

Berkeley has been the first commercial nuclear power station in the UK to undergo decommissioning. The team have developed many new techniques to achieve the work. In consequence the Site has been the first to complete milestones such as reduction of the primary gas circuit, demolition of the Turbine Hall and the Grid Sub-Station. Of particular note has been the complete removal of the Cooling Ponds complex which attracted international acclaim. Another first will be demolition of the Cooling Water structures this year. It will be testing given the huge tidal range (10m) in the River Severn, and undoubtedly the remainder of the ILW Recovery Project will bring its own challenges. Whatever, the Berkeley Team will work to continue its good performance and then bring its justifiable pride and experience to other decommissioning work world-wide. (*Fig 11*)