Retrieval Success from a 1950s UK Fuel Storage Pond: Blazing a Trail for Early Hazard Reduction

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ABSTRACT

Work has begun to tackle one of the biggest challenges in the UK nuclear cleanup program: the retrieval of spent nuclear fuel from the First Generation Magnox Fuel Storage Pond at Sellafield. The UK Government regulatory body, Nuclear Installations Inspectorate (NII) considers this pond to be the country's highest priority in terms of Hazard Reduction, a view supported by the facility owner, UK Government's Nuclear Decommissioning Authority (NDA).

Remotely operated submersible vehicles (ROV's) were used by British Nuclear Group to assess the condition of stored fuel in First Generation Magnox Storage Ponds (1945-60s build). The ROV survey showed fuel condition was better than expected, and engineers were able to prototype retrieval on a selected skip (container) of fuel. The retrieval and subsequent export to the Fuel Handling Plant (FHP) was executed in November 2005 and was completely successful. The next stage is to reprocess the fuel using the Magnox Reprocessing Plant. If this is successful the prototype retrieval will have demonstrated that:

- British Nuclear Group can safely retrieve fuel from its legacy ponds
- British Nuclear Group can safely transport retrieved legacy fuel between facilities
- British Nuclear Group can eliminate the hazard presented by this legacy fuel by use of existing on-site reprocessing facilities

This in turn enables the option to commence larger-scale fuel retrievals from these legacy ponds years ahead of the current plan which assumes new plants to be available to handle all arisings from the legacy ponds in 2015. This hazard reduction could commence as early as 2008.

INTRODUCTION

The First Generation Magnox Storage Pond was constructed in the 1950s at Sellafield and performed a vital and integral role in the UK civil nuclear power program. It operated safely for nearly thirty years storing irradiated Magnox fuel in a reinforced concrete open-air pond, and de-canning (removing outer cladding) prior to reprocessing at a separate Sellafield facility. During operational service a massive 27,000-tons of fuel was stored, de-canned and then exported from the plant.

Due to a lengthy and unforeseen shutdown at the Magnox Reprocessing Plant the spent fuel became stored in the pond for longer than the designed period. This caused corrosion of the fuel's magnesium oxide cladding and degradation of the fuel.

The facility currently contains significant amounts of spent fuel, sludge and other materials that are classed as Intermediate-level Waste (ILW), and overall remediation and cleanup poses considerable technical challenges.

The safe and accelerated decommissioning of the facility is very high on the national agenda of the Nuclear Decommissioning Authority (NDA). It is one of several higher hazard facilities at Sellafield that, along with others at the Dounreay site in northern Scotland, the NDA have publicly stated are their number one priority. The cleanup of this facility will generate the hazard reduction that is necessary to make the site safer for future generations. The estimated lifetime cost for this vitally important cleanup project is nearly $1.9 billion.

This paper primarily describes an innovative retrieval trial to remove one skip of Magnox fuel from the facility, and its subsequent transfer to the Fuel Handling Plant for repackaging, prior to a reprocessing trial commencing in the near future. The safe and successful retrieval of this skip signifies the first fuel export from the facility in fifteen years. If reprocessing proves successful this will open the door to significant hazard reduction much earlier than planned, and will greatly reduce the estimated cost of the overall decommissioning program.

Background to the Project

Poor visibility and significant radiation and contamination conditions exist in the pond. These conditions have meant that inspection and monitoring of both the building structure and the radiological inventory by conventional means has been difficult. British Nuclear Group capitalized on available marine-based technology to confirm the inventory and assess the current condition of the fuel, Magnox sludge, storage skips and debris in the pond.

Submersible Remote Operated Vehicles

Remote Operated Vehicles (ROVs) have been successfully deployed in recent years in assessment of undersea conditions, notable examples being the explorations of deep-water wreckage of Titanic and Bismarck. Technological advances have combined improved digital photography and vehicle control, with miniaturization of components, meaning highly effective ROVs now come in small packages ideal for applications where maneuverability in tight spaces is required (Fig. 1.). Fuel Storage ponds are such an application and British Nuclear Group have successfully deployed ROV technology to survey the entire First Generation Magnox Storage Pond complex and inventory.

Fig. 1. ROV of the type deployed at Sellafield

Is the Fuel Suitable for Reprocessing?

The completed survey has delivered a phenomenal amount of new information on underwater conditions in the pond. This information on fuel, skips, sludge, debris and radiation profiles is currently being analyzed by British Nuclear Group, in conjunction with UK and European regulators. But what struck British Nuclear Group engineers from the DVD stored video footage immediately was the condition of some of the stored fuel. Remaining fuel in the facility has been underwater between twenty and forty years, and in the absence of any definitive information was assumed to be too badly corroded for reprocessing. The DVD footage showed clearly that some fuel was in a condition worth retrieving and attempting to reprocess.

Potential to Accelerate Cleanup

The current life-cycle baseline plan for Sellafield assumes that the fuel, sludge, skips and debris in the ponds are all nuclear waste, and waste streams to deal with this waste are being developed. However the current plan does not deliver an end facility to receive and treat the waste streams until 2015. But if some of the fuel is suitable for reprocessing – what then? Sellafield has existing facilities which have reprocessed spent Magnox fuel for many years. Perhaps some of it could be recovered and routed through these facilities, thereby reducing the radioactive inventory, and hence the hazard, in these ageing ponds. Perhaps this could be done now, instead of waiting until 2015, thereby significantly accelerating commencement of the pond cleanup operation. The British Nuclear Group Cleanup organization began to get excited about that prospect.

A Pilot Scheme

In March 2005 the British Nuclear Group Cleanup lead team initiated a pilot scheme to retrieve a single skip of fuel from First Generation Magnox Storage Pond and export it to FHP with a view to further assessment of condition, and if possible, onward transmission to the Magnox Reprocessing Plant for final reprocessing. This pilot would prove that at least some fuel was retrievable, some fuel could be reprocessed, and that existing on-site assets could be used now, rather than wait until 2015.

Making the Retrieval —How?

A suitable fuel skip was identified for retrieval, primarily because it was recoverable into an existing inlet cell, Inlet Cell 3, but also because it contained fuel which the ROV footage showed to be in good condition. But it had to be done by October 2005 to align with the overall cleanup critical path schedule. The window of opportunity was eight months.

However, Cell 3 was not in a condition to retrieve the skip – all three inlet cells had been externally stripped out as part of a long term refurbishment program to convert the inlet cell building into a modern standards Export facility prior to pond remediation.

Therefore, vital components such as the skip hoist, skip grapple, and flask lid lifter were inoperable because their drive mechanisms, controls and interlocks were no longer there.
The first task therefore, was to decide what was needed to make these items operable again – this was done on the basis that this was a pilot scheme – a one off retrieval – and hence a fit-for-purpose, minimalist approach was taken. This also fitted the need to retrieve the skip quickly.

Innovative Safety Case

The safety case approach was innovative, maximizing the opportunity for supervisory control with less reliance on engineered systems more suitable to routine operations over many years. The safety case was still however subject to the normal peer review and approval process with oversight by the UK regulator.

Innovative Engineering

New lifting devices for skip hoist and flask lid lift functions were designed, substantiated, fabricated and installed as was a new manually operated hydraulic pump arrangement to operate the skip grapple fingers. Extensive use was made of the existing building Electric Overhead Traveling Crane as a lifting beam from which to suspend the above devices. New high quality, (but readily available established technology) cameras and lights were installed in the cell, giving better coverage than ever before of in-cell operations.

The existing flask bogie and shield doors were mechanically intact and were refurbished to an appropriate standard for the job. The ramp bogie, which carries the fuel skips up and down a ramp into the storage pond, was mechanically intact. An existing hand-wind feature through a reduction gearbox was identified and successfully tested – a decision not to re-energize the electric motor on this device was taken on the basis that it took away operator control on a sensitive operation. By the time the safety case had been fully approved the Cell was ready for inactive commissioning – right on schedule.

Inactive (non-nuclear) Commissioning
A rigorous set of integrated plant and equipment tests were designed and incorporated into commissioning schedules – these tests utilized a clean flask, and clean test skip loaded to simulate the fuel in the target skip. These tests were completed in a matter of days, and an inactive commissioning report produced. This report identified that once initial plant and equipment positioning and alignment had been executed, the dynamic testing of the cell as an export facility proved the operation to be reliable and repeatable. The report was approved and the project was set to move into the retrieval phase.

What Couldn’t be Tested —and Last Minute Problems
The only part of the operation which could not be tested during authorized inactive commissioning was the grappling of the target skip in-cell. This was an active (nuclear) test which could only be done when the retrieval was actually made. In addition new information from a more enhanced survey of the ramp using a smaller ROV identified debris on the ramp bogie rails.

A coil of redundant cable resident in the pond had become entangled in the ramp-bogie mechanism some 5 m down in the pond. In addition some sturdy protective PVC bags, used to protect electrical junction boxes in-cell prior to high pressure water jet decontamination operations, had been blasted off and into the water in the cell. These were squarely in the way of the ramp bogie and fuel skip, and if not moved prior to the retrieval could end up in the skip (rendering it unacceptable to the receipt plant) or in the winch mechanism (threatening the operation) or masking a lifting feature on the target skip (making it impossible to grapple). A decision was taken to remove the debris before commencing the retrieval.

Back to the Committees
The resolution of the debris issues required more safety documentation to be produced. This had to be submitted to safety committees, approved and formally issued before any work could start. To remove the cable hazard, the ramp-bogie was moved off the end stops by 1 m, monitored by a camera on a long pole. A 6 m long lightweight telescopic window brush shaft was used to manipulate the cable clear of the rails and bogie.

To remove the bag hazard, men on lanyards stood at the open cell door and used a similar device to relocate the bags into a safe area. The project was now running two days late.

Retrieval
The retrieval itself, despite the last minute hitches, was executed flawlessly in the course of one work shift. There was some tension during the skip grappling operation as the grapple needed to be lowered some 150 mm lower than had been done during inactive commissioning. The designers were adamant that this was allowed for in the design – however until the skip was grappled this was not physically proven. In the event the whole operation was very comfortably completed. Camera coverage and control were excellent with clear views of each grapple finger

finding full engagement prior to the lift. Radiation surveys were conducted throughout and no increase of any concern in the working areas was detected, although the in-cell gamma detectors recorded the significant radiation from the fuel as it arrived in the cell. The skip was introduced to the flask and lidded in-cell, the radiation readings went to background, and the retrieval was complete.

Export

Export of the 50-ton flask was executed over the next two days. Extensive radiation and contamination surveys were successfully completed (the flask was in a PVC bag for the entire operation). The flask was craned onto a low loader and transported by road to FHP - this in itself requiring significant planning. The consignment was received by FHP, and immediately removed from the flask and loaded into their storage pond without issue.

Next steps

In terms of the larger picture of the trial it is now necessary to assess the condition of the fuel at FHP. FHP is a modern, indoor facility with all the necessary systems and equipment to manipulate and assess the consignment. Should the fuel be assessed as suitable, and all current indicators are that it is, it will then be loaded into a magazine and transported to the Magnox Reprocessing Plant. At the reprocessing plant it will be rendered into re-usable nuclear materials and returned to the UK reprocessing fuel cycle. Back at the First Generation Magnox Storage Pond, work continues apace to assess just how much of the inventory is exportable to FHP. If 100 skips of consolidated fuel (i.e. max payload) could be exported to FHP over two years , what does that do to the radioactive inventory, and hence the hazard?

CONCLUSION

The fuel retrieval was planned and engineered by British Nuclear Group Sellafield Ltd over an eight month period. Innovative engineering and safety case approaches were successfully implemented, allowing an aggressive schedule to be adhered to. The retrieval operation was executed in a single work shift. There were no incidents, accidents, and contamination or radiation exposure to workers, releases or problems of any kind. It was delivered within four days of the target date and within budget.

The implications and opportunities resulting from this trial are significant and exciting. The First Generation Magnox Storage Pond may have a viable route out for a considerable percentage of its radioactive inventory, using existing on-site assets and technology. This route could be available to commence inventory reduction in the very short term, as much as eight years ahead of the current cleanup schedule. Significant and early hazard reduction would result in what is deemed one of the higher hazard facilities by UK Government - making a massive impact on what is the largest cleanup challenge in the world – Sellafield, UK.