Preparation for Fuel Storage Pond Clean Up
British Nuclear Group Sellafield Site

A.N. Leigh
Aker Kvaerner Engineering Services Ltd
Ashmore House, Richardson Road, Stockton on Tees, UK. TS18 3RE

N. Routledge
Aker Kvaerner Engineering Services Ltd
Ashmore House, Richardson Road, Stockton on Tees, UK. TS18 3RE

ABSTRACT

The Legacy Ponds at Sellafield represent one of the biggest challenges in the civil nuclear clean up portfolio in the UK. In June 2002 British Nuclear Group contracted with the ACKtiv Nuclear Joint Venture to progress the risk mitigation, asset restoration and the early enabling works associated with preparation for clean up. The ACKtiv Nuclear JV was formed from three major engineering and construction companies in the UK – Aker Kvaerner, Carillion and Atkins.

This paper describes some of the technical, and safety challenges the project successfully overcame in reducing some of the risks that the Legacy Pond represented and the preparation for clean up.

INTRODUCTION

The First Generation Magnox Storage and Decanning Facility (MSDF) was constructed in the mid 1950s at Sellafield and performed a vital and integral role in the UK civil nuclear power programme.

It operated safely for nearly 30 years, storing irradiated Magnox fuel in a concrete open air pond before stripping the fuel of its cladding (decanning) prior to reprocessing at a separate Sellafield facility. The advent of commercial-scale nuclear power demanded recycling facilities on a large scale – able to accept 500 fuel elements per day – to run the 26 Magnox reactors across 12 sites in the UK.

During operational service a massive 27,000te of fuel was stored, decanned and then exported from the plant. It received its last batch of fuel in 1992 before entering its post-operational cleanout (POCO) phase.

However, its unique cleanup challenges were created in the mid 1970s due to a lengthy and unforeseen shutdown at the Magnox Reprocessing Plant and also through a vastly increased throughput of fuel due to electricity shortages.

These factors caused the spent fuel to be stored in the pond for longer than the designed period, resulting in the corrosion of the fuel's magnesium oxide cladding and degradation of the fuel itself. Ultimately this led to increased radiation levels and extremely poor underwater visibility in the pond. These difficulties slowed the rate of decanning, increased residence times for spent fuel and so created a perpetual delay to throughput.

BACKGROUND

Aker Kvaerner Engineering Services Ltd

Aker Kvaerner Engineering Services Ltd, part of the Aker Kvaerner Group (with a turnover in excess of £3.35bn, employing over 23,000 people, over 30 countries worldwide) is a major engineering, project management and site services organisation with its roots in the former Davy, John Brown and Kvaerner companies.

Our purpose is to engineer solutions that improve our customers' business. Our vision is to be recognised as a leading provider of engineering solutions across the full asset lifecycle. This includes conceptual design, engineering, procurement, project management and commissioning, through to operation and maintenance services, reliability and business modelling, modifications and process improvements and ultimately to decommissioning, deconstruction and site clean-up.

The history of our involvement in the Nuclear Industry spans the 45 years, of commercial nuclear power development in the UK, where the necessary skills have not only been retained but expanded consistent with providing a broad offering and is built on long-term successful relationships with the current site "owner/operators".

The Company's nuclear business operates from our UK offices in the north east of England at Stockton on Tees where we have been established since 1905. We have experience of executing projects, supporting our clients operations across all aspects of the nuclear fuel cycle, with a particular focus on providing services and plant to handle, treat and store radioactive wastes.

Through its 45 years involvement in the industry the company has been responsible for many of the major manufacturing and waste management projects both at Sellafield and the Nuclear Power Stations in the UK, projects ranging in capital value from $1.5m to $250m. This included the process design, detailed design, construction and commissioning of the waste handling facility at Sizewell B PWR nuclear power station; a plant which is operating very successfully today, and as part of the ACKtiv Nuclear joint venture supporting the Legacy Ponds clean-up work. Elsewhere in the world we are currently involved in the Salt Waste Processing Facility (SWPF) at Savannah River in the US with Parsons.

ACKtiv Nuclear Joint Venture

The ACKtiv Nuclear joint venture brings together three of the most well respected engineering, construction and full asset lifecycle service organisations in the UK Nuclear sector, Aker Kvaerner, Carillion and Atkins.

ACKtiv Nuclear are able to offer an unbroken asset lifecycle liability chain, from conceptual design through detailed engineering, construction, installation, commissioning, handover to the Operating Unit and post-handover operations support.

With many hundreds of man-years' experience in the nuclear industry ACKtiv Nuclear brings people, systems, specialist knowledge, supply chain partners and – through the parent corporations – the ability to introduce cross-industry technology transfer and best practice.

ACKtiv Nuclear grew out of relationships developed at Sellafield over 20 years between Carillion and Aker Kvaerner. In its current form it was created in 2002 to support the Legacy Ponds clean up.

Over the last four years the ACKtiv Nuclear Joint Venture has supported British Nuclear Group in the successful delivery of a portfolio of projects within the Legacy Ponds.

Legacy Ponds – Project Classification

The complimentary expertise of British Nuclear Group and ACKtiv Nuclear has been utilised over the full project life cycle from business needs assessment to final commissioning and handover. This portfolio of projects is a major enabler to the retrieval of the historical inventory and the subsequent safe decommissioning of the Legacy Ponds. The projects are grouped under three main areas: key retrieval enabling projects, asset management and restoration and risk reduction.

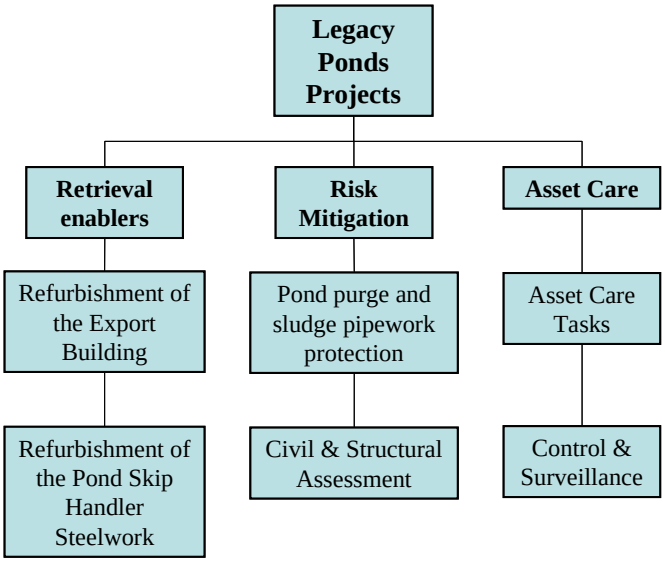

Figure 1: First Generation Magnox Storage Pond Project "Classification"

Significant innovation and successes have been achieved during this period in support of the Clean-Up strategy, including:

- **RETRIEVALS ENABLING PROJECT – EXPORT BUILDING** – The project is tasked with turning the former Pond Inlet Building into an operational Export facility to facilitate the removal of the skips currently contained in the Pond. The work is phased and to date the facility has been decontaminated, support systems upgraded and redundant in-cell and out-cell equipment removed. Significant construction and installation efficiency improvements have been achieved in a hazardous brownfield environment including novel techniques for waste size reduction by the use of stitch drilling as opposed to cutting
- **RETRIEVALS ENABLING PROJECT – SKIP HANDLER STEELWORK REFURBISHMENT** – This project encompasses activity in the water retaining structure specifically the skip handler & gantry. To support retrievals the rail, racks and gantry beams are to be replaced whilst the gantry legs are to be refurbished. To accomplish this work a Gantry Refurbishment System (GRS) has been designed, fabricated, tested and installed to enable the majority of the access and lifting necessary to complete the refurbishment programme.

- **RISK MITIGATION PROJECT – POND PURGE AND SLUDGE PIPEWORK PROTECTION** – The original pond effluent discharge route for the pond purge and de-sludging operations and has been redundant since the early 1970's. The project consists of the design and development of proven systems for the permanent isolation of exposed pipe work and the provision of tools and equipment to enable permanent isolation of the pipe work from the pond in the event of a system failure. As the pipework is located in a radiologically challenging environment all the systems and techniques were designed and off-site tested to ensure minimal "time at the workface" for the installation and operations teams.
- **RISK MITIGATION PROJECT – CIVIL AND STRUCTURAL ASSESSMENT** – An understanding of the structural performance of the facility to support clean-up is fundamentally important. This project assessed the existing structure against current standards and identified a number of shortfalls. These shortfalls were addressed and closed out by utilising more sophisticated analysis techniques without the requirement for costly time and dose consuming remedial site works.
- **ASSET RESTORATION PROJECT – CONTROL AND SURVEILLANCE PROJECT** – The Control & Surveillance project consists of the design, manufacture, installation and commissioning of a new Radiological Protection System, including Control Desk, SCADA, Radiological Surveillance and Building Evacuation Systems within the facility. Novel techniques were adopted for the redundant cable strip out, to ensure it was done safely and methodically.

RETRIEVALS ENABLING PROJECT – EXPORT BUILDING

The Export Project involves the modification and refurbishment of the redundant First Generation Magnox Storage Pond Inlet Building in order to provide a new Export facility which will enable the retrieval of legacy ponds inventory. In its original role the facility received consignments of fuel and transferred the fuel into the pond via one of three cells. The building is old, deteriorating and contains life expired plant and equipment.

The building has been renamed the Export Building and the project has been initiated with the aim of:

- Enabling safe, reliable and sustained control and surveillance operations.
- Improve environmental and radiological conditions within the building.
- Maximise the use of the existing asset.
- Mitigate the risk associated with establishing an engineered export route.

The Export project has been implemented in a two phased approach:

- **Phase 1** - The upgrade of the Export building basic infrastructure which consists of two main tasks:
    - 1a) Rationalisation of the CE & I systems, consisting of design, procurement, refit, commissioning and the strip-out of redundant CE & I equipment
    - 1b) Cell clean-up, involving the cell decontamination and strip-out of all redundant equipment.

  The completion of both tasks acts as an enabler to Phase 2 of the project.

- **Phase 2** –Design, procurement, refit and commissioning of the Export building. The phase 2 section of the project aims to replace all the mechanical plant handling items and other associated equipment. The successful completion of this part of the project will provide a facility capable of retrieving skips of pond inventory, transferring the waste into flasks and exporting these flasks from the building to be stored in a more permanent location.

During the execution of Phase 1, particularly Phase 1b, considerable knowledge was gained about the plant condition and confirmed facts that were previously known but not substantiated. This was achieved by undertaking in-cell and underwater surveys to develop an inventory for each cell. This information was used to underpin the redundant equipment strip-out methodology. Prior to strip-out the cells were decontaminated to reduce the future dose burden when re-fitting the cells. This was achieved by ultra-high pressure water jetting. To support the decontamination a temporary ventilation system had to be installed and commissioned. This had an impact on the secondary containment requirements which had to be upgraded to provide an airtight seal. The results of the decontamination reduced the dose burden by 50% with a subsequent increase in the in-cell working times.

Figure 2: Export cells following completion of Phase 1

RETRIEVALS ENABLING PROJECT – SKIP HANDLER STEELWORK REFURBISHMENT

The purpose of the Pond Area Project is to refurbish the Pond Skip Handler and its supporting structure and to return the Skip Handler to operational service as soon as safely possible. This is essential to enable resumption of pond management activities, including the removal of historical inventory.

The Skip Handler and its supporting structure form an essential part of the pond structure. The radiation levels from the pond liquor make what would otherwise be a straightforward plant refurbishment project into a significant plant access challenge to facilitate safe personnel and materials access to the workface to undertake the refurbishment work.

Following the down selection from an optioneering process the Gantry Refurbishment System (GRS) was selected and subsequently designed, manufactured and installed. The primarily

purpose of the GRS is to provide safe access for personnel and materials in order to facilitate the refurbishment of the Pond Skip Handler supporting steelwork structure. It was designed to be installed over a pond with a highly radioactive inventory and consequently the design concept was based on a modular construction of 12 component pieces. Sequencing of the installation was modelled to aid the design development. Innovation during manufacturing led to an improved solution to lift the machine in a single lift.

The key design requirements of the GRS were:

- It needed to be able to change the structural beam section
- Provide safe access to the work face
- Could be easily installed
- Provide shielding to the operator
- Not adversely affect the existing structure
- Needed to be seismically compliant
- Maximise access capability
- Minimisation of the GRS structural weight

Figure 3: GRS Test lift

The GRS includes two overhead hoist units mounted on traversing cantilevered lifting beams which allow loads of up to 3te to be lifted from the ground onto the GRS. Following manufacture a works trial lift was completed successfully giving confidence for a safe lift at site. However due to the challenging environment the installation were classified at the highest possible radiological safety category. As a result the work was authorised by the Nuclear Installations Inspectorate, Sellafield Nuclear Safety Committee and an independent readiness review panel who assessed the operation against WANO principles. Despite less than perfect weather, the GRS was successfully and safely lifted onto the pond in October 2006, the culmination of three years of planning, engineering and construction. The installation lift, involving the use of an 800te mobile crane was the largest lift undertaken on the plant since 1990.

RISK MITIGATION PROJECT – POND PURGE AND SLUDGE PIPEWORK PROTECTION

The project is concerned with the progressive reduction of the risk posed by the vulnerable and gradually worsening condition of the pond purge and sludge pipework systems which form part of the primary containment. The project consists of the design and development of both well-proven systems and novel techniques to address all issues that could give rise to failure of the pipework and loss of containment. The failure modes consist of corrosion, impact, extreme low temperature and seismic event. The implementation methods of the solutions at site reflect the

extremely arduous radiological environments within which the pipes are situated and the difficult access condition that pertain.

ACKtiv Nuclear and British Nuclear Group have been working together on the project since 2002, when the risk posed by the failure of the pipework system was considered to be of the highest order on Sellafield site. The project has implemented early risk reduction measures in parallel with the development of long term permanent solutions. The scope of work is being undertaken on a phased basis with the risk reduction measures split into deliverable task packages:

Emergency termination devices

Failure of any of the lines due to impact damage, frost, corrosion or seismic would lead to an uncontrolled leakage of active pond liquor and sludge. Appropriate leak termination devices were designed, manufactured, trialled and handed over to the site emergency response team within a period of three months. Further reviews and development work led to the selection and provision of a number of emergency termination devices appropriate to all credible pipe failure scenarios throughout the pipework system.

Encapsulation of the Active Drain Trench

The Active Drain Trench runs along the South side of the facility and contains the Purge and Sludge headers. The presence of a dripping line prevented completion of the encapsulation exercise until the leakage could be permanently isolated from the trench. Specialist resins were trialled and subsequently injected around the leaking pipe. The seal achieved allowed completion of the grout encapsulation exercise. This ensured that all sections of the purge and sludge headers were encased with sufficient depth of grout to satisfy dropped load, frost protection and seismic mitigation requirements. This work was completed in February 2004.

Provision of Frost Protection systems

A series of Infra-red radiant heaters were specified, trialled and installed for frost protection of the exposed lines within the higher dose areas. The heaters were installed in a low dose area, with the capability of being deployed over a shield wall, to direct heat at the down comers. Provision of a series of infra-red lamps allowed the pipe temperature to be increased by an appropriate amount. Installation, commissioning and handover of the frost protection system for the high dose lines was achieved in March 2006

Provision of new Emergency Pumping Systems.

Prior to the implementation of permanent isolation of the Pond Purge and Sludge Pipework System, a number of emergency pumping systems have been installed to return any leaking liquor resulting from line failure back to the pond. Hydraulic modelling software was employed to determine the theoretical worst case leakage rates resulting from various failure scenarios. Emergency Pumps and associated level detection systems have been specified for four separate locations, to mitigate the consequences of loss of containment of pond liquor and eliminate the potential for marine discharge. Two of these systems are now in operation.

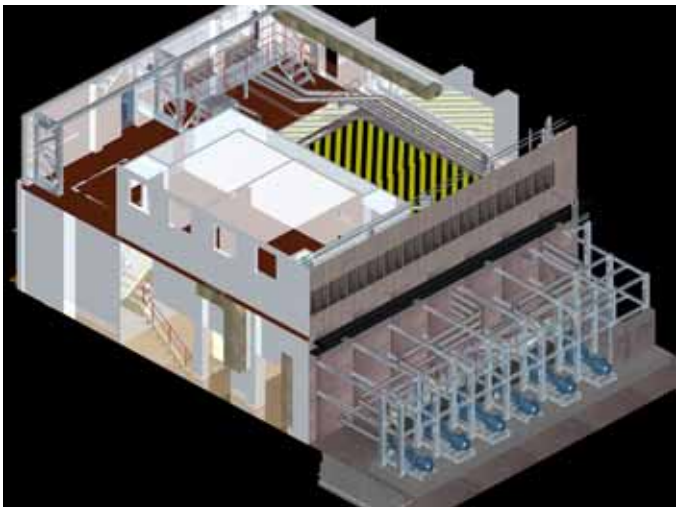

Figure 4: Representation of the emergency pumping system

Long term solutions

Permanent isolation of the lines is considered to be the most appropriate long term solution for active pipework in support of the removal of the pond inventory. Hot and cold tapping techniques have been developed and successfully trialled for the range of pipework systems. Hydraulic jetting has been trialled for removal of sludge simulant from 4" & 8" diameter lines and resin/grout injection techniques have been perfected to achieve the required permanent isolation. Trialling work has been successfully completed.

RISK MITIGATION PROJECT – CIVIL AND STRUCTURAL ASSESSMENT

This major assessment commenced in September 2002 and was undertaken to establish the capability First Generation Magnox Storage Ponds civil and structural systems to cope with all applied loads including modern hazard and extreme loading.

This work was required to ensure the facility was capable of safely containing the legacy fuel and accumulated sludge until such time as the decommissioning programme had removed these materials from the pond. It would also create a comprehensive understanding of the buildings structural behaviour, and therefore form an important platform for the retrievals and decommissioning programme.

The project involved a comprehensive civil and structural assessment, with the first phase being to analyse the structures and assess them for compliance with the modern structural codes. This exercise identified a large number of shortfalls where the structure failed to meet the modern standards, particularly in the seismic case, and where site remedial works would therefore be expected.

A review in March 2004 at the end of Phase 1 of the Assessment, using experts from ACKtiv Nuclear and British Nuclear Group, assessed the probability of being able to remove the shortfalls by further analysis. The prize, if this could be achieved, was significant, avoiding the major Health & Safety issues plus the cost and programme implications of undertaking unscheduled remedial works. The potential cost savings were significant when taking into account the knock on effects to the existing programmes of work within the facility.

The second phase of the project therefore focussed on removing as many as possible of the shortfalls. This was achieved by further advanced analysis to remove conservative assumptions, and by using refined Finite Element models to create a better understanding of the true building behaviour under all load conditions. Major benefits have been delivered by undertaking this detailed work with all but a couple of the identified shortfalls being resolved via the analysis route.

The project has now completed a "guide document" to the vast amount of calculations, reports and drawings that have been produced over a 3 year period. This gives an overview of the assessment conclusions and to allow future retrievals projects to rapidly navigate the latest documentation.

ASSET RESTORATION PROJECT – CONTROL AND SURVEILLANCE PROJECT

The Control and Surveillance project involved the site survey, consultation, scope definition, design, procurement, works test, installation and commissioning of a new control system for the First Generation Magnox Storage Pond facility. The control and surveillance system incorporates a control desk, supervisory control and data acquisition, radiological surveillance and building evacuation systems within the Ponds complex. The project is a key enabler to future Legacy Ponds retrieval activities. The project comprises of two parts; the radiological surveillance/building evacuation system and the control and monitoring system.

The radiological surveillance system (RSS) consists of new radiation monitors, PLC's and I/O hardware along with a dedicated SCADA system with duty / standby servers. The RSS not only provides a method of viewing current radiation levels and actuation of the evacuation system; it logs and trends alarms and radiation levels for later analysis – a feature which was previously unavailable. The two servers are situated in different buildings, one in the building control room and one in the Incident Control Centre (ICC). The purpose of this is to be able to monitor the facility remotely so that in the event of an emergency requiring building evacuation, a structured re-entry can be planned and executed.

A major challenge of the RSS implementation was the installation of the monitors and control desks, which was achieved with the right strategy and input from all Stakeholders. The changeover involved the installation of the control room control desk, 60 gamma monitors, 59 Alpha / Beta in air monitors, 4 Stack Alpha / Beta in air monitors as well as over 2000 metres of cable rack and over 17000 meters of cable. Of course the entire changeover had to be implemented within radioactive environments.

The control and monitoring system comprises of the technological upgrade of the existing system and similar to the C & S system features a SCADA system with duty / standby servers connected to a field mounted PLC. The PLC collects process variables such as pond water levels, instrument air pressures, flow rates and temperatures which are all collected by the computer system. This enables the plant operations team to monitor, trend, retrieve and store data ensuring that the plant is kept within its defined operating limits.

SUMMARY

The Legacy Ponds at Sellafield represent one of the biggest challenges in the Civil Nuclear clean up portfolio in the UK. In June 2002 British Nuclear Group contracted with the ACKtiv Nuclear Joint Venture to progress the risk mitigation, asset restoration and the early enabling works

associated with preparation for clean up. Since then significant progress has been made in preparing the facility, and its support systems, for the clean-up operations. This has been achieved by breaking down the scope, within an integrated framework, to manageable and definable elements, implementation of innovation to target key issues of dose and waste management and undertaking site works to an exemplary safety record by the introduction of a pro-active safety management culture.