Remediation of the FGMSP at Sellafield: The First Transfer of Bulk Sludge-17133

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ABSTRACT

The very first bulk transfers of radioactive sludge have commenced from one of the most hazardous nuclear plants in Europe, using equipment and systems researched, designed, installed and commissioned by Jacobs as part of the ACKtiv alliance.

Sellafield is a nuclear fuel reprocessing and decommissioning site, close to the village of Seascale on the coast of the Irish Sea in Cumbria, England. Sellafield incorporates the original nuclear reactor site at Windscale, which is currently undergoing decommissioning, and dismantling, and Calder Hall, the world's first nuclear power generating reactor. The first nuclear facilities were built in the 1940's.The First Generation Magnox Storage Pond (FGMSP) dates back to the 1950s as part of the UK's expanding nuclear programme and was constructed to store, cool and prepare used Magnox nuclear fuel for recycling into new fuel. It urgently needs to be emptied of 1500 cubic metres of radioactive sludge. In this paper we describe the work undertaken by Jacobs to deliver a very challenging programme of work to provide the capability to remove sludge from the pond.

The FGMSP Retrievals Project was awarded in March 2007 to supply equipment and services for the removal of sludge and miscellaneous waste from the First Generation Magnox Storage Pond at Sellafield. The Project is being executed by ACKtiv Nuclear (Jacobs, Carillion & Atkins) of which Jacobs is a 40% stakeholder. ACKtiv Nuclear is a mature Joint Venture and has been operating continuously and successfully since 2002, the oldest JV still in operation on Sellafield Site. The roots of the JV can be traced back to the 1980's.

The Project covers all project phases from front-end engineering through detailed design, procurement, installation and commissioning support. The Project places huge emphasis on off-Site testing and has several facilities for both installation and integrated testing. This proves equipment prior to installation in a radioactive environment. The Project has achieved success and recognition including winning the 2014 and 2015 Sellafield Business Excellence awards, as well as numerous internal Jacobs awards.

The Project achieved a major decommissioning milestone in March 2016. Since the installation of a 31m pipebridge in 2012, using a 1200te mobile crane surrounded by several other facilities with nuclear inventory, the Project has successfully installed the sludge retrieval and effluent system into the FGMSP. This 4 year programme of work included 2 booster pump platforms, sludge recovery tooling, hoses, umbilicals and a deluge skip wash box which were all trialled and proven off-Site prior to installation in the pond. This milestone to commence transfer of sludge to modern stainless steel containment is a major step forward in the hazard reduction of the facility.

The presentation will cover the installation of the pond desludging equipment, the innovations deployed that ensured that the milestone was achieved under budget and ahead of schedule, as well the benefits to the facility, the Site and the nuclear industry. It will also examine the challenges that needed to be overcome such as high dose, contamination, limited working times and space constraints. The presentation will describe why the work is of national Importance and conclude with the achievement of commencement of bulk sludge transfer to a modern facility.

INTRODUCTION

The FGMSP was constructed in the 1950s at Sellafield Site in Cumbria, with the purpose of storing, cooling and preparing spent magnox fuel for reprocessing. This fuel was a bi-product of the first generation of Magnox nuclear power stations, such as Calder Hall, the UK's first commercial nuclear power station. The need for the Project arose as the FGMSP is an ageing asset in a deteriorating condition which contains extremely hazardous, degraded nuclear inventory and presents one of the highest nuclear risks in Europe. The facility ceased full scale operations in 1986 after which the facility was transferred from an operational plant into a care and maintenance regime, leaving large quantities of fuel rods to decay. Presently the FGMSP contains radioactive sludge, magnox fuel, miscellaneous intermediate level waste and low level waste material. The sludge that remains is a combination of corroded uranium fuel combined with magnesium and aluminium alloy that formed the cladding around the fuel rods that were cooled in the pond and have now corroded.

Sellafield Ltd initiated the FGMSP Retrievals Project to provide high hazard reduction through the capability for the retrieval of the inventory contained within in the FGMSP and to export it for treatment in a newly provided modern stainless steel containment building elsewhere on Sellafield Site. This programme is considered to be one of the most important high hazard reduction at Sellafield Site. Following competitive tender, Sellafield Ltd (SL) awarded the FGMSP Retrievals Project contract to ACKtiv Nuclear Joint Venture, which consists of Jacobs, Atkins and Carillion and work commenced in 2007. The Project scope covers the full Project lifecycle from business case support, concept through design, development, procurement, installation and commissioning through to operational support.

"The relationship between SL and the ACKtiv Joint Venture team and their supply chain contacts is well established and continues to make a significant contribution to the successful delivery of tasks." Quote from Sellafield Magazine

Fig. 1

PROJECT MANAGEMENT

The Project is actually a Programme of 44 individual Projects grouped by area and coordinated by 3 Senior Project Managers, who each had responsibility for circa 15 Projects. The Project Manager was responsible for the budgets, resources and schedules that underpinned the integrated Project delivery schedule.

The work was delivered by an Integrated Project Team (IPT) to improve team dynamics and influence its successful delivery. The IPT was a multi discipline team that consisted of members of the JV partners and the Client, selected on a best person for the job basis. The team were motivated by the challenge of the work which was vital to the UK Nuclear Industry. The strong relationships within the IPT resulted in very few significant issues that could be resolved by the IPT, however a Project Leadership Team (PLT) was formed to provide governance, strategic guidance and issue resolution in a way that does not impact upon delivery. We worked closely with the Client to develop the scope cost and programme, including a fully integrated programme that covered other Projects and operational activities. As an IPT we also worked together to identify risks to the Project, mitigation actions and risk owners.

Given the hazardous radiological environment and the size and complexity of the FGMSP Portfolio, all Projects interfaced with other areas and disciplines using an Integrated Works Management (IWM) process. This is a stage gate process that is initiated 12 weeks prior to any work commencing and ensures that all the necessary deliverables are completed at regular review gates and that resources are correctly assigned. This is particularly important as it ensured effective and efficient use of all resources, both Project and plant. The major benefit of the IWM process is to enable the Project Team to produce a realistic schedule that is fully integrated with all Projects and other work interfaces in the facility which reduces the risk of failure to deliver.

"This required a collaborative approach with the plant operators and maintainers, who were instrumental in the success. In addition, we've had great support from the supply chain through the ACKtiv joint venture, in particular Jacobs whose knowledge of the building and relationship with the plant operators contributed significantly" Sellafield Magazine, Mike Robinson, Client Senior Project Manager, June 2015.

Fig. 2.

There were many challenges that needed to be overcome to provide the equipment and capability to retrieve more than 1,500 cubic metres of radioactive sludge lying at the bottom of the 160m long storage pond and within the wet bays. The sludge would fill over half an Olympic sized swimming pool. The sludge has to be carefully removed from the bottom of the pond, whilst leaving sufficient water in place to provide a radioactive shield for the remaining nuclear fuel. The high radiation levels and risk of nuclear contamination were ever present, impacting on the working times. We actively managed the dose uptake to the team and ensured that work was progressed even in areas where the daily dose limit was reached in 20 minutes. This was combined with the space constraints within the facility as interfaces with other

Projects vying for the same working envelope was a major challenge. The updating of historical records including radiological data was also an initial challenge that was overcome by the production of new drawings and a 3D model of the facility.

The Project risks and opportunities are managed in line with the Projects risk management plan. Key opportunities are actively and robustly perused and managed to accelerate risk reduction by reducing the Project's critical path. The Project was subject to Key Decommissioning Milestones (KDMs) aligning to the Nuclear Decommissioning Authority's (NDA) strategic objectives of removing hazardous material from legacy facilities on the Sellafield Site.

DESCRIPTION

Pipebridge to Modern Storage Facility

We installed a pipebridge to export sludge to a modern storage facility. The 31m, 56t pipebridge was installed using a 1200t mobile crane (the largest in Europe) and a 100t mobile support crane to rig the main crane, the largest crane lift in the history of the Sellafield Site. The size of these mobile cranes and the sensitive area where the pipebridge was being installed meant a fault scenario including the collapse of a crane or incident with a suspended load could have potentially seriously affected up to 10 buildings in close proximity. The impact of a catastrophic failure in the lift could have caused an international scale accident through loss of nuclear inventory. In order to successfully plan the work the whole operation was modelled using 3D design technology. This modelling helped prepare for detailed 'off site' trials that were undertaken using simulated buildings (created by stacking ISO Freight containers) to prove that the lifting of the pipebridge could be carried out safely before lifting it into position within the FGMSP. The "off-Site" trials used the same crane to closely simulate Site conditions. The purpose of carrying out detailed and meticulous safe work planning was to eradicate any possibility of an incident occurring. The duration of the planning and trial work was over 24 months and the actual site installation was successfully completed within 1 working day.

Pond Wall Clearance (enabling works)

Cleaning and preparing the pond structure was required prior to the installation of the retrievals equipment. This was a major enabling task as there had been no access available for over 20 years and it was located in the middle of the Pond, it contained radioactive vegetation, miscellaneous items, and the remains of handrails that all needed to be removed prior to installation activities.

Fig. 5.Pipe Bridge Installation

Fig. 6.Pond Walls Before

Fig. 7.Pond Walls After

Sludge Pumping Platforms

The installation of two sludge pumping platforms over the pond was required to house the pumping system, which was also installed complete with the supporting umbilical's and support structures. This equipment was installed using the lessons learnt from the Pipebridge installation and again utilised trial facilities and ensured that we retained the same key work force to ensure continuity and that crucial knowledge was maintained. The retrievals equipment was delivered to Site pre-assembled for installation using the Clients Skip Handler Crane. The installation of equipment posed numerous challenges including high dose uptake and the potential for unacceptable delays to the risk reduction programme. This involved an intricate installation sequence in a very congested location adjacent to the pond, which was developed in conjunction with lifting specialists Mammoet. The benefits included ease of installation, schedule acceleration, lower impact to third parties and a less onerous safety case categorisation.

"The performance on the major installations has been world class. The environment we work in is very challenging and the current focus on behavioural safety (Human Performance) is applauded." Mike Robinson, Client Senior Project Manager

Fig. 8.

"The ponds programmes have and continue to deliver real progress and set the standard for real pragmatic decommissioning and innovation by which others are judged." Mark Wareing (NDA Major Projects and Programme Manager).

Fig. 9.

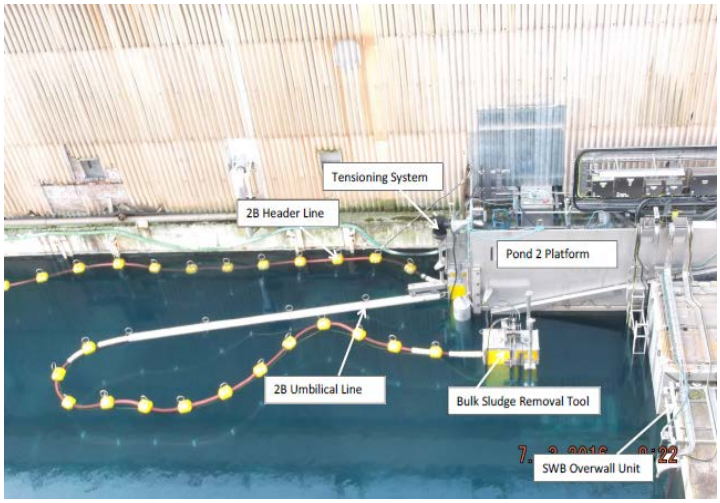

Fig. 10.Retrievals Equipment Installed

During the Project lifecycle we promoted the ethos of working together as a single team. At the earliest opportunity we involved the Client's Operations and Maintenance teams who were the skilled specialists in decommissioning operations and also had a high level of experience of working within the facility.

This ethos was demonstrated in the execution stage as we held daily on site meetings with all the relevant stakeholders in which we planned the work for that day and reviewed the previous day's progress, ensuring that any emerging issues were resolved or actioned as early as possible. The response to emerging issues was a key success factor in the delivery of this Project. The Project utilised pioneering application of existing technology which was modified for the environment. During these daily meetings we encouraged open and honest communication, ensured that everyone knew their tasks for the day with illustrations and detailed plans and stressed how their tasks aligned to the overall Project goal. Prior to the main lifts we engaged a human performance coach to reinforce the right behaviours to deliver the work safely.

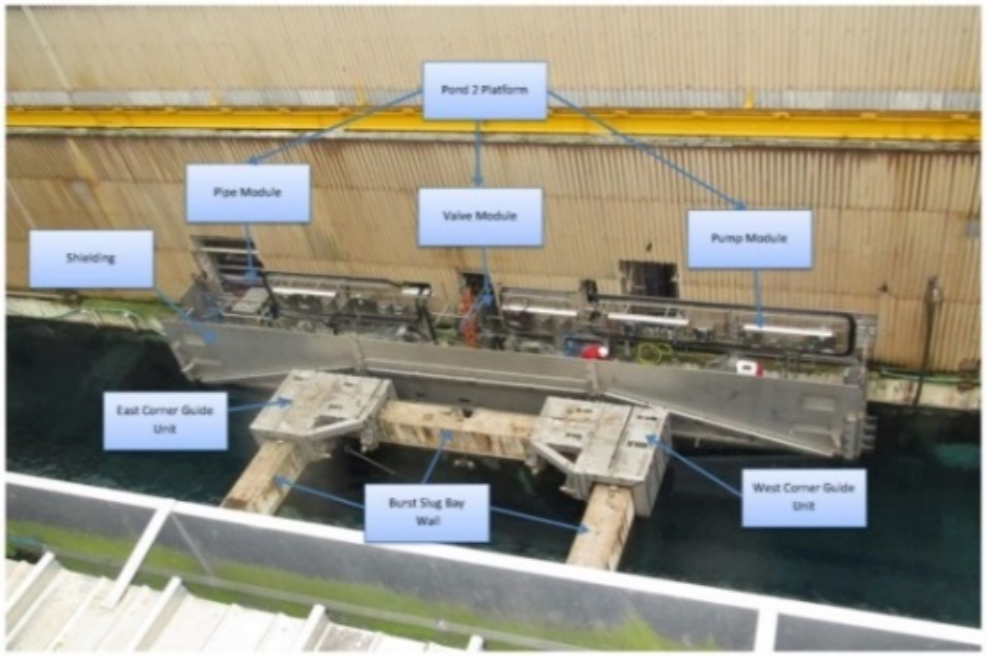

Fig. 11.Pond Platform 2 Installed

RESULTS AND BENEFITS

In March 2016 the KDM to commence of bulk sludge transfer to modern stainless steel containment, was successfully achieved, thus commencing the sludge exportation stage and therefore significantly impacting the FGMSP's hazard and risk profile to the delight of the client.

"One of the best things we've ever achieved" Paul Foster Sellafield Ltd. Managing Director.

Fig. 3.

The KDM was achieved 28 days ahead of schedule and the Project now embarks upon the next phase of delivery and is currently £4.5m under the circa £100m budget.

During the delivery of the phase of the work we supported the Client with an initiative approach to delivery whilst applying a decommissioning mind-set, resulting in an accelerated delivery programme being delivered earlier than baselined and at a reduced cost.

"It is fantastic to see a Project of this size and complexity deliver to schedule" Dorothy Gradden, Head of Programme, Sellafield Ltd.

Fig.4.

The proposed solution to commence bulk sludge retrievals in its most simplistic form was to install a suite of retrievals equipment including the following key stages:

Jacobs Benefits:

The success of this high priority, high profile nuclear decommissioning Project has further enhanced Jacobs worldwide reputation and position within this growing sector, thus aligning to Jacobs' core values of: We Are Relationship-based; Growth is an Imperative; and People Are Our Greatest Asset. The success also aligns to our business strategy of building long term client relationships. We have received 10 consecutive ROSPA awards and completed 4 million hours without any Lost Time Incidents in one of the most environmentally hazardous environments in Europe.

The Project has supported Jacobs' growth in the nuclear sector, supported the opening of a new 200 seat office and continued growth to become the recognised market leader. The Project has been instrumental in winning new work in the nuclear industry including a decade long package a collection of work valued at over £300M, as well as supporting nuclear tenders in France and USA.

Project Team Benefits:

Through the novel challenges and experiences presented to the team on this Project, we developed our people who are highly sought after and recognised specialists in nuclear decommissioning. The Project has also played an active role providing key on the job experience to Jacobs graduates and apprentices. In 2015 a graduate working on the Project was awarded the Nuclear Institute Young Speaker of the Year Award and an apprentice was a finalist in the National Apprentice of the Year Awards. We strongly belive that IPT's are the best way to deliver complex nuclear decommissioning Projects.

Client Benefits:

In 2015 the Project won the Return on Investment Award at the Sellafield Ltd Excellence Awards. These awards celebrate outstanding performance across a range of categories; including safety, innovation, apprentice, and team excellence. In 2014 the Project won The Sellafield Ltd Excellence Awards 2014 – Working as a Single Team for the works completed on the Burst Slug Bay, also in 2014 the Project won the coveted SL Managing Director's Award for Business Excellence.

We saved our Client £20m through innovative solutions and new ways of working, this was demonstrated by our approach to "Sustainability Plus" and "Value Plus", this was resulted in saving the equivalent of 3000t of carbon. Most importantly the Client got the equipment and services to commence sludge transfer and start reducing the hazard.

Other Stakeholders / Wider Society Benefits:

We have awarded more than £110M in subcontracts – 30% with Small and Medium Enterprises (SMEs) and 75% with local suppliers. We have successfully expanded the supply chain to attract more competition, secure more competitive pricing, and to spur innovation. Maximizing benefits to the local communities in West Cumbria is a key aspiration of both the client and the NDA and provides Jacobs with a key reference case example to support growth winning further work.

The Projects successful delivery is helping to improve and restore the general public's perception and confidence of the UK nuclear industry. This will also lead on a more favourable acceptance that the nuclear new build reactors being planned in the local area can be constructed and decommissioned in a safe mind-set not risking the local area or local workforce. The reduced risk profile for the facility has had a positive impact on the local and national environment.

INNOVATION AND LESSONS LEARNED

The Project had a major emphasis on reducing Project risk; this promoted the Project Team to adopt a questioning attitude throughout the Project's lifecycle thus overcoming challenges that were presented due to the sensitivity of the building, asking the question "can this be achieved in a more cost effective and safer manor?" This resulted in a total of 56 Project innovations being raised, including:

- Innovations in the production and delivering of Operations and Maintenance deliverables. Value Plus £686,528 savings.
- Challenge to methodology of ventilation system modifications reducing the critical path by 13 weeks. Value Plus £8,304,785 savings.
- Challenge to the amount of tooling required to achieve the Project end state. Value Plus £1,090,695 savings.
- Procurement innovation, to purchase rather than rent key equipment. Value Plus £374,407 savings.

During this Project our Client, completed an onerous Project review process called a Sellafield Project Execution Review (SPER). The purpose of the SPER is to review the status of the critical decisions and risks identified in the business case, check that the Project has incorporated lessons learnt and transfer of knowledge and undertake a full review of the underpinning estimate and schedule to Project completion. The review team then issues recommendations and findings.

During the latest SPER, 8 "world class" best practices were identified for the Project. These were:-

- Within the Project budget, allowance was been made for retaining key individuals for a period post completion of active commissioning in order to provide support to the operation and maintenance teams. This was a good example of Knowledge Management.

- The Project is functioning well as a genuinely Integrated Project Team. This is a mature relationship, evidenced by a high degree of trust. The lessons learnt from this commercial arrangement and the way it has been managed in practice should be shared more widely. Benefits evident from the relationship include a proactive and collaborative approach to problem solving.
- Lessons learnt have been utilised from other Programme / Projects, directed to enhance the understanding of Project risks.
- All of the Integrated Project Team (IPT) has been involved, at some stage, to underpin the risk register impacts and ensure alignment to the Project schedule and estimate.
- Positive evidence of proactive learning being embedded by the Project.
- Final Accounting has already begun. This will ensure that the risk of claims is reduced and that final accounting is performed smoother with key resources with personal history of the Project being in place. Experience shows that these resources often leave towards the close out of a Project increasing the challenge with final accounting. This was a good example of Knowledge Management.
- Best practise from previous SPER with regard to use of test rigs, allowing operators/designers/ construction to gain knowledge and experience in clean environment before moving onto the main site.
- There is an excellent alignment between cost and schedule. Good evidence of detailed under-pinning schedules and rules of credit / quantity tracking to support Project status. Good detailed estimate that underpins Estimate at Completion (EAC) that is aligned to schedule.

In addition to the SPER several lessons learnt workshops were held with the results being documented and issued to the Project Team and also other Projects with the facility to ensure that these lessons learnt are visible to future Projects for implementation if deemed suitable. The learning was also communicated to the Sellafield Contractors Working Group to share the learning with other companies, other than Sellafield Directorates and the NDA. The key lessons learnt are summarised below:

- The application of decommissioning mind-set to deploy simple, innovative solutions, utilising historically proven techniques in order to achieve safe and timely delivery of key solutions for future decommissioning.
- Innovative thinking using a “can do” approach to achieve results within the time constraints whilst maintaining safety and integrity.
- The importance of trial work prior to installation activities on plant to ensure any problems were resolved before going to site, also used as for training and simulation activities.
- Communication was key success factor with pre and post jobs delivered at the beginning of every shift to focus operators on a daily basis and for issue management.
- Limiting the work area on only essential work force only limiting the number of potential distractions, ensure focus of operators is not disturbed.
- Dedication of scarce resources to the Project, to mitigate against the risk of losing key resource.

- Commercial arrangements and management of the Integrated Project Team.

A good example of using LFE during this Project was employing the techniques and methods that were completed successfully during the Pipebridge installation for the platform installations.

OVERCOMING CHALLENGES

The Project was pioneering advances into accelerated risk reduction in the nuclear decommissioning of legacy high active facilities. This is one of the world's most technically challenging environments and we have achieved repeated success by embracing new ways of working focusing on collaboration, removing barriers, fit for purpose solutions and embracing innovation, and overcoming challenges. A significant challenge was to change the culture of the facility from a state of care and maintenance to an operational state, while focusing on a decommissioning mind-set. Some examples of this pioneering approach are summarised below:

Pipebridge

Originally the Pipebridge design was a concrete construction and this would have closed the main access road within the Sellafield complex causing major disruptions for up to 12 months. The solution to this problem was to erect a steel Pipebridge without comprising structural integrity and reducing road closure down to 1 working day during installation.

Sludge Pumping Platform 2

Due to the work being undertaken in a highly hazardous area over the Pond, a full scale trial was completed and careful consideration was given to working times, occupational safety, radiological safety and nuclear safety. The installation methodology reduced the installation timescales from 3 months to 1 week.

Infrastructure

The FGMSP building infrastructure could not support the new equipment required to commence bulk sludge transfers from the pond. Several infrastructure Projects were completed which included a new building ventilation system, structural repairs and replacement of building roofs and the creation of new electrical switch-rooms. Major upgrades to the building electrical and control systems included the removal of redundant equipment and the installation of new electrical panels, a new PLC with SCADA control, CCTV system and over 60km of new cable and racking.

Unforeseen challenges

Or emerging issues associated with Project delivery were quickly responded to with a focus on finding the right solution. Commercial and contractual issues were then resolved in a manner that did not affect delivery, supported by the PLT when necessary.

“Fabulous Work, a real credit to all involved” Peter Lutwyche NDA Sellafield Programme Director

Fig. 12.

Reference Papers

The paper titled “Preparation for Retrievals from Sellafield Legacy Ponds Installation of the Gantry Refurbishment System” was presented by the author at WM08. The paper described an enabling project was hazard and risk reduction in the FGMSP.