Pile Fuel Cladding Silo Deflector Plate Removal Project Using Long Reach Tooling and Suspended Abrasive Water Jet Cutting System -17541

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ABSTRACT

The Pile Fuel Cladding Silo (PFCS) at the Sellafield decommissioning, reprocessing and nuclear waste management facility in the UK was constructed in the late 1940s and used for the storage of Intermediate Level Waste (ILW) arising from the Windscale Piles, Calderhall & Chapelcross Reactors until the 1960s. The PFCS is 21 metres high and comprises 6 identical tall compartments with the waste added to the silo via a charge-hole at the top of each compartment; each compartment is split by a central dividing wall that runs from the base of the silo to a few metres below the underside of the silo roof. A deflector plate assembly (DPA) supported on two horizontal beams is located between the top of the dividing wall and the roof and allowed the waste to spread as it fell into the silo and prevent excessive mounding.

Sellafield Ltd is currently engaged in an overall programme of works to remove the waste for storage within modern ILW containers. Prior to the commencement of these works the Deflector Plate Assemblies (DPA) and beam structures within the silos are required to be removed to allow access for the waste retrievals equipment through the side of the silo at the point where the DPAs are situated.

James Fisher Nuclear (JFN) & Sellafield Ltd have developed a system using suspended water jet cutting equipment combined with custom long reach tooling, installed through penetrations made in the side of the silo, to enable the remote size reduction of the DPA and beams within each compartment.

The use of a low pressure suspended water jet cutting system has enabled a single water/abrasive hose to be routed down a tool deployment pole and allowed long hose lengths up to 80m from pump to nozzle enabling siting of equipment on a congested and difficult access site. The use of lightweight, yet high strength, carbon fibre poles within the tools has enabled the deployment of tool end effectors at distances of up to 6.5m from the compartment walls using a relatively small 60mm diameter pole. This maximised articulation of the pole within the 300mm wall penetrations to reach all areas of the DPA.

Capability of the operators to install the tooling and size reduce DPA and beam assemblies have been demonstrated through the training on a Full Scale Test Rig (FSTR). The FSTR was integral to the development of the equipment and

techniques and to providing assurance to the client that the project was technically achievable given the tight building restraints and safety issues.

INTRODUCTION

The Pile Fuel Cladding Silo (PFCS) at the Sellafield decommissioning, reprocessing and nuclear waste management facility in the UK was constructed in the late 1940s and used for the storage of Intermediate Level Waste (ILW) arising from the Windscale Piles, Calderhall & Chapelcross Reactors until the 1960s. The PFCS is 21 metres high and comprises 6 identical tall compartments with the waste added to the silo via a charge-hole at the top of each compartment; each compartment is split by a central dividing wall that runs from the base of the silo to a few metres below the underside of the silo roof. (Fig.1) A deflector plate assembly (DPA) supported on two horizontal beams is located between the top of the dividing wall and the roof and allowed the waste to spread as it fell into the silo and prevent excessive mounding. The contents of the silo are kept under a blanket of an inert gas, argon, to prevent the risk of a fire within the silo.

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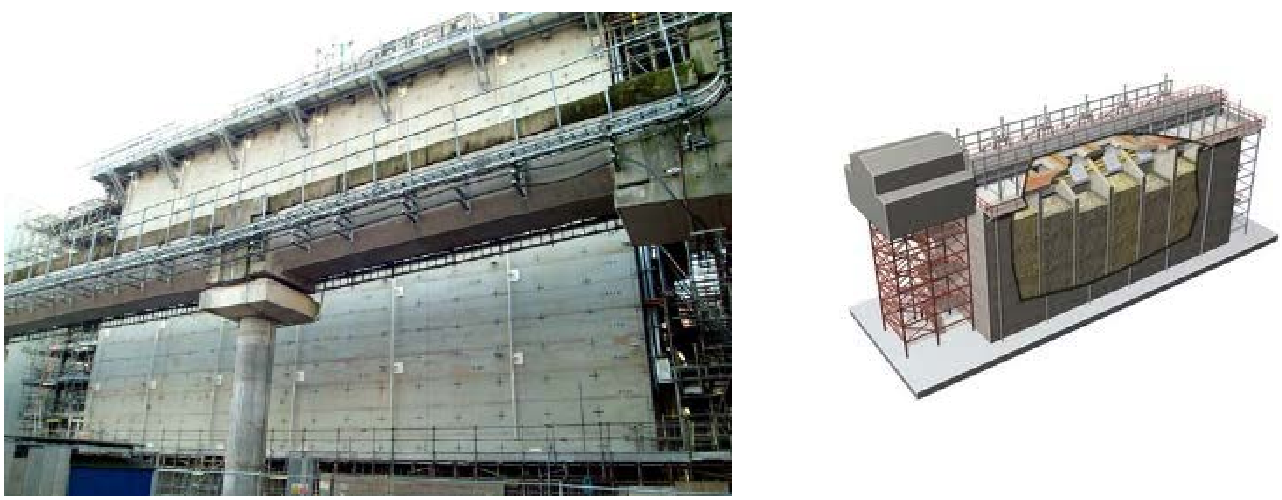

Fig 1 Pile Fuel Cladding Silo: photo of silo and cross section showing the silos

DESCRIPTION

A phased approach to the removal of the deflector plates and beam structures was adopted.

Phase 1 Equipment & Deployment Method Selection

Sellafield Ltd investigated a number of hot and cold cutting techniques and deployment options during early feasibility studies. Water jet cutting was selected by the client, Sellafield Ltd, for the project as the most reliable and effective low temperature cutting technique which had the potential to carry out the work in a timely and safe manner.

JFN proposed a simple manual (nozzle on a pole) deployment option with a suspended water jet cutting system providing the WJC capability. (Fig.2.) A Low-pressure water jet cutting using a suspended abrasive system normally used for bomb disposal was selected, because it can be deployed using compact and lightweight tooling and the pressurising and entrainment equipment can be situated some distance from the compartment. Entrained abrasive systems are more common and hence cheaper, but would have been significantly more difficult to deploy given the site constraints. (Entrained abrasive systems blow the abrasive at the nozzle to entrain the abrasive within the high speed water jet to assist cutting and hence require two services to the nozzle.)

The project safety case requires that the project operates within very tight parameters for the amount of water added to the silo.

Early vendor trials demonstrated that this was a viable technique albeit with some refinement of the nozzle deployment arrangement and overcoming the significant installation and deployment challenges due to the site constraints.

The equipment for water jet cutting mounted in three skids was supplied by the BHR Group. The use of a yacht mast supplier for carbon poles has enabled large reach distances and articulation angles to be attained to deliver the required tool positioning.

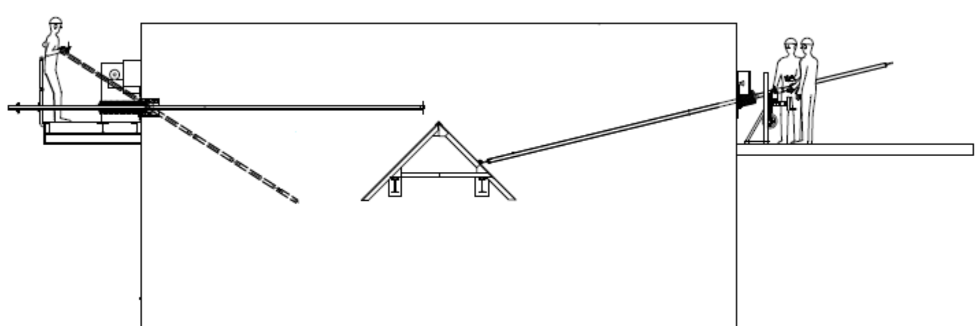

Fig. 2. The delivered project concept

Phase 2 FSTR Build & Prototype Trials

JFN constructed a Full Scale Test Rig (FSTR) geometrically equivalent to the top 3m of a single silo compartment complete with DPA and beam assemblies. (Figs. 3, 4, 5.) JFN procured a single WJC system and manufactured a set of WJC tools to enable testing works to be carried out. JFN also designed and manufactured waste clearance tooling to allow the waste to be cleared from the DPAs to provide suitable access for subsequent WJC operations.

Fig.3. Photo of the Full Scale test rig (FSTR)

Fig. 4. One of the penetrations in the FSTR, representing the new penetrations in the North & South walls.

Fig. 5. FSTR working platform representing the platforms on the PFCS

JFN completed a series of trials ranging from the installation and removal of tools, removal of waste from the DPAs through to the full size reduction of a single DPA excluding beams. This demonstrated that the equipment could be installed, operated and removed from both the South and North sides of the building to successfully size reduce the DPAs. (Figs. 6, 7.)

The trials enabled optimising the speed of the cutting as a function of the metal thickness and elimination of wasted cuts to minimise the amount of water required for the cutting operations. An analysis of the structure indicated that the cuts needed to be positioned to an accuracy of better than 50 mm. This accuracy can be achieved with practice by positioning and magnetically clamping a guiderail on the structure and then driving the water jet cutting head along the guide rail at a fixed speed. The optimised cutting plan is shown in Fig.8

At the conclusion of the trials programme Sellafield Ltd requested that JFN consider if the same system could be used to remove the beams and requested this be achieved exclusively from the South side. JFN carried out a bench test to confirm that the WJC system could cut a beam from the top flange using an acceptable quantity of water. At this point Sellafield Ltd had sufficient confidence in the developed techniques to commence the coring of penetration in the compartment walls and this committed Sellafield Ltd to the methodology and equipment developed to date.

It was noted during this phase that the positioning of tools manually using CCTV was a skill that required practice to meet the accuracy requirements of the cutting plan and hence water usage.

Fig.6. Undertaking trials on the FSTR

Fig.7. Positioning of the tools manually using CCTV during trials on the FSTR

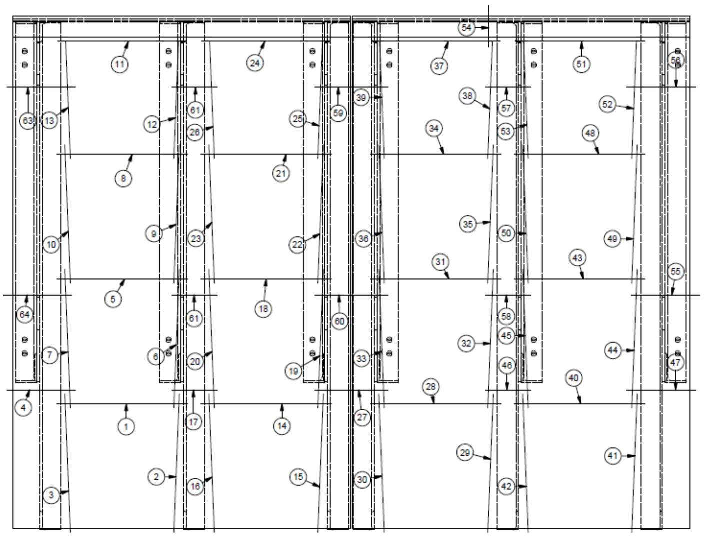

Fig.8. The Cutting Plan

Phase 3 Site Equipment Manufacture & Beam Cutting Trials

JFN manufactured the waste clearance tools and DPA size reduction tools. The plate cutting tool in operation during trials is shown in Fig.9. and a schematic of the plate and angle WJC tool is shown Fig. 10.

Fig. 9. Cutting Trials with Plate Cutting Tool

Fig. 10. Plate and Angle WJC Tool

JFN also designed and manufactured beam cutting tools featuring a custom joint to enable both North and South beam cutting operations to be performed from the South side. This was technically challenging due to the narrow 1.6m wide nature of the platform and hand rail clashes. The tie angle and beam WJC tools are shown in Fig. 11.

The addition of the longer poles and pole joints rendered the original installation scheme using rollers as unmanageable for operators. In replace of this JFN designed and manufactured an overhead Niko Rail system with custom bridle arrangement to enable the installation of all WJC tools. This installation methodology saved significant scaffold costs (500k) and associated operator radiological dose uptake.

The ability to perform the beam cutting exclusively from the South side has saved the client significant programme delays and costs, because it allowed other retrievals project work to continue unhindered.

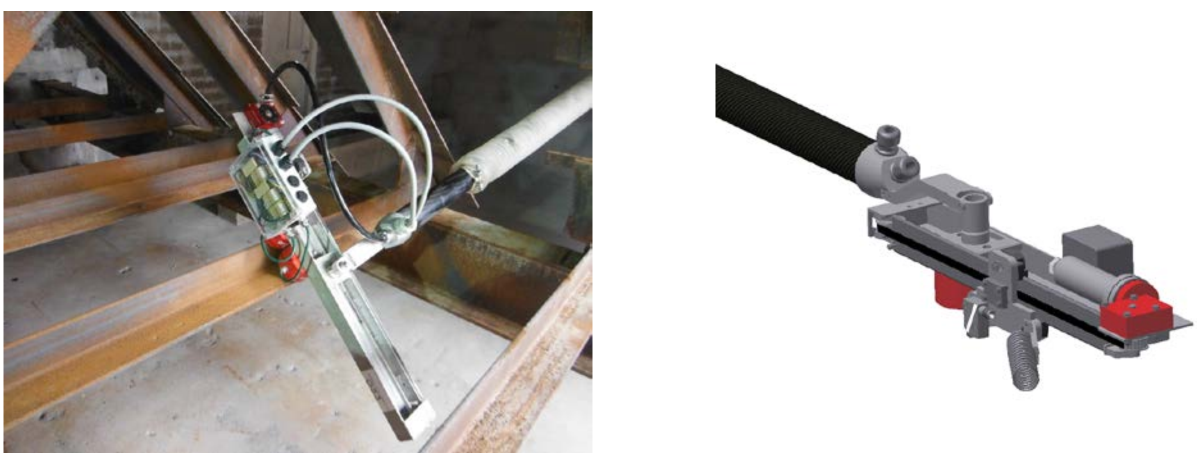

Fig. 11 Tie Angle & Beam WJC Tool

Phase 4 Training and Site Deployment

JFN were appointed as the site contractor for the size reduction operations and formed a joint team with locally based company, Shepley Engineers Ltd, to provide the required number of operators to enable the 7 day working required to meet site programme constraints. JFN defined a training programme and using the 3 trained operators, used for all prior FSTR trials, to train all operators up to the required level and meet water usage targets and operate in a safe and efficient manner. In total, three DPAs and two sets of beams were removed by the operators during the training phase. Water usage tracking of these works has demonstrated that with a clear training plan and aspirational targets operators can be trained to a high standard within a relatively short period and meet the stated targets.

CONCLUSIONS

Retrieval and safe storage of material in the Pile Fuel Cladding Silo (PFCS) is one of four major risk reduction programmes for the legacy ponds and silos at Sellafield. This project to remove the deflector plates is a key enabler to allow the main retrievals programme to commence.

JFN and Sellafield Ltd have worked in partnership throughout multiple phases of the project from early feasibility to prototyping and development to final tooling manufacture and readiness for site deployment. It is through this partnership that the project has been successful and some significant challenges overcome. The following conclusions are drawn on this basis:

- Constructing this FSTR in an off-site location gave the project team a key asset for the testing of equipment in a realistic environment. As the project moved from the trialling to the delivery phase, the operators could train, rehearse and refine the techniques they would be deploying on site. In parallel, it was an excellent communication tool to engage all stakeholders.
- The use of a WJC suspended abrasive system normally used for bomb disposal has enabled the deployment of compact and lightweight tooling and allowed equipment to be situated some distance from the compartment.
- The use of specialist suppliers from other industries to provide a technical solution. An example of this is the use of a yacht mast supplier for carbon poles enabling long reach distances and wide articulation angles to be attained to deliver the required tool positioning within the existing site constraints.
- The ability to perform the beam cutting exclusively from the South side has saved the client significant programme delays to the larger preparation for retrievals project and hence significant cost.
- Development savings were re-invested into spares and consumable for additional confirmatory testing and to ensure smooth site operations, as well as investigating other emergent issues.
- JFN and Sellafield Ltd worked in close collaboration enabling more flexible change control and problem solving.
- JFN and Sellafield Ltd have proposed and developed a mainly manual, yet simple solution to the problem of DPA and beam size reduction. Early identification of project risks and credible faults through extensive trials, allowed these to be designed out of the equipment

- Extensive trialling, training and rehearsal with the equipment in an off-site location ensured operations were streamlined and optimised for efficient delivery and minimal water usage.

The overall success of the project can be attributed to the combination of a capable client/contractor technical and project team taking a pragmatic and sensible approach to contract management alongside a step by step approach to the problem. This step by step approach has sought to remove risk where possible and push the boundaries of difficulty where a clear client driver exists whilst maintaining an overall view of what is required to enable final waste retrieval.

REFERENCES

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