The Complex Challenges of Remotely Removing Redundant Pipework and Cleaning/Remediation of Aging Civil Structures at Sellafield - 12446

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ABSTRACT

This paper identifies how a joint Sellafield Ltd/Nuclear Management Partners Tactical Review Team and main contractor, SA Robotics, developed and successfully deployed a solution to clean and coat the wall surface of an aging structure on the Sellafield Site. This involved removal of redundant pipework from the wall, cleaning and coating of the surface using a bespoke designed robotic manipulator with various end effectors. This system was able to safely and in a controlled manner remove the pipework, clean down the wall and prime and coat it within the required programme duration which was 5 months earlier than a previous shielding only option. This was done in a high radiation field and in the challenging conditions of winter in Northern England.

INTRODUCTION

This paper highlights a new technology system developed to maintain and strengthen legacy civil structures and prohibit the effect of continuous degradation. This technology also allows the safe stabilisation, isolation and removal of redundant pipework fixtures and fixings while having no effect on the surrounding facility architecture. This technology has been developed to work remotely and is therefore suitable to operate in high radiation and other challenging areas where human presence is prohibited. This gives the facility owner the ability to enhance the structure or containment capabilities.

Civil Structures constructed in the mid 50's are now predictably showing signs of age related deterioration, such as surface abrasions, efflorescence and general degradation, this radiation tolerant technology provides a portable transferable solution to maintaining other aging facilities. This paper looks at the challenges that faced the team as they firstly; isolated and removed a section of redundant pipework and secondly, cleaned down and coated the surface to prevent any potential future deterioration.

The work was undertaken using a "Task Force" approach engaging a "Core Multi-Disciplinary Team" supported by fully resourced service groups, including Safety and Engineering with heavy reliance on the international supply chain.

The unique work involved:

- Deployment of bespoke robotic technology to remove the redundant pipework in a high radiation environment.
- Remote cleaning and preparation of the wall surface using Hydrolasing (high pressure water washing technology) and a unique Powered Remote Manipulator Arm (PRM).
- Remote coating of the civil structure to prevent future degradation using a "surface keying" primer followed by a coating of Polyurea resin.

The task addresses a specific feature on an area of concrete wall which, quite early in its operational life, established a high radiation field. Control and surveillance arrangements were established to restrict access and control operator dose local to the area of influence. These high levels of activity were until now deemed too difficult to remove until such time that this new advanced remote robotic solution became available. This type of contamination removal and prevention of future degradation have never before been attempted at Sellafield and particularly where such high levels of radiation were present.

PIPE REMOVAL, CLEAN, AND COAT SCHEME

The scheme was to remove the redundant pipework, clean and coat the wall using PRM technology, water based primer and polyurea resin. The scheme's major advantage over the shield or demarcation of the area, is the removal of a potential nuclear and conventional safety hazard that would have been present should the pipework or structure have been left to degrade to an unsafe state. A Task Force approach was adopted to give the optimum chance of success. This was a "Core Multi-Disciplinary Team" supported by fully resourced service groups, including Safety, Engineering with heavy reliance on the international supply chain. Recognising advances in technology the original date of July 2013 (for completion of shielding) was discarded and programme logic developed with the execution phase being expected to commence when a suitable environmental window becomes available in late 2011. This was achieved as planned giving an approximate 5 month programme saving.

DESIGN, PURCHASE, MANUFACTURE, ASSEMBLE

The outline design scheme was worked up by a joint SL/NMP Tactical Review Team and main contractor, SA Robotics and consisted of a mobile deployment crane with an attached PRM. The system to attach the PRM to an "off the shelf" mobile deployment crane, was followed in order to minimise both the design and procurement phases leaving the main design to concentrate on the integration of equipment, by SA Robotics. The development of resins/foams, to be used for the keying and coating of the surface abrasion, went on in parallel via AMEC and Sellafield Ltd. Designers, working closely with the SA Robotics design team. The main contract was set up with SA Robotics, with instruction given to utilise off the shelf short lead time items where possible. Further instruction was given that due to the nature and constraints of the site, on site manufacture and assembly is to be kept to a minimum. The philosophy being, that the system integration be carried out at the SA Robotics facility local to site.

Hydrolasing

The Hydrolasing system comprised of the following primary systems:

- Hydrolasing tool
- High pressure pumping system
- Vacuum System
- Cyclone
- HEPA filters
- Cyclone make-up / flushing
- Pond return / purge line.
- Camera viewing system

The Hydrolasing Tool was deployed on the surface by the crane deployed PRM. The tool comprised of a proprietary high pressure rotary cleaning head that was electrically driven within a secondary containment shroud to perform a cleaning pass of approximately 0.6m total length by 0.15m wide.

Primary containment was provided by the head which was provided with perimeter brush seals aided by an inner guard mesh. High pressure water was delivered to the spray bar within the head performing its cleaning function. This water and released debris was removed from this primary containment by a vacuum collection system. This vacuum system was the sole method of collecting active effluent generated by the operation of the Hydrolasing Tool.

High pressure water was fed to the rotary cleaning head at approximately 14 litres per minute, between 500 & 1000 bar. The high pressure water was provided via a tank fed diesel driven pump provided along with the Hydrolasing Head by a high pressure water specialist. The rotation of the spray head was generated by the reaction force generated by the spray bar mounted nozzles.

The vacuum extract was approximately -0.6bar of depression which drew the active effluent from the hydrolasing head through a cyclone which separated the liquid effluent from the extracted air stream. The cyclone was located on the “active” side of the shield wall and connected to the Hydrolasing Tool via a flexible hose that incorporated a quick connect coupling to facilitate disconnection / replacement of the Hydrolasing Tool The hose between the cyclone and Hydrolasing Tool was fitted with a lanyard that allowed retrieval of the section with the quick connect coupling fitted to be retrieved onto the “Low Active” side of the shield wall whilst the Hydrolasing Tool remained on the “Active” side. This facilitated manual disconnection of the coupling and connection of a replacement Hydrolasing Tool. From the cyclone the separated air was drawn by the liquid ring pump through a primary and secondary High Efficiency Particulate in Air filter prior to it being discharged to atmosphere. This system configuration ensured that virtually no liquor or aerosols from the cleaning process escaped from the unit and cleaning left only minor staining of the wall surface. This phase was completed within the agreed programme requirements and around ninety passes.

Coating

The wall coating system comprised of a primer/sealer, water base primer and a sealing coat, D40 Polymer. These were applied using two separate proprietary dispensing systems as follows:

- Primer: Glas-Craft Merkur 36:1 Pump system.
- Polymer D40:Glas-Craft reactor H-XP2.

The primer and the sealing coat had two separate spray nozzles, each modified for remote deployment by the PRM. There were several types of PRM friendly handles which were interchangeable on the tool, this allowed the operator to obtain the required stand-off distances at specific locations, resulting in safe deployment around existing on-site obstacles, for example the High Level Service Lines (HLSL). The operator was assisted in locating the nozzles by means two lasers, one identified distance to either the pipe or wall and the second provided a visual alignment aid.

FULL DEPLOYMENT TRIALS AND TRAINING

A full representative mock up of work the area was constructed at SA Robotics facility, (10 miles from the Sellafield Site) in order to: prove the methodology, substantiate the safety case, mature stakeholder confidence, formulate an execution method statement and train the both SL and contract supplied system operators prior to site deployment. Over eighty thousand man hours of operator time was invested in honing the execution and predictability of the scheme. The same equipment and personnel used throughout the trials were the same as those used on the “Active” workface. The “Full Dress Rehearsal” was successfully completed for all tasks prior to commencement of the site works. Documentation, where possible, was completed on the contractors own templates, to ensure familiarity of the operators and to minimise duplication and unnecessary hold-ups. This included Quality Records and Controlling Documentation.

REGULATOR APPROVALS

Early engagement with the regulator was undertaken and was key so achieving successful site delivery. ‘Promissory’ documents were issued in order to gain approvals while proving trials continued in parallel. Regulators also witnessed several trials and gained a good knowledge of the job enabling them to issue two license instruments, one for pipe removal and one for clean and coat.

METHOD / SITE WORKS

Installation of Equipment and Pipework Removal

Installation of the equipment on site took the form of bringing the mobile deployment crane and PRM to the Low Active side of the shielded area. The tool boxes holding the various attachments for the PRM were placed as per design into their designated positions a with a second tool stand placed on the "Active" side of the barrier to account for the possibility of contaminated tooling. A remote Control Room and PRM control panel were set up near to the workface to minimise dose to the operators from the high contact dose and the surrounding areas.

Equipment for the Hydrolasing stage of works was then installed, fully commissioned on site and set to work. This included the raising and suspending of the powered remote manipulator in front of the workface.

Pipe Spray Redundant Pipework

Using the resin spray head both vertical and horizontal pipes were resin sprayed to stabilise the redundant structure and add structural integrity (Figure 1 – top right). A foam support was then placed at the base of the vertical pipe using the gripper attachment (Figure 1 – bottom right). This was made secure using the resin as an adhesive and provided a firm footing for the substantiated steel bracket. This was again bonded to the wall using the epoxy resin as an adhesive in order to further support the pipework during the cutting and removal stages.

Pipe Cutting

The horizontal pipe was removed in sections using the reciprocating saw tool attachment on the PRM. The remaining stub was then isolated by the insertion of a foam filled bag and capped with the same epoxy resin. The T-piece section between the vertical and horizontal sections was then removed. This pipe was the isolated from the redundant 200mm Purge Main. PRM Operators positioned and inflated a SARCO bag into the base of the vertical pipe and made a successful seal. The remaining liquor trapped above the SARCO bag was then educted and a second nylon foam filled bag was then placed into the pipe to provide a more permanent isolation. The pipe was then size reduced to 700mm from drain trench covers and just above the height of this foam filled bag when a capping epoxy resin applied. This constituted the substantiated seal of the redundant pipework. Lastly, the Valve Spindle, a steel shaft running adjacent to the now removed pipework, was also removed and disposed of.

Hydrolasing Tool Showing Rotational Cleaning Brush and Traversing Beam

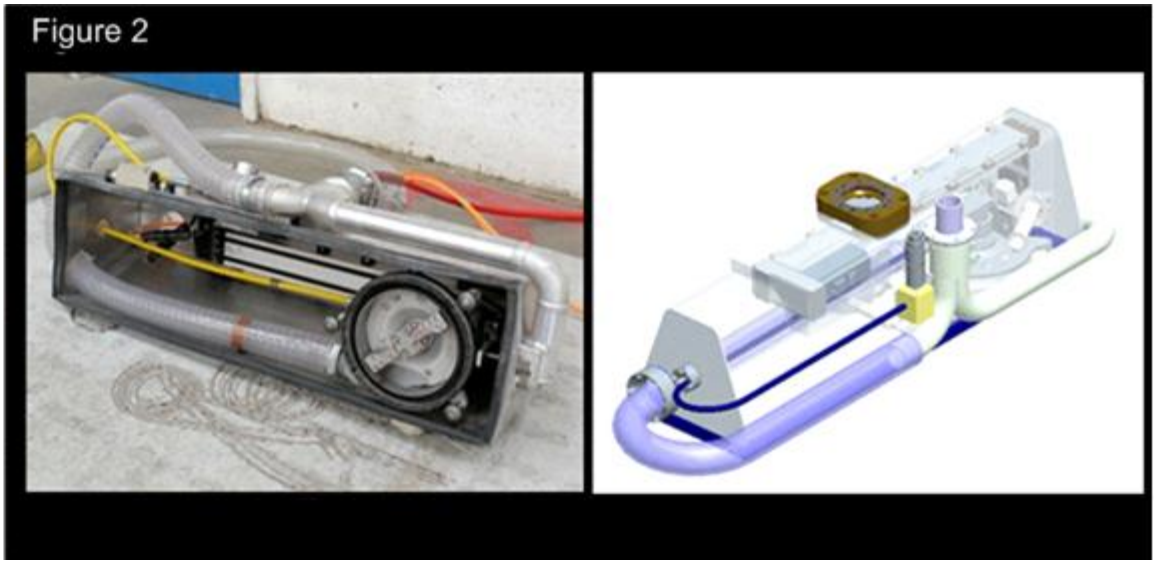
Figure 2

The PRM then attached the hydrolasing tool (See Figure 2) positioned the unit onto the wall and began the process of cleaning the efflorescence off the surface with the high pressure water. This is thought to be the source of the high contact dose, however until final pictures and assessments from the companies RAD scan technology are confirmed the magnitude of the activity and subsequent dose reduction cannot be confirmed. This process was repeated until the entire wall has been cleaned and took approximately 90 passes as per design. The equipment was then shut off in sequence and the Hydrolasing Tool disconnected and replaced by the gripper.

Coating

To begin coating, the resin spray head was connected to the PRM and the keying primer sprayed onto the concrete where the efflorescence and surface abrasion were previously present and on to the surrounding areas. Once sprayed, the surface was allowed to fully dry before the outer coat was applied. It is the role of the primer resin to seep into the surface layer of the concrete and provide a firm layer for the outer Polyurea resin to adhere to. When dry the primed surface was coated with the Polyurea resin which has been substantiated for a ten year lifespan.

Checks were then completed, confirming the successful covering of the whole area. Lay down areas were then established on the “Low Active” side of the workface and items will be transferred from the “Active” side using the crane. The full compliment of plant and equipment used to complete the work was then removed to a storage location until a further workface is identified and to allow normal access to the facility to be resumed.

SUMMARY OF WORK COMPLETED

- Delivery of equipment to the work area
- Commissioning and setting to work
- Establishment of the remote operation room.

- Stabilisation of the redundant pipework.
- Installation of foam and steel support structures to allow controlled pipe removal
- Removal of approximately 5m of redundant pipework.
- Substantiated sealing of redundant pipework stubs to ensure protection from future seepage during plant operations.
- Hydrolasing of the wall
- Coating and sealing of the wall

ENVIRONMENTAL CONTEXT

This work was carried out in Northern England, in the winter where wind rain and temperature challenges gave only opportunistic access to the workface. This work was carried out within the programme window allocated by the facility and without exceeding any pre-planned dose requirements. The suspected contaminated efflorescence was removed from the surface of the facility and the resultant area primed and coated without any uncontrolled release of activity from the area.

The remaining work to be completed on the task is the obtaining of RAD scan imagery and subsequent assessment to determine the magnitude of the reduction in dose.