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Re-engineering a stacker truck to decommission a 30-year old vitrification cell

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Figure 1. The FINGAL Cell in operation

Abstract

A 30-year old abandoned vitrification cell has been successfully decommissioned at United Kingdom Atomic Energy Authority's Harwell site. The major piece of hardware used to carry out handling tasks was a re-engineered pedestrian stacker truck. The 1 tonne capacity truck was used to disassemble the chemical process cell, from which 45 tonnes of lead shielding bricks were removed, in the breakdown and movement of the contaminated six-stage vitrification furnace and in the support and removal of the main process vessels, some of which contained remnant process liquors with radiation levels of up to 45 mSvh^{-1}. Following the completion of this project, the stacker truck was removed from the cell, decontaminated and moved across the site to the High Activity Handling Building. There it has been used to construct a new lead shielding wall.

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UKAEA

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Government Division

Introduction

In the early 1960s, the United Kingdom Atomic Energy Authority (the Authority) experimented with different types of processes that would facilitate safe, long-term storage of highly active liquid wastes. The Fixation in Glass of Active Liquors (FINGAL) project[1] explored the feasibility of producing 50 kg glass blocks and optimised process parameters for production-scale equipment (Figure 1). The last few runs used highly active liquors from the Authority's Windscale Laboratory. Pipe leakages within the FINGAL cell spread contamination over plant items, walls, the floor and ceiling. Attempts were made to clean the cell so that operations could continue and the planned experimental programme was completed in 1965. Spillages on the cell roof from transfers between the shielding liquor flask and the plant and from sampling points were finally dealt with by putting down a concrete screed over the roof shielding blocks. Samples taken recently from hot spots in the shielding blocks showed that radioactive contamination had penetrated to at least a depth of 0.5 m with activity levels up to 10^4 Bqg^{-1}.

The FINGAL cell is situated at the end of a 36 m long storage pit in the old Chemical Engineering Building (Figure 2). This building is the subject of a decommissioning programme with a scheduled green field end point in 1998.[2] Initial tasks have been to strip the building of the multitude of redundant chemically and radiologically contaminated process plant, rigs, laboratories and stores. The building fabric is being decontaminated so that near-conventional demolition techniques can be employed. The FINGAL cell had to be decommissioned to allow access to the pit which must also be extensively decontaminated. Even after 30 years of abandonment, FINGAL represented one of the largest single inventories in the building. Later experimental and near-production scale vitrification facilities such as HARVEST were not heavily contaminated and were relatively easy to decommission.

Figure 2. The Chemical Engineering Building

Plant Configuration

Analysis of the way in which the cell and its contents could be decommissioned presented some fundamental problems. Design and construction details had not been kept and plant drawings had been archived as microfilmed images taken from second generation masters. The resultant prints lacked clarity and were of little use. Despite the elapsed time, information from original operators was of more value. Two campaigns of careful man-entry provided checks on the physical conditions and dimensions of main plant items. Video and photographic records were taken at the same time and radiation and contamination surveys were made.

The main cell was found to be in a decrepit state. The six-stage vitrification furnace and two pre-heating ovens were discoloured and their steel supports were badly corroded. The pipework was poorly supported and in places had been cut to allow removal of connections to the balance of plant that had been removed from the outside of the cell in the late 1960s. Contaminated, used items of plant had been left on the cell floor. Lighting and power circuits had been only partially isolated. The remaining sections of ventilation ductwork were found to be heavily contaminated. Areas of loose and fixed contamination

could be found throughout the cell; subsequent analysis showed that the predominate isotopes were ^{90}Sr and ^{137}Cs.

Within the main cell was a lead-shielded chemical process cell, which contained the active stock and feed tanks. This cell consisted of approximately 800 lead bricks with an estimated mass of 45 tonnes. The walls of the cell were made of 'System 10' bricks which each weighed 150 kg, and were built up to the full height of 3.2 m. It was impossible to view inside the lead cell, but during the man-entries rudimentary β/γ radiation measurements were made with a telescopic probe through a hole in the top of the shielding.

The furnace and two ovens were joined by remotely operated connectors that were unmade and made every time a vitrification cylinder was moved through the plant. The steelwork supporting the pipe closure gear prevented close examination of the tops or internal surfaces of the three vessels. This inspection was carried out from the outside roof of the cell, by inserting a miniature colour CCTV camera down the bore of each vessel in turn. The inspection showed that despite the degradation on the outside of the vessels, their internal surfaces appeared to be in good condition.

The cell roof consisted of six interlocking concrete blocks weighing up to 20 tons apiece. The blocks were supported by internal walls that were set into the west area of the pit. FINGAL components were originally put into the cell and the roof blocks positioned by the 50 ton capacity pit crane. The spilt activity on their top surfaces and contamination within the blocks precluded their easy removal so a reverse assembly was impossible. The cell had only one entrance which was 29" (0.74 m) wide. All decommissioning equipment and all generated waste had to pass through that limiting doorway and negotiate a right-angle turn at the end of the cell access corridor.

The lack of space within the cell dictated that an extra handling/breakdown/decontamination/packaging area had to be constructed adjacent to the FINGAL cell. A Modular Containment System (MCS), developed in the Authority's Winfrith laboratory, was built in the pit with a passageway linked to the FINGAL cell doorway. A low level waste half-height ISO packaging facility was commissioned further down the pit to receive FINGAL and other building waste materials.

Selection of handling equipment

The numbers of extremely heavy bricks that needed to be moved from height and processed focused attention on possible solutions. New European legislation on manual handling that would become enforceable during the decommissioning project dictated that a specific analysis should be undertaken to minimise risk to individuals from mishandling of loads. Several options for handling were compared.

Fixing a structure within the cell would be difficult because of inaccessibility and wall contamination. Installing a conveyor for lead brick handling between the cell and the external MCS was impractical as it would block the

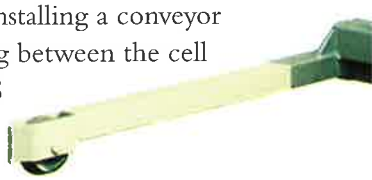

Figure 8. Creep control for inching near the roof

tank was carefully planned to ensure that operators' dose budgets were not exceeded. A contingency plan of adding a level of remote control to the truck to remove contaminated (>50 $mSvh^{-1}$) components was not necessary despite the drain tank liquor values (45 $mSvh^{-1}$) being close to this threshold. The additional control envisaged the use of a telerobot such as NEATER to manipulate and load the trolley with components from the truck for transfer to the MCS. The truck was used to remove all the furnace segments which were wrapped and then transferred to a half-height ISO container.

Towards the end of FINGAL decommissioning, the truck was split and brought back into the MCS. Basic decontamination was carried out and the truck was declared free of loose contamination for transfer across the site as a wrapped package. It has been moved to the High Activity Handling Building where it has been used to construct a new lead shielding wall which included some of the bricks from FINGAL.

Conclusions

The modification of a commercially available pedestrian stacker truck enabled the restricted-access abandoned vitrification cell to be decommissioned safely and efficiently. The use of the 1 tonne truck in a variety of roles with different lifting attachments (e.g. forks, jib and pallet plate) showed that it is a versatile piece of equipment that can be used readily in areas where access is a problem. Although in this application the truck was used manually, it would be possible to use it in conjunction with an advanced telerobot such as NEATER.

Acknowledgement

The assistance of Mr H Matthews of Crown Lift Trucks Ltd and Mr M Moody of Fast Scheme Ltd is acknowledged.

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References

(1) J R Grover, W H Hardwick, R Gayler and M H Delve, *'The FINGAL Process'*, Con-660208, USAEC, Richland (1966).

(2) E Abel and C Hamblin, *'Dismantling a chemical engineering building'*, Atom, Jan/Feb 1993, (426),34-39.

(3) E Abel, *'Telerobotics and 3D TV: What you need to know'*, IEEE Trans Nuc Sci, 37 (3) 1443-1451 (1990).

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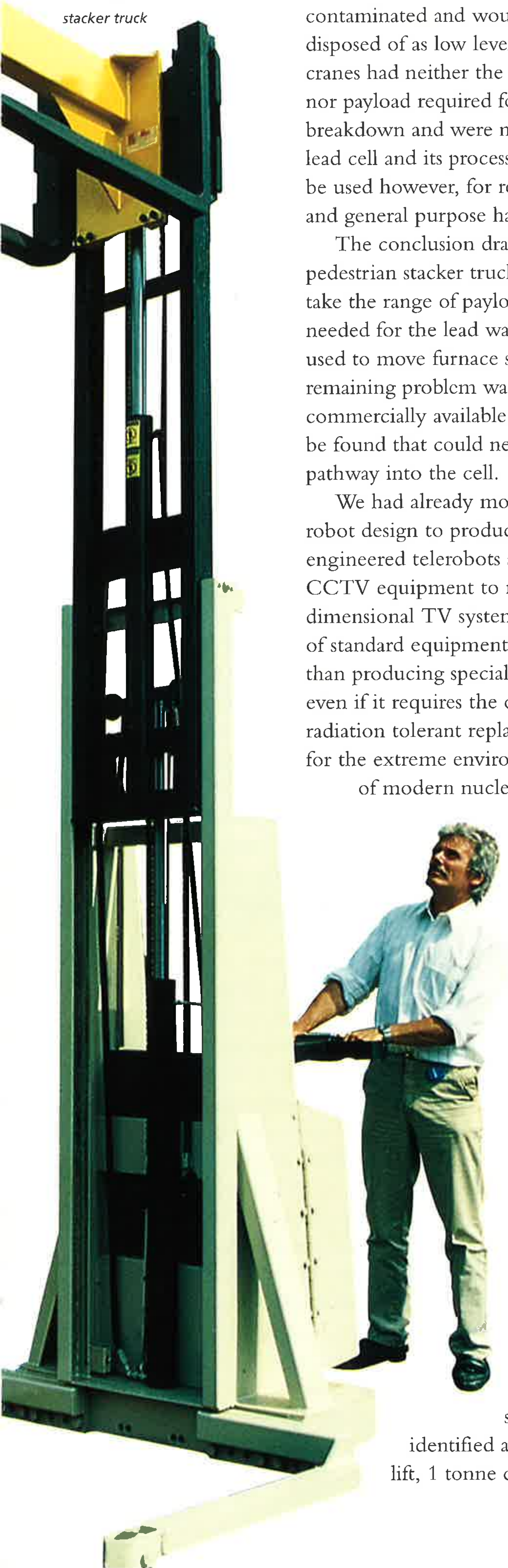

Figure 3. The 1 tonne capacity pedestrian stacker truck

only escape route from the cell. The conveyor would inevitably become contaminated and would have to be disposed of as low level waste. Mobile cranes had neither the operational envelope nor payload required for the furnace breakdown and were not suitable for the lead cell and its process vessels. They could be used however, for removal of the ovens and general purpose handling in the MCS.

The conclusion drawn was that a pedestrian stacker truck would be able to take the range of payloads, offer the reach needed for the lead walls and could be used to move furnace segments. The remaining problem was that no commercially available stacker truck could be found that could negotiate the restricted pathway into the cell.

We had already modified an industrial robot design to produce nuclear engineered telerobots and had adapted CCTV equipment to make robust three-dimensional TV systems.[3] Modification of standard equipment is often cheaper than producing specialised equipment, even if it requires the development of radiation tolerant replacement sub-systems for the extreme environmental conditions of modern nuclear facilities. For the FINGAL cell, the majority of dismantling operations were planned as being manual and the problems of radiation tolerance were not an issue. It was decided that modification of an existing truck should provide a solution to the problems of in-cell handling.

Modifications

A survey of available pedestrian stacker trucks identified a 3.8 m three-stage lift, 1 tonne capacity truck from Crown Lift Trucks Ltd as being the most suitable for modification (Figure 3). As standard, this truck has removable forks and outriggers. The later are easily removed (by unbolting) from the truck lower body. The rear battery compartment, power drive wheel and tiller are joined to the truck body through a bolted hinge. Electrical connections between both parts are directly wired (Figure 4), through two main cable bundles.

The sequence of modifications made were:

- **removal of the internal battery charger to provide space in the truck body**
- **re-routing of wiring and addition of quick-connecting plugs and sockets for control and charging circuits (Figures 5 and 6)**
- **addition of a battery Ah meter**
- **addition of a brushless fan to purge the truck body during charging**
- **rewiring for remote charging; packaging the charger in an IP65 enclosure**
- **addition of limit switches and linear cam on the lift assembly to limit vertical movement to less than the cell roof height (Figure 7)**
- **addition of creep control mode for inching at near-roof heights (Figure 8)**
- **elimination of fast-motion speed on drive wheel motor**
- **addition of jockey wheels for stabilising stripped down main truck body**
- **seal holes and openings and totally cover truck surfaces with strippable coating.**

The modifications were made using, wherever possible, components similar to those specified by Crown in their truck assembly. Crown supplied cable for additional runs and advice on the functional connection of the electrical circuits. Keyed quick-connect connectors with substantial handles were used in the wiring break points between the main truck body and the front battery compartment. This modification allowed the decommission team to reassemble the truck quickly without error, despite being encumbered by protective clothing.

All aspects of the modifications were considered from the view of operational constraints imposed by lack of space in the cell and the difficulties of potential

Figure 4. Original connections inside the battery and drive compartments

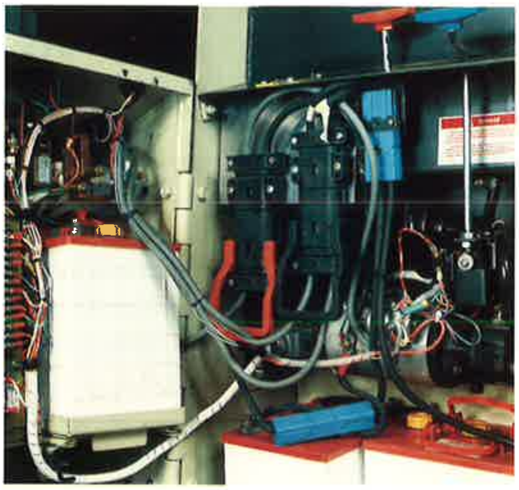

Figure 5. New wiring – connectors mated

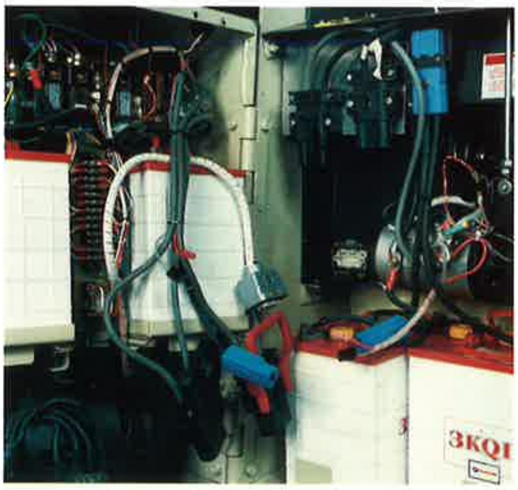

Figure 6. New wiring – connectors detached

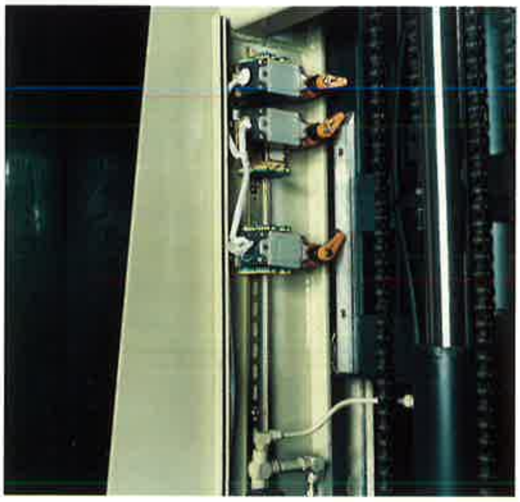

Figure 7. Linear cam and limit switches

unplanned maintenance or failure of key components.

Before the truck was taken into the cell, a trial breakdown and reassembly was practised in the full-sized cell mock up. The simple mock up was used to set camera parameters and test accessibility for the truck and mobile cranes, before work in the cell began. The breakdown and reassembly was video recorded as an aide memoire for the team that would eventually remove the truck from the cell.

Once the FINGAL ovens had been removed, the truck was craned into the pit in two parts and taken through a removed side panel of the MCS. Access down the corridor posed no problems and in the cell the truck body reassembly took only 10 minutes. Functional tests showed that the performance parameters of the modified truck were within specification.

Operations

Operation of the truck allowed all of the 800 lead bricks to be removed safely from heights of up to 3.2 m. A 400 kg payload jib extension was used to lift the large bricks individually to ground level and a trolley. The trolley was manually moved through the access corridor to the MCS and all the bricks were removed and stacked using one of the mobile cranes. The jib was used to lift out all the large vessels from the chemical cell, including those that still contained process liquors and washings.

All operations were supervised from outside the MCS from a control desk. Operators inside the cell and MCS were in contact with the controller at the desk via a CCTV system and audio link. The same type of miniature camera used for inspection of the ovens and furnace was used for this surveillance and communication link. The stacker truck and the operational staff could be observed wherever they were working and this ensured that difficulties in decommission could be resolved quickly without the need for supervisory entry to the controlled area.

During the removal of the lower layers of the process cell wall, ambient radiation levels increased rapidly. Removal of the lower process vessels, including the drain