Cleanup Progress on High Hazard Legacy Facilities at Sellafield: Magnox Swarf Storage Silos

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ABSTRACT

British Nuclear Group manages a number of legacy nuclear facilities including those involved in the reprocessing of spent Magnox fuel at Sellafield, in the North West of England. The cladding from this fuel (known as swarf) was, from 1964, stored under water in the Magnox Swarf Storage Silos. In addition, a large volume of fuel debris, and contaminated redundant equipment was also stored in the silos. Thus there is a significant inventory of hazardous waste, stored across 22 compartments. Much of the swarf has, by intent, corroded in water to form sludge. This sludge and other waste presents the most challenging and hazardous clean up task facing the UK nuclear industry. Achieving early, high hazard reduction is the number one national cleanup priority for the Nuclear Decommissioning Authority (NDA) who owns the site.

This task is being safely progressed using a highly experienced and committed team, which includes many years of British Nuclear Group plant operations and project delivery experience. The team includes experience from elsewhere on the Sellafield site, and from other British and American nuclear sites. The team has recently been further strengthened with the arrival of personnel from Fluor.

Progress towards waste retrieval is going well with the development of three retrieval machines underway. Project work to enable the introduction of these machines is already being safely delivered on plant, and is described below.

INTRODUCTION

The swarf waste generates large volumes of hydrogen while corroding in water. Temperature control is required to prevent increases in hydrogen generation and thermal stress on the silo structures. High integrity ventilation systems are used to ensure hydrogen concentrations are maintained well below the required safety levels.

The strategy for the cleanup of the Magnox Swarf Storage Silos involves retrieving the bulk waste and liquor to enable the wastes to be conditioned into a suitable form for long-term storage. Three streams of work are in progress to support this;

- Safety system improvements to support waste retrievals.
- Preparing the building for waste retrievals.
- Retrieval machines and infrastructure.

The original silo of six compartments was built in the 1960s and later silos were then added up until the 1980s. The age of the building and supporting infrastructure are such that some of the equipment requires upgrading or replacement to ensure that key safety systems are maintained during the waste retrieval program.

In order to prepare the silos for future waste retrieval operations, a significant amount of work is required to:

- Remove over 500-tons of redundant contaminated equipment from the silo operations floor.
- Remove sources of high radiation (working times of less than one second in some areas).
- Upgrade and relocate key safety systems which are in the way of future retrieval equipment.
- Structural strengthening and steelwork to support the retrieval machines.

The final program of work is for the waste retrieval machines and supporting infrastructure. During the mid 1990s, 586-tons of swarf was successfully retrieved from four of the twenty-two compartments and treated by encapsulation for long-term storage. This cleanup task provided extensive knowledge and experience, which has been used to design and build second generation retrieval machines for the removal of waste from all of the compartments. Three retrieval machines are being built, the first of which is now undergoing testing.

The range of challenges involved in the clean p of the Magnox Swarf Storage Silos is extensive. The examples below provide an insight into some of these challenges and recent examples of where successful progress and benefits have been achieved.

DECOMMISSIONING OF REDUNDANT WASTE RETRIEVAL AND TIPPING MACHINES

Decommissioning and removal of redundant equipment from the silo operations floor is needed to make way for the new waste retrieval machines.

Removal of the Swarf Retrieval Facility (SRF) used in the 1990s, was the first step towards operations floor clearance. The SRF was decommissioned in-situ by disassembling all removable items from the main module and sealing all apertures. The internal surfaces had been directly exposed to the swarf and silo liquor; therefore, significant levels of contamination were experienced. High-pressure spray methods were used, which proved to be very successful with all swarf pieces removed and radiation levels reduced enough to allow direct access for sealing the residual contamination.

Even with significant amounts of equipment removed, the remaining 45-tons SRF module was too large for transport to the Low-level Waste Repository (LLWR) by rail and needed to be transported by road. The module had to be fully sealed and pressure tested to meet transport regulations. This proved to be difficult because the module was not designed for with sealing, pressure testing, or road transportation in mind. Due to space constraints within the building a great deal of precision was required to traverse the module over the operations floor, with only centimeters of clearance between it and other equipment in some areas (Fig. 1.)

Fig. 1. SRF 45-ton module being removed from the silo operating floor

In addition to the SRF, three redundant Tipping Machines have also been removed from the operations floor. These machines had each tipped around 2,000 m^3 of waste into the silos during operational service. Decontamination methods similar to those used on the SRF were employed successfully. The size of the machines meant that they had to be split into two or three modules to be within the 55-ton safe lifting capacity of the building crane and physical constraints within the building. Each module had to be individually decontaminated and sealed before being loaded into a purpose built transport container.

Transport by road to the LLWR required careful planning with full consultation with the local village council involved in the transport route. The team planned a tight timetable to minimize any disruption to the village residents and this was successfully achieved. During 2004 333-tons of this equipment was safely removed and disposed of. Work programs for the removal of the final redundant Tipping Machine, heat exchangers and other equipment from the operations floor are currently being developed.

OPERATIONS FLOOR DECONTAMINATION AND CLEANUP

Historic contamination of the operations floor above Compartment Seven meant that the radiation levels in that area were particularly high, preventing direct access. The dose levels in some areas were measured at 200 rem/hr. This meant a daily working time limit of less than one second! The main objective of the project was to reduce radiation levels so that it would make it possible to install a rail system for the new waste retrieval machines.

Simply shielding the area was not viable, as the amount of shielding required clashed with the rails needed for the retrieval machines. The contamination was caused by silo liquor being absorbed into the concrete. Various methods of contamination removal were considered from chemical treatments to laser-scabelling. All options would have to be carried out remotely due to the high radiation levels.

The chosen solution was to remove 10 mm of concrete from the operations floor using a conventional industrial shaver. The team used their experience of working with high radiation levels to adapt the shaving equipment to be suitable for operations using a Remote Operated Vehicle. The main hazard was the generation of Intermediate-level Waste (ILW) dust which could potentially become airborne. To address this issue, a fully ventilated enclosure was designed and built to provide containment protection. The enclosure was partly pre-assembled and designed so that it could be lifted in place with minimal working times and radiation exposure to the workforce. An additional challenge was to find a safe and cost effective route for the ILW concrete dust generated. The solution was to return the dust back into a silo compartment via a Cyclone Separation System. This was again a low cost standard industrial piece of equipment that was adapted to suit the remote working conditions. The cyclone discharge was mixed with water to form slurry before discharge to the silo.

The implementation of the project was successfully achieved ahead of schedule with a decontamination factor of 80 achieved on the shaved floor area. The radiation exposure to the workforce was below forecasted levels due to the use of remote techniques and the practice and testing undertaken by the team prior to implementation on the plant. The removal of the bulk contamination will now allow the installation of the new retrieval machine rail system.

SAFETY IMPROVEMENTS TO SUPPORT RETRIEVALS: RE-ESTABLISHING COOLING

The operating regime ensures safe control of silo waste under quiescent conditions. However, during future retrieval operations, there is an increased risk of higher compartment temperatures due to disturbance of the waste and potentially increased corrosion rates. Therefore, it was necessary to re-establish direct routine cooling to some of the older compartments. This entailed making new pipe connections to the existing silo cooling pipes, which were highly contaminated. The radiation levels at the Compartment Eight pipe connection meant that remote techniques needed to be employed.

The first step was to provide a mock-up of the actual plant conditions in an inactive facility so that the team could develop the required techniques. Learning and experience from similar challenges were used as part of this process. Many of the solutions involved the use of a ROV. Particular challenges were the remote:

- Removal of existing shielding and debris,
- Removal of existing pipe work bolts and flanges,
- Preparation of the pipe flange (Fig. 2.) for welding,
- Welding of a new pipe connection (Fig. 3.),
- Performance of a helium leak testing to confirm integrity.

Fig. 2. Compartment Eight Cooling Flange connection prior to preparation.

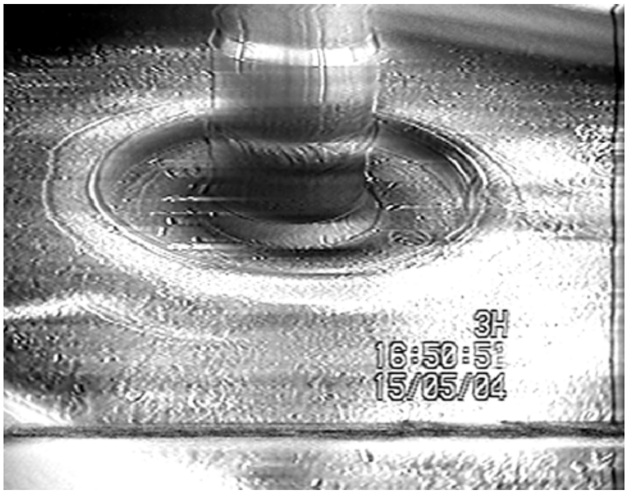

Fig. 3. Compartment Eight Flange connection after remote welding operations.

The highest risk to the project was the remote welding operation. The consequences of weld failure were significant and it was therefore vital that the weld was successful the first time to ensure project success. The optimization of the tools and techniques in an inactive facility paid dividends and the project was successfully implemented ahead of schedule with a good quality first-time weld. Remotely operated orbital welding equipment was designed specifically for this task and was successfully deployed. This and other new connections to the compartments have allowed the cooling systems to be re-commissioned and routine cooling to be established. This has provided more robust safety arrangements for the storage of the waste and will directly benefit future retrieval operations.

PREPARING FOR WASTE RETRIEVALS

The most recent success in October 2005 was the safe replacement of a 55-ton overhead crane (Fig. 4.). This required fifteen separate lifts, of loads weighing up to 50-tons, above the silo structure. The fault scenarios associated with impact on ventilation or containment systems meant that this modification was considered to be one of the highest hazard tasks on the Sellafield Site during 2005. Planning for this task involved a very detailed safety case and demonstrably robust contingency plans to be deployed. The project also involved a lot of work at height and heavy engineering, yet was safely executed with zero on site events or accidents, not even a cut finger!

Fig. 4. 50-ton lift – the chassis of the redundant crane was the heaviest lift and took seven hours to safely balance before lifting

Further work planned in preparing the building for retrievals includes:

- Installation of over 1,000-tons of rails and brackets for the future retrieval machines.
- Movement of existing safety systems and services to allow space for retrieval machines.

All of the above work has been undertaken in high radiation environments. Detailed planning and logistics has been critical to success due to the space constraints and use of common systems such as building cranes.

Following the above successes, a new Lifecycle Baseline Plan has been produced, which accelerates the start of retrievals by six years, to 2011.

CONCLUSION

The cleanup and decommissioning of the Magnox Swarf Storage Silos represents one of the major challenges of the UK cleanup program. Significant progress has already been made in delivering cleanup projects. The successes are summarised as follows:

- 586-tons of Magnox fuel swarf has already been safely retrieved and encapsulated for long-term safe storage. This experience has enabled the construction of new retrieval machines.
- Commercially available equipment has been used in innovative ways to develop low cost solutions.
- Early and full consultation with the local community has enabled successful transport of 333-tons of redundant equipment to be decontaminated, decommissioned and transported by road for disposal.
- High levels of contamination have been successfully removed from the concrete operations floor using remotely operated shaving equipment.
- The safety of the building has been improved by re-establishing direct cooling to the compartment contents.
- Significant progress was made in preparing the building for future waste retrievals.