Sellafield Ltd

GAMECHANGERS
DELIVERING NUCLEAR INNOVATION

Dounreay

CHALLENGE: Removal of Contaminated Concrete from Ponds

Across the Sellafield and Dounreay sites there are several ponds that require their concrete walls and floors to be remediated prior to final decommissioning and demolition. Sellafield Ltd. and Dounreay Site Restoration Ltd. are now seeking novel solutions or improvements to existing processes to decommission some of these ponds with two specific opportunities highlighted in this Game Changers challenge statement.

Both organisations have similar pond designs and are collaborating via the Game Changers process. This call for innovation is open to applicants from any sector including industries such as oil and gas, mineral mining, chemicals, civil engineering and construction. Sellafield and Dounreay are seeking a proof of concept capable of deployment as soon as practicably possible.

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Introduction

Nuclear fuel ponds are used to store spent fuel from nuclear reactors. Fuel rods are exported from the reactor to the nuclear pond for immediate “cooling” which allows short-lived isotopes to decay and thus reduce the ionising radiation emanating from the rods. In addition to cooling the fuel, the water provides radiological protection shielding until the rods can be sent for reprocessing or further long-term dry storage.

Across the Sellafield and Dounreay sites there are several ponds that require their concrete walls and floors to be remediated prior to final decommissioning and demolition. Sellafield Ltd. and Dounreay Site Restoration Ltd (DSRL) are now seeking novel solutions or improvements to existing processes to decommission some of these ponds with two specific opportunities highlighted in this Game Changers challenge statement.

Dounreay

Dounreay Fast Reactor (DFR) pond facility consists of two identical reinforced concrete tanks (East and West) separated by an adjoining concrete wall, incorporating a sluice gate. It previously contained approximately 1,000 m^3 of water.

Fig. 1
DRF Pond Dounreay

The original installation comprised a pond divided into two identical halves, each one measuring 14.6m x 7m and 6m deep. The concrete bottom of the pond is at ground level. The walls are greater than 1m thick and include an inner reinforced concrete liner 286mm thick (reducing to 210mm at the pond wall separation) and a bitumen layer that is 19mm thick. The bitumen layer in the floor is 25mm thick. The reinforced concrete floor of each pond is fitted with multiple steel locating pins that stand 50mm proud of the surface in a regular pattern. The East and West Pond floors have been covered in self-levelling concrete to depths of approximately 100mm and 400mm respectively to reduce dose rates. This concrete therefore covers the locating pin locations.

Contamination has migrated into the concrete on both ponds. Core samples have shown that this contamination has migrated more deeply into the concrete of the West Pond than that of the East Pond.

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Built and commissioned between 1948 and 1952, the Pile Fuel Storage Pond (PFSP) provided the storage, cooling and decanning facility for the Windscale Pile reactors and early Magnox reactors. The facility is about to commence a period of incremental dewatering by approximately 2024 and be completed in 2029 (current estimates).

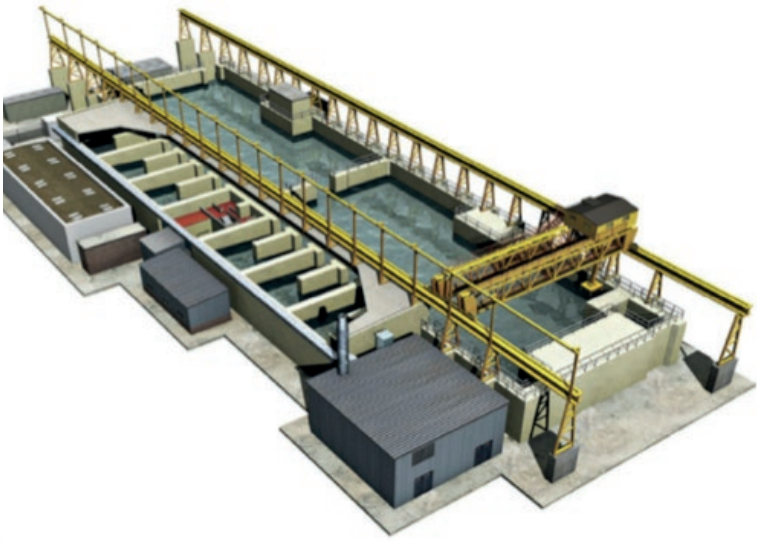

Fig. 2 PFSP Pond Sellafield

The PFSP pond structure is subdivided into an East Pond and West Pond separated by a sluice gate which starts at approximately 1.4m from the base of the pond. The internal pond dimensions are approximately 98m long x 13m wide x 7m deep. A decanner building is located on the south side of the pond and contains a series of 12 sub-ponds connected underwater to the main pond. Each sub pond is approximately 10m x 10m x 5.8m deep (bay floors are 1.2m higher than the main pond). The total pond bay water volume is 16,800m^3.

Water tanking is provided by a bitumen layer approximately 19mm thick within the walls and 25mm thick within the floor.

The PFSP 'interim state' is to be achieved by 2029 and will involve:

- Potentially a new floor cast underwater to a thickness of 300mm
- All water being removed
- Contaminated concrete on the walls been removed or shielded
- Following dewatering the pond surfaces will be sealed with a cementitious sealant and the facility will remain in a Care & Maintenance Phase for up to 10 years after which time it will be demolished to base slab. It will then have achieved its 'end state'

Current Practice

Dounreay

Work had begun on removing the East Pond concrete liner using a remotely operated saw to remove blocks ~ 1000mm x 1000mm x 286mm (33 blocks were removed from the 1st row of the East Pond and 14 from the 2nd row) but this was found to be taking too long, in part due to the effort to remove the liner blocks from the bitumen liner and in part due to effort required to setup the saw.

A decision was made to suspend the project to further explore novel solutions or improvements to existing processes of removing the pond liner (walls and floor).

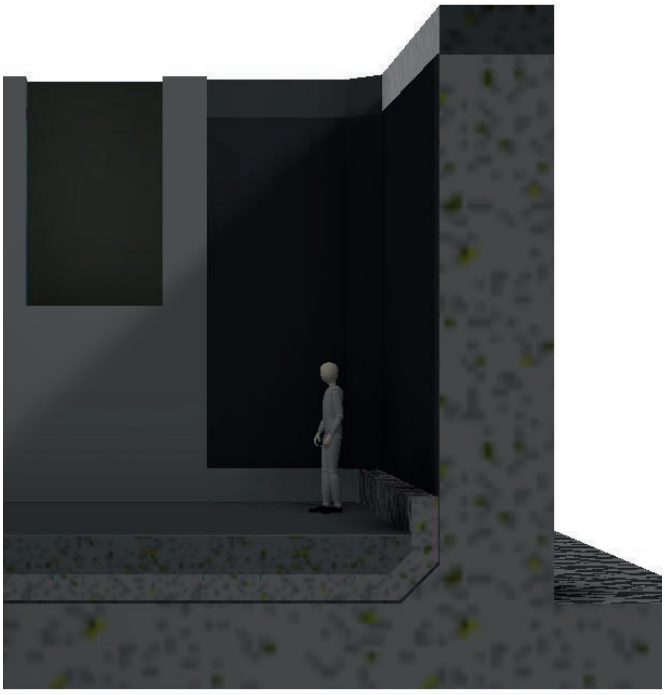

Fig. 3 Section of pond floor and wall removed

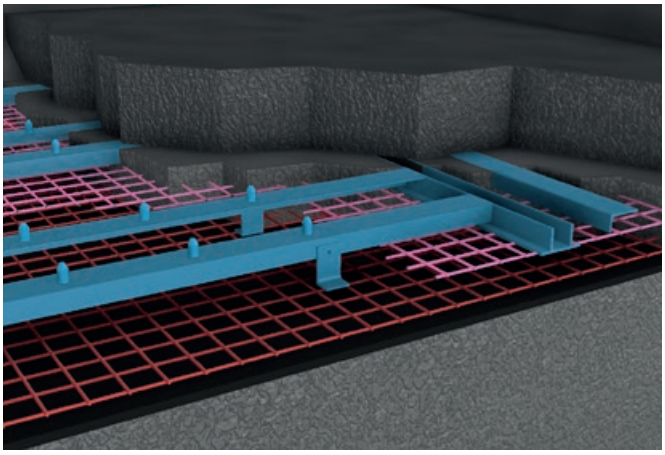

Fig. 4 Cross section through the pond floor

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Contamination consisting of Caesium-137 and Strontium-90 in the pond concrete walls and floor is known to be concentrated in the near surface (within approx. the first 10mm in the pond and 25mm in the bays) and will be a high dose rate source when the water shielding is removed.

The current plan to remove surface concrete (to a depth no greater than 28mm) from accessible pond walls involves the use of an off the shelf shaving method during dewatering. This concrete will be highly contaminated and sent as Intermediate Level Waste (ILW) concrete dust for interim storage. Dewatering will be done in 700mm dewatering increments. Where shaving

to remove the highly contaminated surface is not practicable, steel or concrete shielding may be installed in order to achieve the radiological goal of R2 levels (<25μSv/hr) at a distance of 1m.

When the Pond has a water depth of between 1.0m-1.5m, it is planned to cast a self levelling concrete floor underwater to a depth of 300mm for the following reasons:

- To act as a shield to lower what are anticipated to be high dose rates from the exposed floor surface and achieve the radiological goal of R2 levels (<25uSv/hr) at a distance of 1m when the pond is dewatered
- To entomb remaining radioactive debris left on the pond floor after a thorough clean up

After casting the new floor underwater, remaining water will be removed and a 50mm levelling screed applied. This solution will prevent radiological matter becoming airborne but taking this approach will generate approximately 1000m^3 of contaminated concrete which will probably have to eventually be disposed of as Low Level Waste (LLW). It is likely that the entombed radioactive debris material will require separate disposal. This approach is also likely to be a costly solution.

Challenge Aims

Both Sellafield Ltd. and DSRL are seeking improved and/or novel solutions to remove contaminated concrete from the surface of their ponds and are seeking to reduce the amount of waste produced during this decommissioning process. It should be noted with both opportunities that there is flexibility with regard to the nature / physical form of the removed concrete and it could be removed as slabs, granules, powder etc.

The solution must be capable of:

DSRL

Ponds Walls and Floor

It is challenging to argue that dose uptakes received during the semi-remote saw cutting operations currently used remain As Low As Reasonably Practicable (ALARP).

Dounreay are looking for innovative approaches to address the requirement for the removal of the contaminated concrete (to a minimum depth of 50mm), including the adjoining concrete wall, sluice gate and the pond floor. There have been improvements in concrete removal techniques in recent times so it seems realistic that a more efficient solution(s) can be identified.

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Pond Walls

Opportunities exist to seek an alternative to shaving the near surface of the pond concrete walls (or as a minimum, to improve the collection of the highly active concrete shavings). Shaving the concrete walls and collecting the dry concrete dust safely as the water level is lowered brings its own challenges and Sellafield Ltd. are looking to other solutions which will:

- Reduce complexity and therefore engineering risk
- Create less radiological waste
- Move decommissioning forward and seek to not rely on the mass installation of shielding during the dewatering process / dewater and waiting for up to 10 years until the facility is demolished
- Reduce the time to dewater the pond (currently 5 years from start to end of dewatering)

Pond Floor

Sellafield are looking to an alternative solution to remediate the pond floor which will:

- Remove the engrained radioactivity in the existing floor (to achieve R2 levels) and remove loose radioactive debris from the base of the pond/bays (remaining after a thorough clean up) without the need to cast a new concrete floor thereby avoiding the costly and difficult disposal of 1000m^3 of newly contaminated LLW concrete.

Benefits to DSRL and Sellafield Ltd.

It is expected that solutions will bring benefits to Sellafield Ltd. and DSRL's decommissioning programmes, including:

- Acceleration of contaminated concrete removal
- Reduction of the overall amount of contaminated concrete produced and in turn a reduction in disposal costs
- Reduction of the overall cost of decommissioning and demolition
- Increase in the safety of operations through reduced human intervention, leading to a reduction in operator exposure to radiation
- Development of shared learning and collaboration between Sellafield Ltd. and DSRL that can be utilised in the decommissioning of other pond structures across the Nuclear Decommissioning Authority estate and wider Nuclear industry.
- Demonstration to the regulator that alternative scenarios and solutions have been considered that therefore support the 'Best Available Technology' argument for any solution eventually adopted

Constraints to DSRL and Sellafield Ltd.

These constraints need to be considered when developing potential solutions for either or both challenges, including:

Environment

- Dose rates provide significant challenges to all work within the pond areas. Typical radiation levels range from 20μSv/hr to 2.5mSv/hr
- The use of equipment with radiation tolerant components or those with minimal on-board electronics is preferential but not necessary
- Targeted environments can be damp and humid and therefore solution providers need to consider the Ingress Protection (IP) rating of equipment
- May be in an environment which is submerged by water (Sellafield only)

Access

- Working at heights must be considered
- Weight and loading limitations exist within the existing pond structures
- An ability to work from the top of the Sellafield PFSP pond wall is desirable but it should be noted that the pond wall is narrow
- Removing blocks from the PFSP concrete liner is not possible as it would impact drastically upon the width of the pond walkway
- The ability to suspend a device from a crane is desired
- The PFSP pond is currently serviced by a 20Te SWL main crane and a 2Te SWL auxiliary crane from the one overhead gantry. The cranes can travel beyond the full extent of the pond allowing materials to be off-loaded onto an area outside the pond
- These cranes require regular attention. The mechanical lifting capability required to service the pond to the end of dewatering (2029) is currently the subject of a thorough study
- The Dounreay DFR pond does have a walkway but workers must be attached to a safety line
- The DFR pond has already been dewatered and therefore there is an ability to work from the pond floor or wall
- The DFR pond has a motorised transporter platform mounted on rails to the north and south walls of the ponds, this platform has the ability to traverse across the full length of the East and West Ponds. The transporter's working platform is 39 m^2 and it is also fitted with a 2Te SWL hoist that has an overreach of approximately 1200mm either side

Retrieval

- The solution should not lead to the generation of significant amounts of secondary waste and the generation of additional ILW concrete is to be minimised
- Any removal technique must limit and control the spread of contaminated concrete
- The bitumen is strongly adhered to the surface of the concrete of the DFR pond and is likely to be the same for the PFSP pond
- Radioactive debris left on the existing floor may contain uranium oxides and therefore cannot be allowed to dry out and become airborne. Any sealant material suggested would have to be disposable to existing waste routes

Functional Requirements

The proposed solution should consider the following functional requirements:

Dounreay

- The solution must be capable of removing contaminated concrete to a minimum depth of 50mm. This can be removed in incremental depths and does not need to be removed in one pass
- The device must be capable of working in a dry environment
- The bitumen is strongly adhered to the surface of the concrete
- Remote operation is preferable

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- Capable of removing contaminated concrete on the walls to a depth of approx. 10mm and no greater than 28mm depth
- It is assumed the pond floor has contamination to the same depth as the walls
- Newly exposed contamination free concrete surfaces must not be exposed to contamination from the pond water in the surrounding environment
- Contaminated surfaces should be sealed or as a minimum not allowed to dry out since loose material may become airborne
- Remote operation is preferable

What Next?

Game Changers are hosting an online briefing workshop for this challenge. Details of the workshop will be available on the Game Changers website www.gamechangers.technology.

If you have new ideas or innovations which can be applied to address this challenge, we invite you to join us. If you'd like more information about the funding available through the Game Changers programme, please visit www.gamechangers.technology/our-process/

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