Sellafield Ltd

GAMECHANGERS
DELIVERING NUCLEAR INNOVATION

CHALLENGE:

Remote deployment method for sensors in nuclear store structures

Sellafield Ltd is seeking a method to remotely deploy corrosion-sensing and inspection equipment to and from corrosion sites via the ceiling ports or ground-level ventilation duct of cells within the Sellafield Product and Residue Store (SPRS), to help inform decision-making around the 100-year plan for the store and its special nuclear materials (SNM) content.

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United Kingdom National Nuclear Laboratory

Introduction

The **Sellafield Product and Residue Store (SPRS)** houses **special nuclear materials (SNM)** that have resulted from nuclear fuel reprocessing activities over the last 60 years. SPRS is playing a key role in delivering Sellafield Ltd's mission to create a safe environment for future generations. The SNM are packaged into containers for safe and secure storage within the SPRS for around 100 years.

The Sellafield site is in a coastal location so the air surrounding the SPRS is humid and salt laden. The SPRS is ventilated by the natural convection of unfiltered air, and it is known that the moisture and salt in the air are causing corrosion of steel and aluminium structures (extrusions) within the SPRS.

Housing of SNM within the SPRS

Prior to storage, SNM are packaged into stainless steel canisters, such as the one illustrated in Figure 1. The SPRS can hold a maximum of 9,600 SNM canisters.

Figure 1: Image of a typical SNM container

The cylindrical SNM canisters are housed within aluminium alloy channels that consist of 8mm-thick aluminium 6063 extrusions. A cross-section of the structure of the aluminium extrusion is shown in Figure 2. The aluminium extrusions provide secondary nuclear containment, with the stainless-steel canister being the primary nuclear containment.

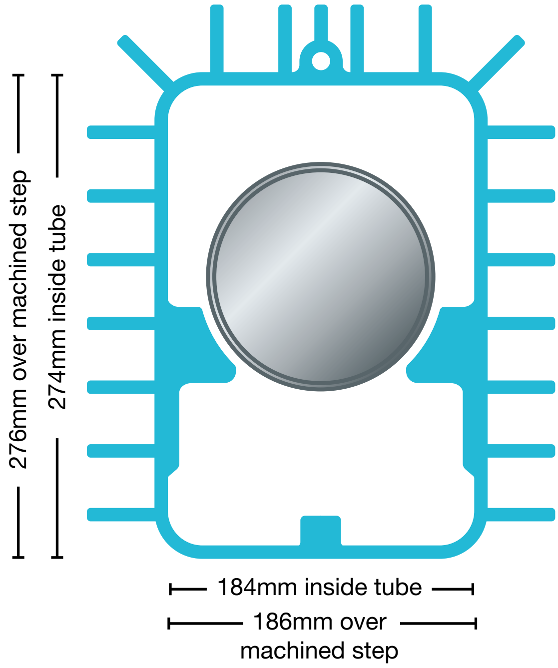

Figure 2: Cross section illustrating the positioning of an SNM canister within an aluminium 6063 extrusion

An illustration of the longitudinal arrangement of SNM canisters within an aluminium extrusion is shown in Figure 3. The SNM canisters are entirely surrounded by the aluminium extrusion and are, therefore, not visible once they are located in the SPRS.

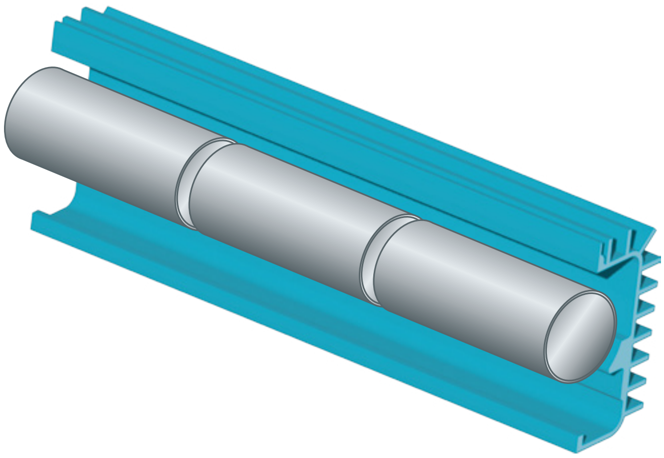

Figure 3: Section of an aluminium extrusion containing SNM canisters

The SPRS contains 16 cells. The structural arrangement within cells, illustrated in Figures 4 and 5, is as follows:

- Each cell contains 40 aluminium alloy extrusions of 6.3m in length
- There are 20 extrusions in the upper cell and 20 in the lower cell; these are highlighted blue in Figure 4
- The extrusions are arranged in a horizontal parallel formation with centre-to-centre spacings of 750mm
- The extrusions are supported by a steel support structure labelled on Figure 4
- The vertical distance between levels of extrusions is approximately 450mm
- The horizontal gap between adjacent extrusions is approximately 550mm

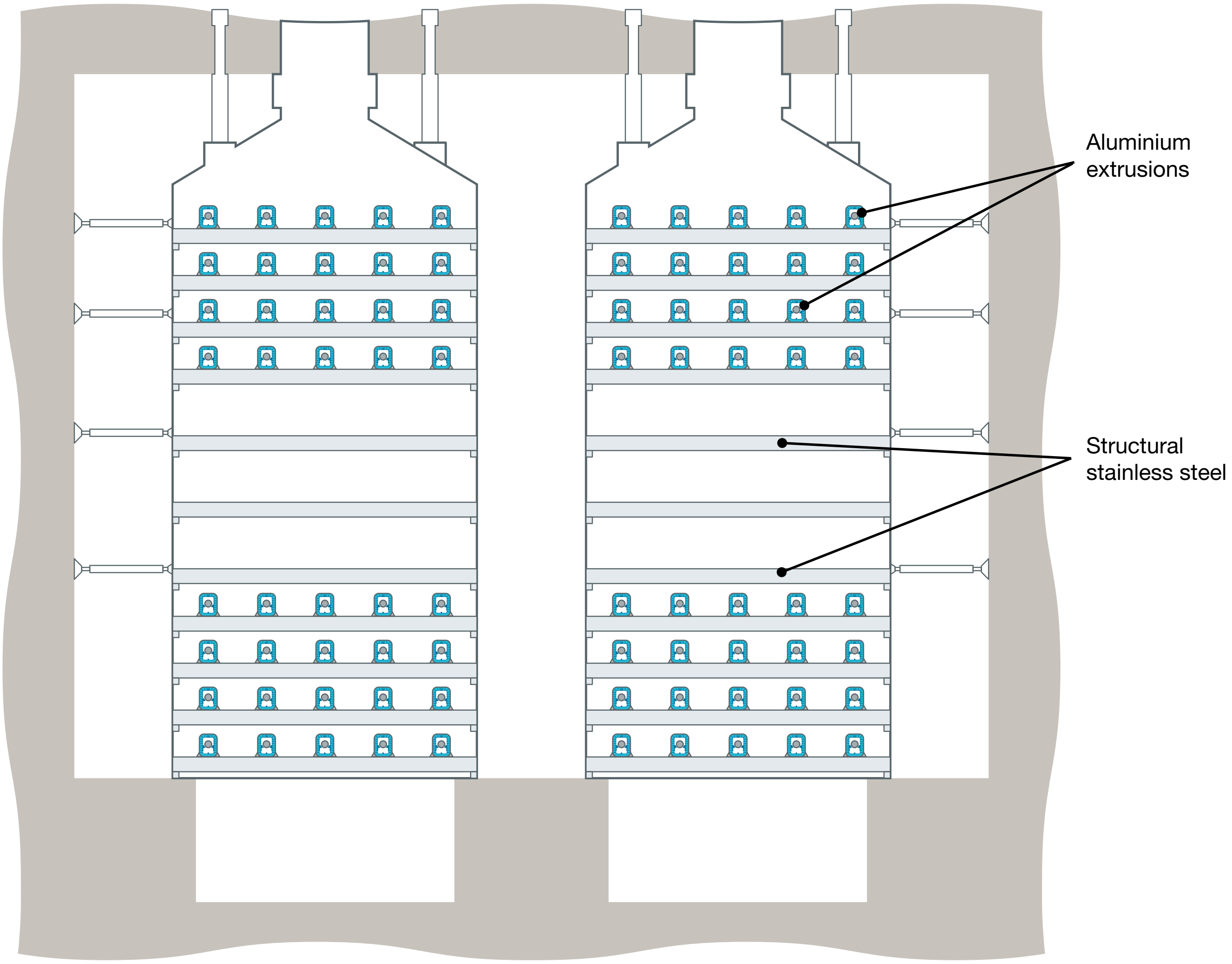

Fig 4: Schematic of the interior of an SPRS cell

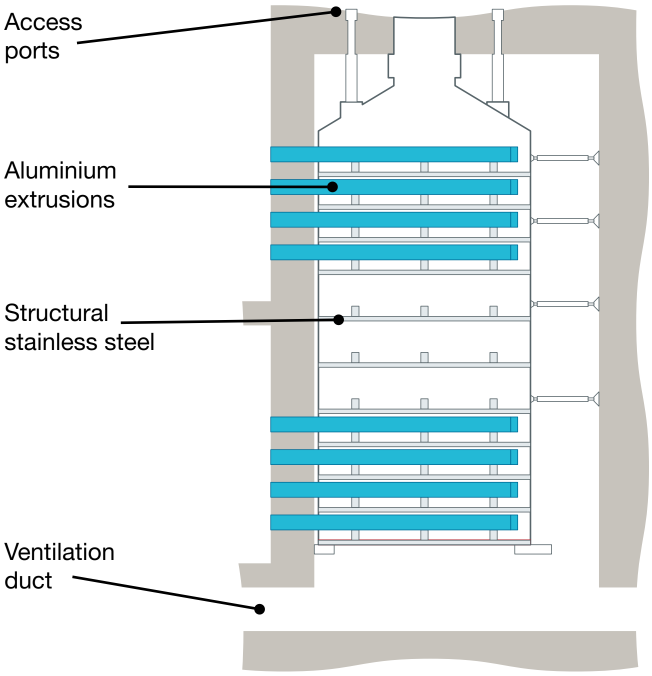

Figure 5: Schematic drawing of the cross section of a storage cell as viewed from the side with the aluminium extrusions highlighted in blue and steelwork highlighted in grey. Note the access points via ceiling ports and floor level duct

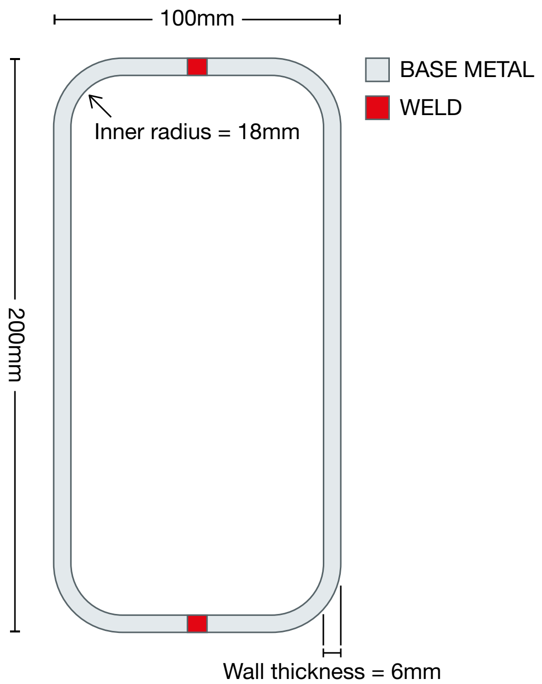

Figure 6: Schematic of the cross section of a stainless-steel box section. The inner radius is 18mm and the wall thickness is 6mm

The corrosion situation

Within the SPRS, the supporting steel framework has started to corrode and appears to be dripping corrosion products onto the aluminium extrusions, as shown in Figures 7, 8 and 9. This is corroding the aluminium; however, it is not possible to see to what extent the corrosion is occurring or what corrosion products are forming. If the wall of the extrusions is breached, they can no longer serve their secondary nuclear containment purpose. Sellafield Ltd needs to understand whether the observed corrosion is going to be limiting to the forecast 100-year lifetime of the SPRS store and needs a method of deploying corrosion-sensing equipment to the sites of the corrosion. The deployment system will carry the sensing equipment at all times, holding it in place at the corrosion sites.

Figure 7: Corrosion is seen forming here, predominantly on the central weld of an LDX 2101 stainless steel box-section. Corrosion product is visibly dripping down onto the underlying (finned) aluminium extrusion

Figure 8: Green/brown corrosion products from the LDX 2101 supports can be seen on the surface of the aluminium extrusion

Figure 9: Salt can be seen forming on the aluminium extrusion. These extrusions are shown supported and strapped to the structural stainless-steel box-section

Work is ongoing to develop corrosion-sensing and measurement equipment, which requires contact with the store and extrusions for effective usage.

Access and entry to the cells

This challenge is about deploying corrosion-sensing equipment to all relevant extrusions within the store, and Sellafield Ltd is seeking a robust method for the deployment of such sensing equipment to the extrusions/corrosion sites within each SPRS cell to place the sensing equipment where it is needed.

Manned entry to SPRS is not possible, so remote deployment of corrosion-sensing equipment will be required via the access points described below.

There is access via two ports in the roof of each cell (see Figures 4 and 5) and via a floor level ventilation duct at the base of the store (see Figure 5). The access ports through the roof of the cell are circular, with a diameter of 140mm and an approximate length of 2m. The ventilation duct at floor level has a flat, relatively unobstructed, concrete surface with a square manhole access of 730mm by 730mm and a depth of 500mm. Any solution deployed via the ventilation duct will need to be lowered through this hole into the duct itself. Within the ventilation duct, there is a crawl space opening into the cell, 1m high by 3.4m wide.

The distance between the access ports in the cell roof and the upper most level of aluminium extrusions is approximately 3m. The distance from the access ports in the cell roof to the floor of the cell is approximately 16m. Both the cell roof and floor access points present possible routes for a remote deployment system.

Any deployment system will need to be robust enough to deploy multi-kg sensor payloads at a distance, with a key target area being the welds of the structural stainless steel box section (Figure 6), as these are particularly susceptible to corrosion.

A robust, remote deployment system is required to convey sensor equipment to all possible corrosion sites within each SPRS cell.

Current Practice

Currently, the only means of observing the interior of an SPRS cell is to lower a camera on the end of a pole through the inspection ports at the top of the store. This visual inspection method enables monitoring of the progress of corrosion but does not give any chemical information or allow for assessment of the depth of corrosion. Work is ongoing to develop corrosion-sensing and measurement equipment, which requires contact with the store and extrusions for effective usage.

Samples of corrosion products from structures within the SPRS were last taken during a manned store entry in 2016. However, the radioactive dose rate within the cells increases over time as the store has been filled with SNM inventory. Manned access, therefore, becomes increasingly difficult and would require the movement of SNM inventory to allow access for only a matter of minutes. As a result, the best current means of monitoring the corrosion within SPRS store is via the two circular inspection ports in the cell roof.

Any inspections would involve lowering a sensing payload through the ceiling port. Due to the distance between the top and bottom extrusions within the cell (16m) there are limitations around reach versus payload capacity.

The ventilation duct at the base of the cell is the manned access route to the store, which whilst constrained (low ceilings, not particularly designed for manned entry) is big enough to navigate without too much difficulty. This opens up the possibility for mobile remote deployment solutions to enter and deploy telescopic arms or other payload delivery methods.

Challenge Aims

Sellafield Ltd is seeking a method to remotely deploy corrosion-sensing and inspection equipment via the ceiling ports or ground-level ventilation duct of cells within SPRS. The deployment solution should be able to reach all required parts of the cell to place corrosion-sensing equipment at all required sites of corrosion including those on the extrusions and on the welds, as previously highlighted.

The deployment solution should be able to carry and deliver the sensor payload to where it is required and hold the sensing equipment in place at all times. It should be able to tolerate the radioactivity levels within the cell. It should also be able to record the locations of analysis/data or sample collection and should be robust so that it can be repeated across other cells within SPRS.

Sellafield Ltd is seeking any solutions to this challenge to be operational/business as usual by 2029. This means that an active demonstration of a solution would be required by early 2028 at the latest. However, if an earlier solution is presented, this would be desirable.

Benefits to Sellafield

The SPRS store has a capacity of 9,600 SNM packages, which require interim storage until 2120. Sellafield Ltd needs to fully understand the extent of corrosion within the SPRS. This will inform strategic decision-making and drive future planning to ensure operational safety.

The capability to routinely, remotely inspect and gather data on corrosion in all areas of SPRS will:

- Enable a better understanding of the rates and extent of corrosion within the store
- Provide the ability to confidently predict the lifetime of the store
- Inform the maximum capacity of the store
- Inform store maintenance requirements
- Enable development of potential strategies for remediating the existing corrosion
- Enable development of potential strategies for preventing or minimising future corrosion development

Solving this challenge will improve the safety of store operations and improve inspection and maintenance capability. This supports the strategy to keep the storage facility online, as building a new storage facility would cost in the region of £1bn.

Constraints

Any solutions to this challenge will need to factor in the following aspects:

- The configuration of an SPRS cell as detailed in this document
- Remote, non-manned access to the interior of the cells within the SPRS either via two 140mm inspection ports at the top of each cell or the ventilation duct at the cell base
- The 140mm diameter inspection ports are approximately 2m long and require the removal of the shield plug to enable access
- The ventilation duct access is a square manhole of 730mm by 730mm and 500mm deep. Therefore, any deployment solution via the ventilation duct will be lowered through this manhole access into the duct itself
- Within the ventilation duct there is a crawl space opening into the cell of 1m high by 3.4m wide
- Access to the structural steelwork and aluminium extrusions, particularly in the lower part of the cells, is extremely complex
- There is no lighting within the SPRS cells
- There is no power supply within the SPRS cells
- Relative humidity within the SPRS cells is around 70–80%
- Temperatures within the SPRS cells can reach as high as 50°C
- Radiation levels within the SPRS cells are approximately 2 mSv/hr gamma and 2 mSv/hr neutron, although levels may be higher than this in localised regions of some stores
- Equipment or contamination should not be left within any SPRS cell

Functional Requirements

Solutions to this challenge must be agile, remote deployment techniques that are feasible within the constraints of the SPRS cell.

Solutions to this challenge should:

- Consider the configuration of an SPRS cell
- Provide a deployment solution that works via the access points described in this document
- Be capable of deploying sensing equipment to any area of corrosion on the exterior of the aluminium extrusions within an SPRS cell covering the 16m maximum distance between extrusions
- Be repeatable across all relevant extrusions within the cell
- Be retrievable so that it can be redeployed within other cells across SPRS store
- The deployment solution should be able to hold the corrosion-sensing equipment in place at the corrosion sites for the period of time required by the sensing equipment
- Log the precise location from where any data was gathered or samples taken
- Be able to repeat the precise location deployment of the sensing equipment annually
- Be radiation tolerant for a minimum of 2 mSv/hr gamma and 2 mSv/hr neutron
- Be radiation tolerant enough to retrieve samples without breaking down, with multiple entries preferred
- Be able to carry a payload of around 2kg
- Have a camera and a light to observe where it is within each cell

Find Out More

Game Changers are hosting a workshop for this challenge where delegates will have the opportunity to meet challenge owners. Details are 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 Our Funding Process (gamechangers.technology).

The deadline for applications for this challenge is 3pm on Thursday 30 October 2025.

Delivered by

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