Sellafield Ltd

GAMECHANGERS
DELIVERING NUCLEAR INNOVATION

CHALLENGE:

Wireless, long-term environmental monitoring of nuclear stores

Sellafield Ltd would like to remotely monitor the environment inside long-term nuclear product storage facilities by using sensors that can regularly transmit data wirelessly.

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Introduction

Sellafield Ltd is responsible for the safe, secure, long-term storage of the UK's inventory of Special Nuclear Materials (SNM). These materials are the result of spent nuclear fuel reprocessing activities undertaken on the Sellafield site over the last 60 years. To deliver Sellafield Ltd's mission to create a clean and safe environment for future generations, existing SNM packages will be repackaged into more robust containers for safe and secure long-term storage. Prior to repackaging, the existing SNM packages must be stored safely and securely. Environmental monitoring of the SNM package stores is necessary to demonstrate that the SNM packages remain in a stable environment. Sellafield Ltd are looking to improve the monitoring capability of older stores which have less environmental monitoring equipment than newer stores. As such, Sellafield Ltd would like to explore a suite of sensors that can be situated within an empty SNM package and be placed in storage along with the real SNM packages, providing regular environmental data.

SNM stores

SNM stores typically hold 100s-1000s of packages within an array of storage channels. Within each storage channel, packages are positioned horizontally. They are placed into the channel base first, with the lid facing the channel opening. The storage channels are typically between 4m to 6.5m long. Figure 1 illustrates the interior of a typical SNM product store. The left of the image shows the charge face, through which the SNM packages are loaded into the storage channels. The port within the charge face wall is the only route of access to each storage channel. Each access port in the charge face wall is shielded by a 25kg concrete shield plug that is inserted into the port from the exterior side of the charge face wall. Humans can access the charge face, but not the interior of the SNM store.

Figure 1: Typical SNM store

SNM packages

SNM packages, as shown in Figures 2 and 3, are cylindrical and vary in size, with a typical length of 310mm and diameter of 133mm, and typical mass of around 10kg (maximum 20kg). An SNM package typically consists of a lidded outer body (outer can), within which resides an inner sealed body (inner can) that contains the SNM. The outer parts of the packages are constructed from 316L stainless steel. Sellafield Ltd are looking for a solution that would reside within an empty outer can within the SNM stores.

Figure 2: SNM package

Aim

Sellafield Ltd would like a suite of sensors that can fit within an empty SNM package and provide daily environmental monitoring data from inside the SNM package store. In addition to the daily automated output, Sellafield Ltd would like the package to send an alert if any of the sensors hit a relevant threshold measurement. Packages are expected to be in place for decades. Sellafield Ltd would like the technology within the dummy package to transmit wirelessly and continually for 30+ years.

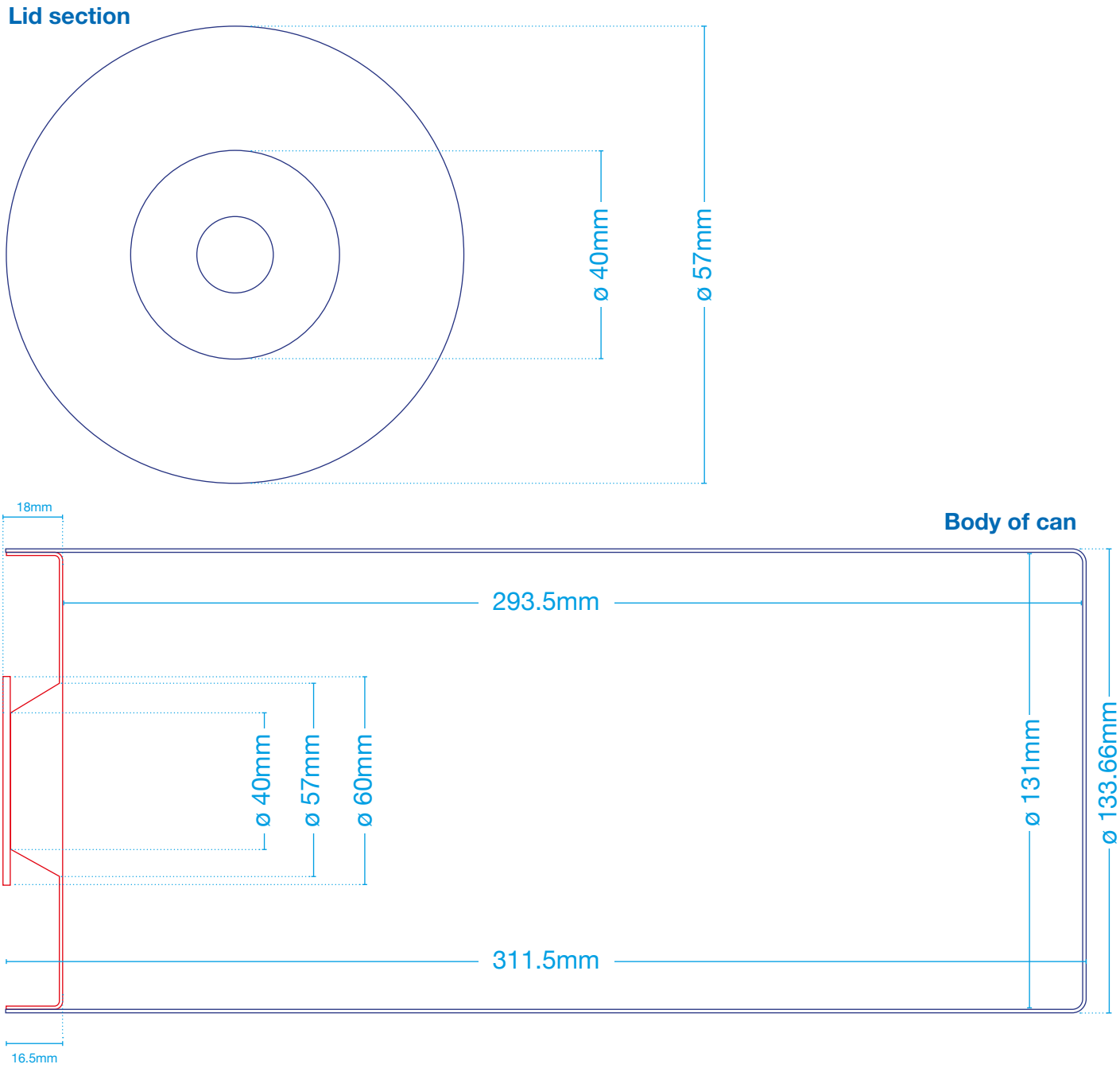

Figure 3: Schematic of SNM package

Current Practice

Currently, environmental monitoring of the SNM stores is done by measuring the inlet and outlet temperatures of store ventilation ducts. Tinytag data log monitoring is also used, whereby a small sensing device is placed in one of the storage racks to collect data for around 6 months. Installing and removing the tag requires the stores to be opened and the device removed. This is a time-consuming and expensive process.

Sellafield Ltd are currently funding a smart sensor can project whereby sensors can measure the base deflection and temperature of live packages and transmit the data to a receiver at the charge face. This means only short distances are required to get signals from individual cans. The aim of this new challenge is to apply wireless technology to a dummy can containing instrumentation to allow ambient measurements of the cell conditions to be obtained.

Challenge Aims

Sellafield Ltd are seeking remote monitoring devices that can:

- Provide regular cell environmental data remotely (temperature, humidity and salinity)
- Provide an alert if alpha radiation levels reach a threshold value
- Be able to transmit measured environmental data from inside the cell through the concrete cell wall to a receiver at the charge face, where it will be transmitted by Wi-Fi or existing plant IT infrastructure to a standalone laptop
- Function within a modified dummy package in SNM package stores, which is a radioactive environment
- Operate for 30+ years

In addition to the monitoring device, the solution should consider how the signal will be transmitted from the outside of the cell to the control room several tens of metres through the building fabric. There are pre-existing cables that run up to the control room. The data will be managed through interaction with a user interface that would enable operators to visualise data trends, although this is not an expected output of any feasibility study.

Alternative methods of measuring environmental conditions will be considered a bonus.

Sellafield are seeking a Proof of Concept within 12-18 months, and a deployable solution by 2026.

Benefits to Sellafield

It is anticipated that the implementation of a system capable of the wireless, long-term environmental monitoring of nuclear stores will:

- Support the safety case for long-term storage of SNM in package stores
- Result in increased safety due to reduced operator exposure
- Lead to increased regulator confidence due to improved data quality and quantity
- Aid increased productivity
- Improve understanding of the conditions inside the SNM stores

Constraints

Environment

SNM packages are stored in a dark, humid (70% to 80%) environment.

The environmental temperature typically ranges from 10-40°C. Typical SNM can outer temperatures may range between 40 to 120°C.

Radiation levels of the packages need to be considered when developing equipment that will be used in the dummy packages. Typical β/γ radiation levels are 3.5 mSv hr^{-1} on contact and 90 µSv hr^{-1} at 1m and a typical contact neutron dose rate is 2 $mSvhr^{-1}$.

This is a GPS-denied environment.

No wires can be installed in the active store area so this solution must operate entirely remotely. There is the potential to include transmitter and receiver capability.

Access

SNM packages are stored in racks, sometimes referred to as channels or extrusions. These channels can only be accessed through 150mm diameter ports at varying positions. Ports are configured vertically. The dummy packages would be added to the same channels, alongside the SNM packages.

Once installed, it is anticipated that the sensor packages will be left in place for 30+ years.

Condition

The condition of the SNM packages that would surround the dummy package are variable and could be delicate. It is very important that the proposed solution doesn't damage surrounding packages in any way.

Functional Requirements

Any proposed solutions should have the following features:

- A suite of sensors that can be installed within an empty standard SNM package with a typical length of 310mm and diameter of 133mm. Internal dimensions of the can are 293mm long and 131mm diameter. The package can be modified to allow measurements of the cell environment outside of the can
- Capable of operation at temperatures between 20 to 90°C, and relative humidity up to 95%
- Radiation tolerant up to 5 mSv hr^{-1}
- Able to measure temperature, humidity, salinity and alpha radiation. In respect of alpha radiation measurement, it is essential that the detection system is able to compensate for the presence of naturally occurring radon
- Able to provide daily maximum and minimum readings
- Able to provide alerts if the sensor readings reach pre-set threshold values
- Able to work continually with no maintenance or intervention over 30 years
- Self-calibrating
- Consideration of wireless control and functionality to give additional readings on request
- Capable of remote operation, along approximately 5m length of extrusion, through a concrete cell of about 1.3m. The requirement is to be able to transmit data from inside of the cell through the concrete cell wall to the charge face. The signal will be transmitted from the charge face to a laptop in the control room several tens of metres through the building fabric from the outside of the cell either using building Wi-Fi or existing IT infrastructure. There are pre-existing cables running from the charge face up to the control room
- Consideration of data management and user interface should be made
- Meet appropriate engineering standards

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 6pm on Wednesday 29th November 2023.

Sellafield Ltd

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