Sellafield Ltd

GAMECHANGERS
DELIVERING NUCLEAR INNOVATION

CHALLENGE:
Automated Alpha In-Air Monitoring

Airborne alpha radiation monitoring is an essential requirement within many of Sellafield Ltd's facilities. The current monitoring systems require regular maintenance. Sellafield Ltd would like to explore the possibility of implementing a fully automated airborne radiation monitoring system that does not require frequent, routine maintenance.

FIS 360
INNOVATION | TECHNOLOGY | BUSINESS

NATIONAL NUCLEAR LABORATORY

Introduction

Alpha particles are a relatively large and heavy form of radiation, so they can only travel a few centimetres in air and are unable to penetrate human skin. However, alpha is the most ionising type of radiation, which makes it extremely harmful if ingested by humans. Sellafield Ltd must, therefore, have the ability to detect any airborne alpha radiation on-site in order to be alert to loss of containment and to keep personnel safe. It is necessary to constantly monitor for dust particles that may be carrying alpha or beta radiation emitting substances. There are over 500 alpha in-air monitoring instruments on the Sellafield site as a whole.

Alpha and beta in-air monitoring instruments

There are several types of radioactivity in-air monitors used on the Sellafield site, but they all use the same basic principle of operation. Air is drawn through the instrument, usually by means of an external pump. Airborne particulate is then deposited onto a removable filter card. This card filter is positioned under a detector where radiation deposits can be continuously monitored by the unit and appropriate alarms generated. The detector gives live readings of alpha and beta radiation levels combined. Characterisation of causative nucleotides is only possible once the filter paper has been removed and analysed in a laboratory.

As depicted in Figure 1, depending on the model of monitoring instrument, the filter paper may be formatted as:

- A single sheet (referred to as single card) that has to be replaced routinely and as often as every 24 hours in particularly dusty environments
- A roll of tape (referred to as moving film) that moves at approximately 5 cm per hour and has to be replaced on a monthly basis. The tape may roll more quickly if triggered to do so by reduced air flow or detection of alpha or beta activity

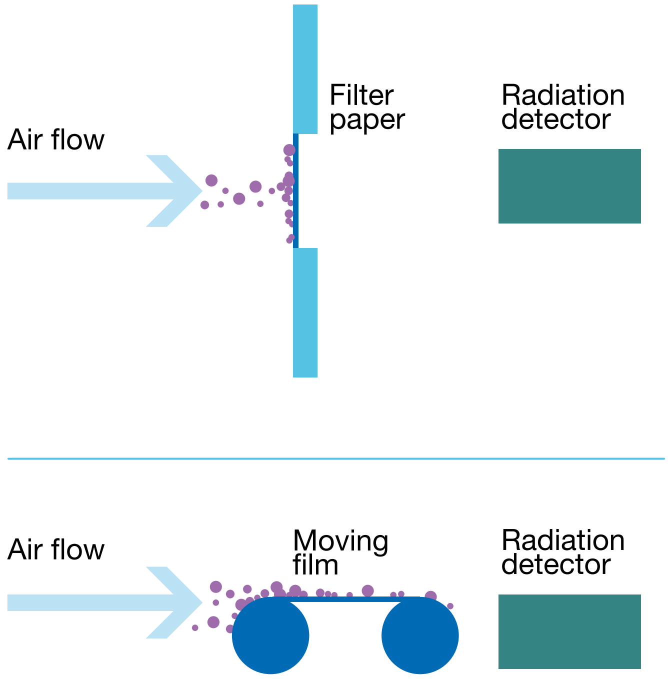

Figure 1 – Schematic of the basic components of two types of alpha in-air monitoring device – the top image is a single card filter paper system and the bottom image is a moving film filter paper system.

Alpha or beta in-air false alarms

The air within plant buildings on the Sellafield site tends to be warmer than ambient and very dry due to air conditioning, with high levels of airborne dust being common in many areas. These high levels of airborne dust lead to rapid build-up of excessive dust accumulation on the filter paper in the monitors. This reduces or even blocks the airflow, which causes the alarms on the existing instruments to be triggered.

Once an alarm has been triggered, access to the corresponding area is restricted until the monitor has been reset and the filter paper changed by Health Physics personnel. This procedure is time consuming because prioritising filter paper changes against other routine work undertaken by Health Physics is often difficult. Therefore, areas of the plant are routinely, unnecessarily, rendered inaccessible for excessive periods of time.

Sellafield Ltd are seeking solutions for airborne alpha and beta monitoring that require little or no maintenance or intervention and allow operators to determine whether an alarm is due to genuine detection of alpha or beta radiation or some other factor such as radon build up.

Current Practice

Sellafield Ltd currently deploys large numbers of radiation in-air monitoring devices across all areas of the site. Generally, the single filter card system is deployed in easy-to-access areas, such as corridors, where devices are usually positioned at waist height. In more difficult-to-access areas such as ducts and chimney stacks, the moving filter roll assembly is used. This can be manually or automatically incremented to present clean filter medium under the detector.

With single card systems, the card is replaced at least every 24 hours in the dustiest environments. This is to mitigate against the device going into an alarm state due to excessive dust build-up. Despite this, the monitoring systems still require regular maintenance and often go into alarm due to dirty filtration papers on the air intake.

With the moving filter system, any alarms triggered by the presence of radiation are cleared when the filter paper next scrolls on, leading to possible false negatives. This could result in an operator falsely believing an area to be free of radiation – clearly an undesirable situation. Another problem with this system is that, in the event of a genuine alarm being generated, it is not possible to pinpoint the part of the moving filter film that captured the contamination. Whilst these issues can be mitigated through software controls, behavioral changes and locking-out the fault conditions, there are other issues with swapping the filter papers which still present a manual handling and maintenance challenge for current operations.

Challenge Aims

Sellafield Ltd is seeking an airborne alpha monitoring system that:

- Can cope with a dusty environment
- Has an alarm output that allows the operator to distinguish between the genuine detection of alpha or beta radiation and reduced airflow or any other false alarm states
- Reports its status digitally to a central location
- Can act as a first-line defence against alpha or beta contamination and provide reliable safety assurance for operations

The ultimate aim is to install a maintenance-free system that requires no intervention.

With the publication of this challenge statement, Sellafield Ltd is aiming to discover the ‘art-of-the-possible’ rather than alternative commercially available products.

It is expected that applicants successfully awarded funding should be able to complete 12-week feasibility studies by the end of March 2024.

Benefits to Sellafield

Sellafield Ltd has several legacy nuclear facilities where there is a requirement to continually monitor for airborne alpha radiation.

Across the Special Nuclear Materials plant alone there are hundreds of radiation in-air monitoring devices, some of which require their filters to be changed on a weekly or even daily basis in extreme cases. Considering the whole of the Sellafield site, this could scale up to thousands of devices.

A successful solution to this challenge would significantly reduce the requirement for routine maintenance of airborne alpha monitoring equipment, as well as reducing the downtime for areas of the plants that have shut down due to a false alarm.

In addition to legacy buildings, a new plant is scheduled to be constructed in the 2050s with design work starting in the next decade. Any solution to this challenge may become a component in the new plant that will require monitoring in around 20 distinct areas.

There is also the possibility of applying a suitable solution across the whole of the Nuclear Decommissioning Authority estate.

It is hoped that by addressing this challenge, there is potential to:

- Reduce the requirement for routine maintenance
- Significantly reduce the human resource required from the Health Physics department when dealing with false alarms

- Prevent the unnecessary closure of areas of plant
- Provide better confidence in the ability to monitor airborne alpha and beta radiation and therefore improve safety for operators

Constraints

Existing monitoring devices are located in well-lit, easy-to-access areas with ready 110v power sources.

There are no specific constraints or preferences in terms of the size and weight of future monitoring devices; although, a potentially mobile device would have some advantages. The existing devices are around the size of a large shoe box.

Battery-powered solutions may be considered, but the use of lithium-ion batteries on the Sellafield site is not preferred.

Functional Requirements

Any proposed solutions should have the following features:

- Able to detect the presence of airborne particulate alpha or beta activity across a range of particulate sizes, typically ranging from 0.1μm to 10μm aerodynamic diameter
- Be self-calibrating
- It is essential that the detection system is able to compensate for the presence of naturally occurring radon
- Provides the same level of confidence as the existing capability
- Be suitable for UKCA marking
- Provides a specific indication of the presence of alpha or beta activity via an alarm that is distinct from an alarm to indicate that the device requires attention for any other reason, such as a blocked filter
- Requires little or no maintenance
- Offers automated replacement of air filtration media or involves an alternative approach that does not necessitate the use of filtration media that requires replacement
- A device that can be deployed either in a fixed location or be mobilised is required
- Capable of digitally self-reporting status to a central location
- Preference is for mains powered (110v - 240v AC, 47Hz - 63Hz) devices, although battery-powered systems may be considered

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 Thursday 30th November 2023.

Sellafield Ltd

Delivered by

FIS 360 INNOVATION I TECHNOLOGY I BUSINESS

NATIONAL NUCLEAR LABORATORY

Twitter: @GC_Innovators
Email: apply@gamechangers.technology