Sellafield Ltd

GAMECHANGERS
DELIVERING NUCLEAR INNOVATION

CHALLENGE:

Non-intrusive characterisation of legacy waste drum contents

Sellafield Ltd is seeking methods to characterise legacy waste drums that contain Plutonium Contaminated Material (PCM). The ability to determine the chemical, physical, radiological and fissile nature of the waste within the drums without opening or disturbing the drum contents is required.

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Introduction

There are thousands of legacy waste packages on Sellafield site, the contents of which will ultimately be disposed of in a Geological Disposal Facility (GDF). In preparation for disposal in the GDF, the waste must be processed into a safe and passive form suitable for long term disposal. To process and treat the waste in the most safe, efficient and cost effective way, Sellafield Ltd needs to fully understand the chemical, physical, radiological and fissile nature of the waste within the legacy packages.

This challenge is focused on legacy waste packages that contain untreated and unprocessed Plutonium Contaminated Material (PCM). These waste packages are typically 200 L mild steel drums that are currently housed in Sellafield's PCM stores. Some of these drums have reduced integrity due to degradation of the drum. Where this has occurred, the original 200 L drum is placed into a 210 L drum to ensure continued containment. These 'over' drums are known as Nova drums. All PCM was PVC bagged before being placed inside the drums. Prior to final disposal, the raw waste contents of these PCM drums will be converted to a safer, passive form in Sellafield's Waste Treatment Complex (WTC). Prior to processing in the WTC, it must be established that the PCM waste is safe enough to handle and process and that resultant waste products will be suitable for transport and disposal in a future GDF. This requires a full profile of the chemical, physical, radiometric, and fissile properties of the PCM waste in each drum.

Waste must be packaged according to the specific Conditions for Acceptance (CFA) that apply to all wastes entering the WTC. In modern times, detailed records are maintained for individual drums, but Sellafield Ltd must also deal with some populations of drums that were packaged several decades ago, even as far back as the 1950s. These pre-date modern treatment facilities and waste tracking systems; therefore, records of what those drums contain and where it came from can be inadequate for enabling treatment and disposal of the waste. The proportion of legacy waste drums with little or no provenance is significant, with numbers in the region of 5,000 to 10,000 drums. These represent several years of processing capacity by Sellafield's WTC.

Sellafield currently subjects PCM drums to X-ray imaging and radiometric assay, but this does not satisfy the full chemical and physical characterisation that is required prior to processing. The current lack of suitable methods for the required characterisation impacts on PCM store operations and prevents High Hazard Risk Reduction (HHRR) analysis of aging drums which may be in poor condition. Key to this challenge is the ability to obtain the required characterisation without opening or disturbing the contents of the PCM drums.

Current Practice

Within Sellafield's PCM stores the PCM drums are characterised by neutron counting and High-Resolution Gamma Spectrometry (HRGS) to determine the fissile and radionuclide content. However, these techniques do not provide the full characterisation of a drum's contents that is required for acceptance by the Waste Treatment Complex (WTC).

Certain restricted or excluded waste types, such as bottled liquids and non-compactable items (i.e. scaffold poles), are identified by the use of X-ray imaging. This also provides an indication of the physical nature of the contents, such as liquids, gels, powders, granules, large lumps etc. This is implemented as a screening process with technical analysts reviewing X-ray images and radiometric assay data to determine the potential presence of restricted or excluded items. This is a resource-heavy and conservative process where drums are excluded if they contain any items that can't be readily identified, particularly if they are dense. See Figures 1-6 for some examples of results obtained by X-ray imaging of PCM drums. A large number of PCM drums are deemed unsuitable due to a lack of understanding of the chemical and physical composition of their contents. Chemical species of particular interest that cannot be determined by X-ray imaging include aluminium, beryllium and graphite. Sellafield Ltd also needs to understand the chemical make-up of dusts, powders and liquids within the PCM drums.

In some cases, records can be used to obtain an adequately confident assessment of the contents of some older PCM drums. These could be waste stream records, which detail the content of waste from a particular area, or PCM drum fill records, which identify what materials are in the waste. Electronic records may also provide the year and plant of origin. However, there are still a large number of PCM drums that don't have sufficient recorded information to satisfy the Conditions For Acceptance (CFA) required by the WTC.

Figure 1: These drums potentially contain powers or granules. In the drum on the left, it appears that the contents are being held in position by PVC wrapping.

Figure 2: The container in the bottom right corner of this image appears to contain dense granules.

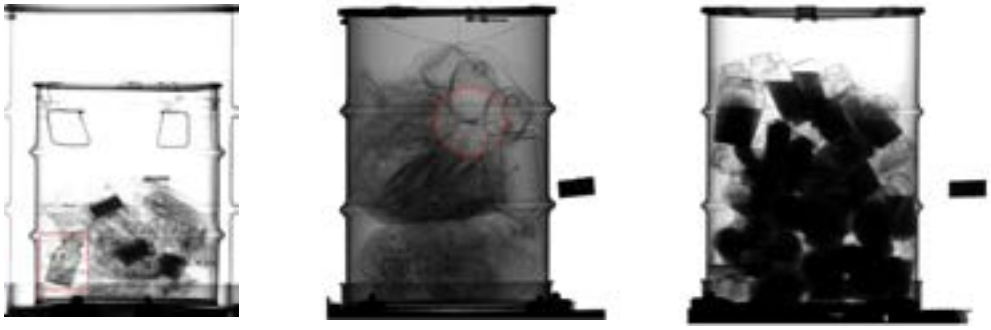

Figure 3: These drums contain bottled liquors; it is possible that the liquor in the right hand drum has set to a solid form.

Figure 4: These drums contain dense items.

Figure 5: This drum contains dust in a PVC bag.

Figure 6: This inner drum potentially contains dust with rubble at the bottom.

Challenge Aims

The following is a high-level list of the characteristics that Sellafield Ltd needs to identify or discern with regard to their PCM drums, prior to processing in its Waste Treatment Complex:

- Physical nature of the contents, such as solid lumps, powders, liquids, sludges etc
- Chemical composition of the above, with particular focus on potential explosives
- In the case of pressurised vessels, it is important to understand whether the vessels have retained their pressurisation
- Identification and quantification of reactive metal species
- Quantification of the surface area of any aluminium present
- Presence and nature of any complexing agents
- Presence and quantities of asbestos
- Presence and quantities of any neutron absorbers and reflectors, such as beryllium and graphite

Further specifications on these criteria are given in the functional requirements section of this document.

The challenge owners are willing to consider any solutions that can provide some but not all of the information required. All valid information relating to the contents of these packages is useful.

Sellafield Ltd is seeking to implement solutions within a 2- to 5-year time frame.

Benefits to Sellafield

The ability to accurately characterise the contents of its legacy PCM drums will enable Sellafield Ltd to appropriately sentence the drums for processing in the WTC. It will also inform the development of alternative waste treatment options for drums deemed unsuitable for processing in the WTC. Currently, WTC operations are limited by the availability of fully characterised waste feed. The ability to find suitable solutions to this challenge will support continued operations within the WTC, ensuring the asset remains in operation with the knock-on benefit of freeing up space within Sellafield's PCM stores.

Solving this challenge will:

- Expediate remediation and High Hazard Risk Reduction by enabling raw, uncharacterised PCM waste to be converted to a safe and passive form
- Streamline the treatment and/or disposal routes for PCM drums, with associated cost savings
- Reduce risk to operators
- Improve regulator confidence by reducing the potential hazard associated with the containment of unknown contents
- Free up resources to focus on other remediation challenges on Sellafield site
- Provide waste package characterisation techniques that could be applied to waste packages across the whole of Sellafield and the NDA estate

Constraints

The following constraints may not apply to all PCM waste packages, but are included here to give an indication of potential considerations.

- Most PCM drums are 200 L, but some are a different size and/or off-standard dimensions
- Some PCM drums have been overpacked for extra protection, the size of the overpack drums varies, but most are either 210 L, 400 L or 500 L
- Within the PCM stores, the drums are either arranged in pyramid arrays or stacked in four drum stillages. Both of these arrangements make the drums difficult to view, access and retrieve
- Any movement of PCM drums must be undertaken with extreme care and ideally in a single operation
- Techniques that require physical contact with the exterior of a PCM drum, or its overpack drum, are acceptable, providing there is no damage or alteration to the PCM drum or its overpack drum
- PCM drums may contain dense materials
- PCM drums contain a mixture of different wastes

- PCM drums are contained within radioactive environments. All drums are contact handleable, but dose rates from some drums mean exposure should be limited. Remote techniques may need to be considered
- Lighting and access to power varies between stores

Functional Requirements

- The ideal scenario is to be able to achieve full chemical and physical characterisation of each PCM drum without having to move the drum
- A single measurement in time is required, rather than ongoing monitoring
- Details of the chemistry of all of the contents of PCM drums
- Flags on the following, no matter how small the quantities:
  - Aluminium
  - Any potential explosives
  - EDTA (ethylene-diamine-tetra-acetic acid) and any other complexing agents
  - Neutron absorbers/reflectors such as beryllium and graphite
- The required sensitivity of detection and quantification accuracy depends on the substance in question. An approach of carrying out an initial screen for what is present could be undertaken, followed by subsequent quantification of any substances of interest
- The time required to obtain data from a waste package is not critical, but should take less than a couple of hours. In any case, quicker is definitely preferred
- Secure transmission and storage of data must be considered
- Output data should be reasonably straightforward to capture, store and interpret

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 Tuesday 21st January 2025.

Sellafield Ltd

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