Sellafield Ltd

GAMECHANGERS
DELIVERING NUCLEAR INNOVATION

Dounreay

CHALLENGE: Detection of organics in pipes and vessels

Nuclear site facilities go through a full cleaning process at the end of their operational life to reduce risks and hazards and, in turn, make the plant cheaper to care for and dismantle. Residual or bulk organics in vessels and pipework may lead to issues during decommissioning, for example presenting fire hazards during cutting operations of stainless-steel pipework when reducing their size.

Sellafield Ltd and Dounreay Site Restoration Limited (DSRL) are seeking ideas, innovations and technologies that will deliver game-changing improvements over the current techniques used for the **characterisation of organic residues to confirm that they have been removed to an acceptable level** in reprocessing vessels and pipework.

Applications are invited for technological solutions to meet this challenge.

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Introduction

Post Operational Clean Out (POCO) is the process that takes place when a nuclear plant has reached the end of its operating life prior to decommissioning. The aim of POCO is to reduce the risk and hazard in a facility by safely removing the nuclear and chemotoxic inventory and, ultimately reducing the lifetime cost of the redundant plants. In simple terms, it gets the plant clean, which reduces the risk and hazard and, in turn, makes the plant cheaper to care for and dismantle. It is estimated that the cost benefit of POCO could be a saving of £1.8bn across the life span of three key facilities at Sellafield. Multiple facilities across the NDA estate, including those at Dounreay, are due to undergo POCO over the next 40 years.

Residual organics are expected to be found in pipes and vessels across a wide range of facilities as a result of reprocessing, which is an organic solvent extraction process. These organics can be found in the form of solid cruds, bulk organics, or as residue in the form of heels, films and beads on associated plant furniture. In addition, organic residues may be present as films on aqueous liquors.

Access to the organics may be difficult for example the pipes, vessels and column packing in which they're found may be in high radiation areas with no permitted man access. Organics may be present where the reprocessing process has been acidic or alkaline in nature. Most of the residual organics will have associated radioactivity.

The presence of organics may present a hazard during decommissioning, particularly the risk of ignition. This risk must be reduced as dismantling reprocessing equipment could involve techniques such as flame or plasma cutting and grinding.

There is also the potential for organic material to be accumulated in vessels which may also contain acidic and aqueous liquor. Proving the absence of organic residues (or quantifying their presence) will have a significant impact on hazard reduction.

The principle organic species which need to be identified are tributyl phosphate (TBP), its breakdown products (dibutyl and monobutyl phosphate), and odourless kerosene (OK).

However, other organic species may be present. A list of the specific organics of interest can be found in the functional requirements section of this challenge statement.

Current Practice

Current POCO practice is focused on carefully sequenced washout of the plants using water or nitric acid, employing existing process equipment and techniques. Successful POCO requires the mobilisation of materials which:

- Are highly radioactive and chemotoxic.
- May be either solids, liquids, or sludges.
- Have become adhered or attached to vessel walls, process equipment and pipes.
- Have become engrained within metal vessel walls.
- Are remaining solvents within process systems.

Characterisation is critical to understanding if POCO targets have been met but this is challenging as many plants were not intentionally designed to support post-operational sampling or characterisation.

Current characterisation methods include visual inspections, collecting samples via engineered sample routes for laboratory analysis and via installed density meters which can be used to detect bulk organics in some plants.

These techniques either cannot detect small volumes of residual organic material (for example by density measurement), or cannot be deployed to confidently determine the presence or absence of organic residues in all the locations of interest (for example due to lack of access to take samples or conduct visual inspection).

Challenge Aims

Sellafield Ltd and Dounreay Site Restoration Limited (DSRL) are seeking ideas, innovations and technologies that will deliver game-changing improvements over the current techniques used for **in-situ characterisation to confirm the presence or absence of organics** in reprocessing vessels and pipework.

- **Sellafield Ltd and DSRL are not looking for solutions which focus on methods of deployment for this challenge, however there are some deployment compatibility criteria that will need to be considered. Please see the constraints section of this challenge statement.**
- Both Sellafield Ltd and DSRL are looking for solutions that can be commercialised as soon as practicably possible but accept that there may be some period of development.
- Sellafield Ltd and DSRL will support successful applicants as appropriate to put controls in place to ensure containment is maintained.

Benefits to Sellafield Ltd and DSRL

- Solutions are expected to reduce hazards and make decommissioning easier, safer, faster and cheaper.
- Organics are expected to be present in many areas of Sellafield and Dounreay. The ability to remove remnant organics during POCO will reduce the need for subsequent decommissioning activities and enable the use of some technologies that might not otherwise be acceptable. It is expected that the **resulting cost savings will be in the region of £10M's**.
- Characterisation of pipes and vessels will improve the development of safety cases for any further works in those areas by providing a starting inventory of materials found.
  - Knowledge of what organics are present and in what volume will enable fire risk calculations and risk mitigation.

Constraints

- Reprocessing facilities are made up of cells which house the pipes and vessels. These vary in nature depending on the particular stage of the reprocessing process carried out.
- Some of the cells have doors and can be accessed, but some areas are not accessible and can only be **reached via cell ports (approximately 150mm in diameter)**. These can be opened and used to deploy tools through the **cell wall (which can be up to 1.5m thick)** into the cell.
- Some vessels have open tops or engineered access ports, but many don't and would need access to be created. Therefore, the smaller and lighter the solution the better.
- This challenge does not need to solve the access and deployment challenge but does need to propose a solution that is deployable in the environment described.
- The solution should be designed with ease of decontamination in mind.
  - Solutions should preferably have demountable and possibly "sacrificial" parts of the device that might enter a vessel.
  - In-expensive and disposal parts could be an advantage.
  - All wastes must be compatible with current routes.
- There are no power supplies within the cell environment so all equipment to be used during POCO must be powered externally to the cell or independently.
- **The solution must not introduce further hazards (i.e. can't introduce source of ignition!)**

Functional Requirements

Whilst Sellafield Ltd and DSRL fundamentally share this challenge, Table 1 below separates challenge criteria into specific criteria for SL and specific criteria for DSRL. Table 1 also denotes must-have (essential) criteria and those that are nice-to-haves (non-essential).

Table 1 - Criteria matrix

	MUST HAVE		NICE TO HAVE	
Criteria	**SL**	**DSRL**	**SL**	**DSRL**
A method that can be deployed in-situ	✓	✓		
Presence of organic (yes or no?)	✓	✓		
Detection in vessels and pipes of different shapes and sizes	✓	✓		
Can be deployed internally or externally to the vessel/area of interest	✓	✓		
Small and light enough to be deployed via an inspection port (approximately 150mm diameter)	✓	✓		
Full identification of substances			✓	✓
Characterisation of the chemical class of substances (e.g. phosphate containing)			✓	✓
Estimation/characterisation of concentration levels of substances			✓	✓
Detection of residual organics			✓	✓
Identification of the interface between organics and aqueous and its location			✓	✓
Estimation of volumes above and below the interface			✓	✓
Will operate in liquids that which may contain amorphous colloids/cruds/sludges			✓	✓

Organics that may be present and are of interest to be detected include, but are not limited to, odourless kerosene (OK), tributyl phosphate (TBP), dibutyl phosphate, monobutyl phosphate and dibutoxydiethylether.

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/