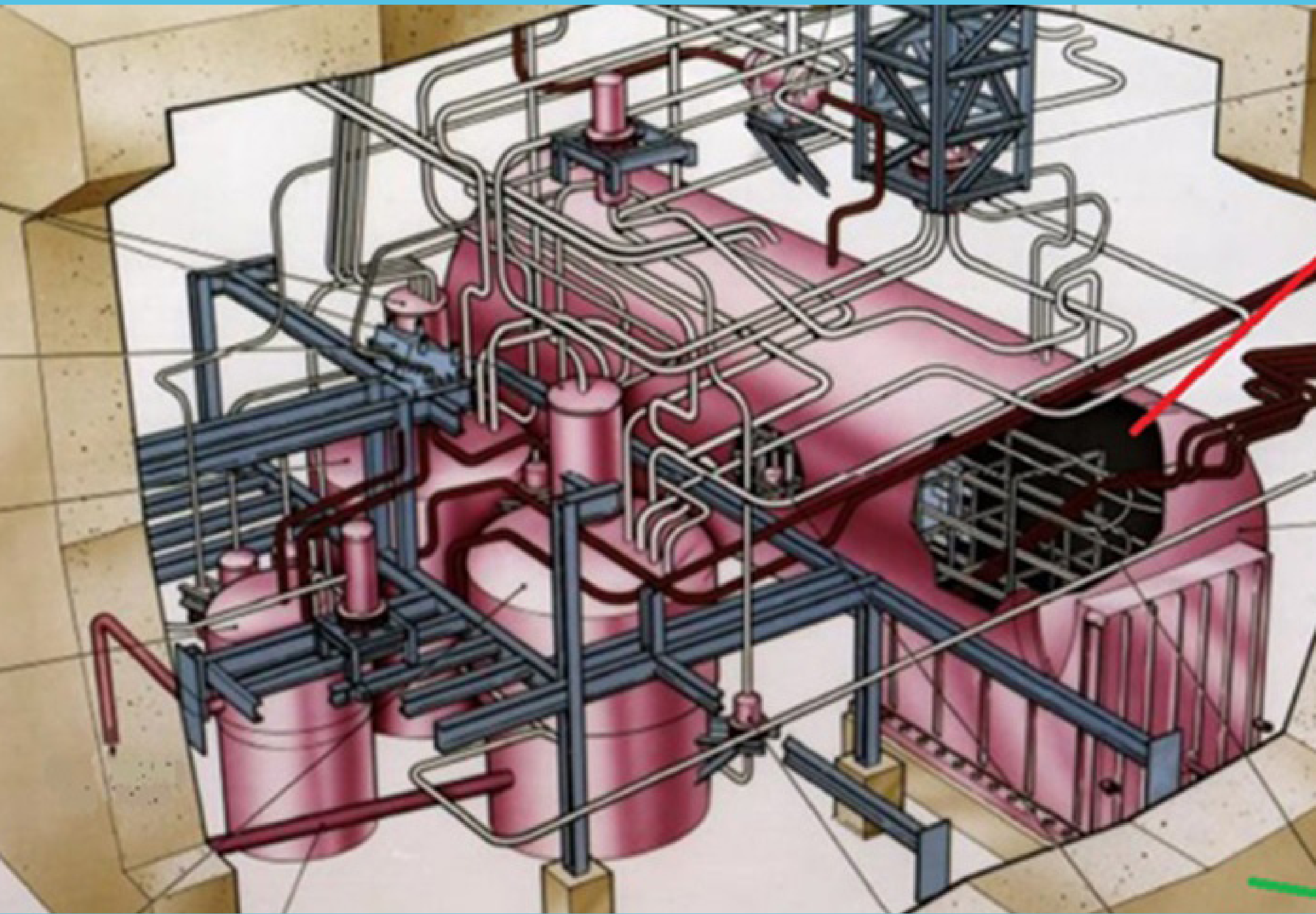

CHALLENGE: Directional decontamination head deployment into large, congested, highly radioactive vessels

Sellafield Ltd is seeking innovative solutions that will deliver improvements over the current techniques used for deploying vessel cleaning heads into large, highly radioactive vessels with complex internal configurations.

Introduction

For most of its existence, the main business focus of the Sellafield site in West Cumbria has been nuclear reprocessing. Reprocessing activities have come to an end and preparations have begun to transition into a Post Operational Clean Out (POCO) phase.

POCO is the process that takes place when a nuclear plant has reached the end of its operating life. It reduces the risks and hazards in a facility by safely removing the nuclear and chemotoxic inventory. In simple terms, it gets the plant as radiologically clean as it can be, making it less expensive to care for.

This challenge focuses on large, highly radioactive vessels that need to be cleaned internally. The vessels occupy volumes of between 30 cubic metres up to 200 cubic metres with background radiation levels of up to 1 Sv/hr. The vessels cannot be internally or externally accessed by humans but small access ports can be created, through which technology can be deployed to clean/decontaminate them internally. The vessels are contained within thick concrete cells which provide radiation shielding. Access is achieved by going through an inspection port in the cell wall or roof, then through an additional access port in the vessels themselves (see Figure 1 for an example cutaway view of the challenge). The vessel access port is accessible from a rooftop several metres above and therefore any long-reaching tool needs to reach a distance of between 5m to 10m in order to reach the vessel access port (see Figure 2 as an example of typical access through a cell roof). The access ports are typically 150mm in diameter and for the purposes of this challenge, assume a direct line between the cell access port and the vessel access port.

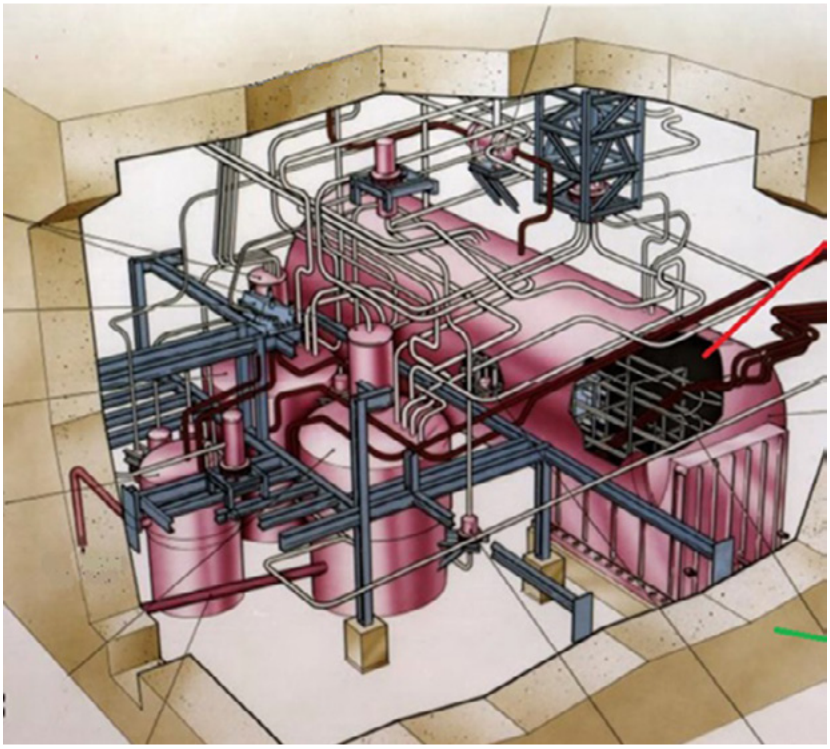

Figure 1: Cutaway view showing complex internals inside a vessel inside a cell

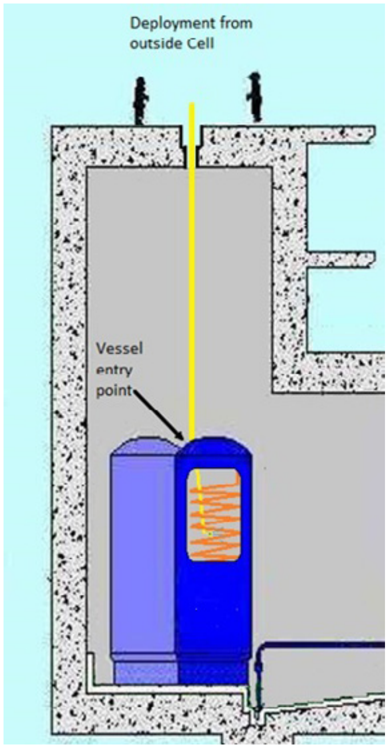

Figure 2: Vertical vessels in cell schematic demonstrating potential access route through cell and into vessel from above

The vessels contain complex internal structures (see Figures 3, 4 and 5 for examples) which can include:

- Cooling / heating coils.
- Fluid mixing and transfer devices.
- Instrument dip-legs.
- Internal vessels such as solvent float-off vessels.
- Pipe support brackets.

All of these internal structures require full surface decontamination. Any tool deployed to clean these internal structures would need to be able to navigate around them whilst cleaning them.

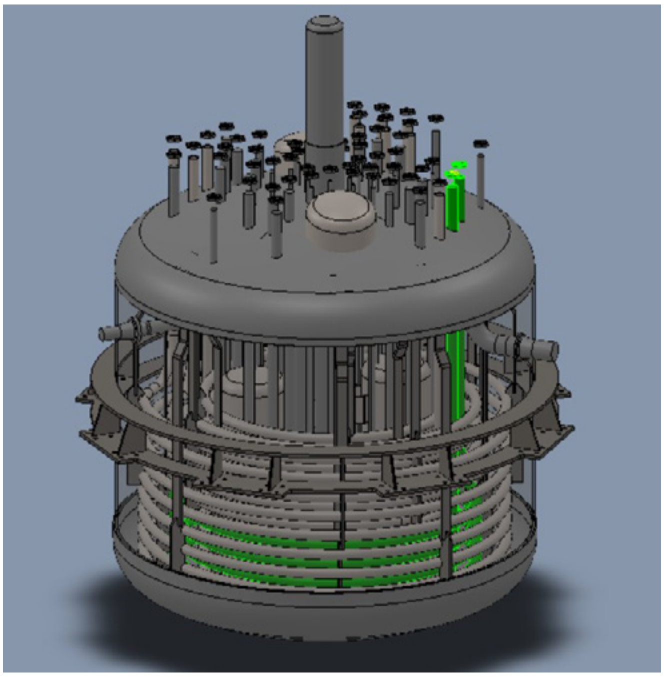

Figure 3: Cutaway of vessel showing internal pipes and coils

This challenge is looking for technology which can deploy a jetting nozzle/cleaning heads to spray the internal surfaces within a large, difficult-to-access vessel containing complex internal architecture.

Sellafield Ltd is seeking innovative solutions that will deliver improvements over the current techniques used for deploying vessel cleaning heads into these vessels which have complex internal configuration (see Figures 3, 4 and 5 for examples of internal structures). The cleaning heads could be used to deploy ultra-high and

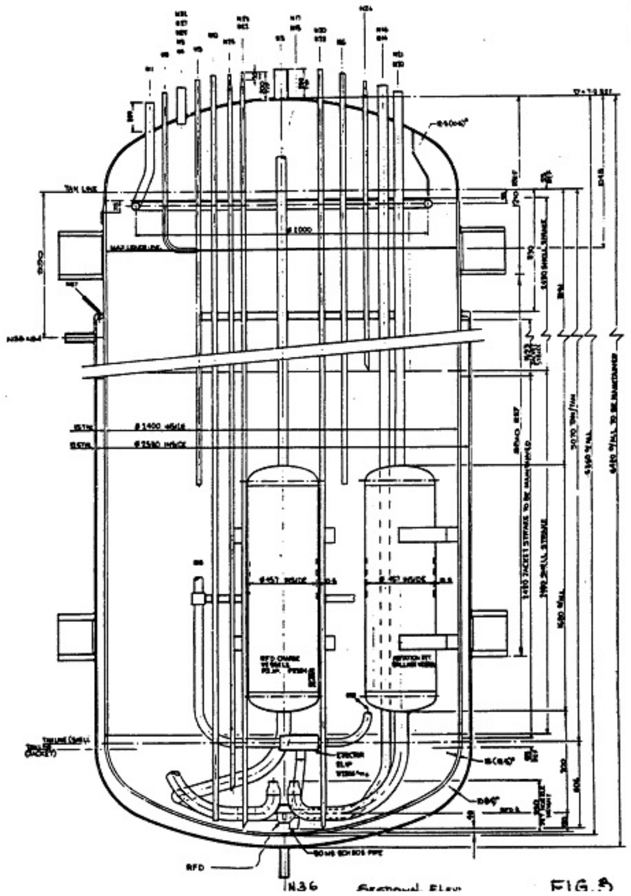

Figure 4: Typical vessel internals side elevation

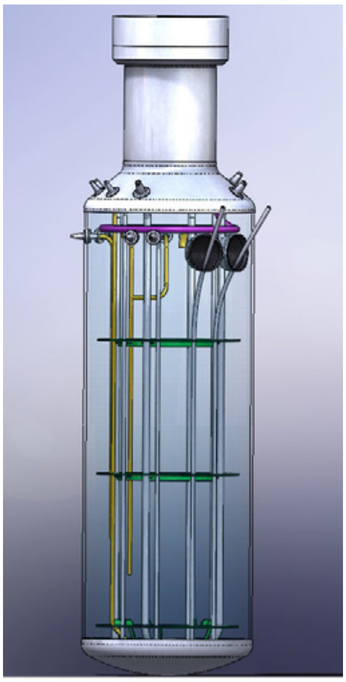

Figure 5: The internal pipework within a dissolver vessel

high-pressure water jetting or spray nozzles to deploy decontaminating chemicals and foams.

POCO plans for cleaning the vessels include washes with chemicals already used elsewhere on plant, such as water and nitric acid. However, experience with other facilities suggests that after these washes, radiation levels are still several orders of magnitude too high for human 'hands-on' dismantling of process equipment. More aggressive decontamination techniques are required to strip off the protective oxide layer and a proportion of the metal substrate on the stainless steel process equipment.

Ultra-High Pressure Water Jetting (UHPWJ) is being considered, as water is the only effluent produced, which is entirely compatible with downstream effluent treatment plants. However, to remove the surface from the metal, the jetting nozzle needs to be 50 to 100mm from the metal surface, with a jetting angle of between 30° and 45°.

Cleaning heads could also be deployed with electrochemicals and/or aggressive oxidising agents, which can chemically strip the oxide film. Use of these agents could enable full surface coverage to be achieved with a stand-off distance of a few metres.

Current Practice

Access to the vessels is restricted as they are inside thick concrete cells which provide radiation shielding. Cells usually have access points via inspection ports, which are typically 150mm in diameter.

Most vessels do not have any internal access ports, but where there is access, manually deployed pressure washing has been shown to remove loosely adhered contamination; however, this cleaning method is not aggressive enough to remove ingrained radioactivity strongly bound on or in the surface of the metal.

Methods are being developed to remotely cut additional access penetrations into the vessels via the cell inspection ports. This would allow a removeable access plug to be fitted, through which any technological solution could be deployed.

Challenge Aims

Sellafield Ltd is looking for technology that can deploy an ultra-high pressure water jetting (UHPWJ) head or other tools into a vessel that can:

- Cover the full internal surface of the vessel including internal pipework and structures.
- Operate from a nozzle to surface metal distance of 50mm to 100mm.

The aim is to decontaminate the vessel by removing the entire internal surface layer of metal.

Access into the vessel is achieved via 150mm inspection ports that pass through the 1.5m thick concrete cell wall, then through a 150mm diameter access port on the metal wall of the vessel itself.

Technology is being developed to cut an access port into a vessel and then fit a removable access plug through which any technological solution could be deployed.

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.

Aggressive chemicals can be deployed by filling the entire vessel undergoing POCO; however, this produces unacceptable volumes of effluent. The ability to spray chemicals onto the internal surfaces of the vessel would use less of the reagent and reduce the effluent challenge. Ultra-high pressure water jetting (UHPWJ) or electrochemical methods would remove the need for reagents, if the deployment challenge can be solved.

Benefits to Sellafield

- By enabling POCO to achieve the removal of all radioactive contamination from these vessels, subsequent decommissioning operations can be achieved more safely, quickly and at a much lower cost.
- It is estimated that the cost benefit of POCO could be a saving of £1.8 billion across the life span of three key reprocessing facilities at Sellafield.

Constraints

- The interior of vessels that require decontamination are often highly complex and congested.
- Some of the cells are not man accessible and can only be **accessed via cell ports (150mm in diameter)**.
- The cell ports can be opened and used to deploy tools through the **cell wall, which can be up to 1.5m thick**.
- These cells tend to be congested with pipes and vessels (see Figure 6) and in many cases the vessel you want to access **is several metres away** from the cell access port.
- 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.
- Active residue remains within vessels and pipes (typically dose rates of up to 1 Sv/hr). These rates mean that only remote handling is possible.
- Access to the vessels is restricted; the vessels are located within shielded cells constructed from 1.5m thick concrete. No human access is possible and there is no visibility to the inside of vessels.
- Access to the vessels must be through 150mm diameter ports cut into the top of the vessel. It is possible to fix onto the vessel at the location of the access port.
- Vessels are typically 10mm to 25mm thick stainless steel. Navigation to the associated vessels and pipework within the cells is through congested environments (see Figure 4 for a typical top view of a vessel from within a cell).
- Assume for this challenge that there is a direct line between the access port in the cell and the access port in the vessel.
- **Power Supplies:** There are no power supplies within the cell environment so all equipment used during POCO must be powered externally to the cell or independently.
- The UHPWJ nozzle needs to operate within a nozzle-to-surface distance of 50mm to 100mm, so that the entire internal surface can be decontaminated by removing the surface layer of metal.
- The vessels are very large and can occupy volumes of between 30 cubic metres, up to 200 cubic metres.
- The vessel access port is accessible from a roof top several metres above and therefore any long reaching tool needs to reach a distance of between 5m to 10m in order to reach the vessel access port.

It is acceptable to fix onto the vessel via this access port to support any device or tool being deployed.

Figure 6: Top view of a vessel in cell, showing pipes entering the vessel

Functional Requirements

This challenge is looking for technology which can deploy a jetting nozzle to spray the internal surfaces within a vessel containing complex internal architecture.

- The internal architecture of the vessel could be pipework or other structures, all of which needs to be cleaned/decontaminated, in addition to the vessel's main internal surfaces.
- The jetting nozzle should, ideally, have a stand-off distance of 50mm to 100mm and deploy an ultra-high pressure water jet (UHPWJ). However, if this stand-off distance is not achievable then the proposed achievable distance should be stated as other cleaning technologies use larger stand-off distances.
- Access to the vessel is via a 150mm diameter port into a cell and then via another 150mm port into the vessel, with an assumed straight line between these two access ports.

- There is no visibility inside the vessel – they are dark and so any solution may need a light source and a camera attached to it.
- The technology should be able to navigate the complex internal structure, e.g. by scanning the vessel internals to map their 3D configuration.
- The technology should control an arm to deploy a jetting head to give full coverage of the internal surfaces; though, other methods of getting a jetting head to the internal surfaces will be considered.
- It is possible to create more than one vessel access port to the vessel.
- The vessel selected is around 6.4m tall and 2.5m diameter with tori-spherical dished ends. The vessel contains various pipes and some smaller internal vessels for instrumentation, liquor transfer and agitation. See Figure 4 for a side elevation drawing of a typical vessel which shows the internal pipework and instrumentation.

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 2pm on Wednesday 21 August 2024.

Assessment questions for this challenge can be found on the challenge webpage.

Sellafield Ltd

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