INL - NNL an International Technology Collaboration Case Study - Advanced Fogging Technologies for Decommissioning – 13463

Anthony Banford*, Rick Demmer**, Jeremy Edwards *, Richard Rankin**, and Jeremy Hastings***

* National Nuclear Laboratory, 5th Floor Chadwick House, Birchwood Park, Warrington WA3 6AE, United Kingdom, anthony.w.banford@nnl.co.uk

** Idaho National Laboratory, Idaho Falls, ID 83401, United States*** National Nuclear Laboratory, Central Laboratory Sellafield, Seascale, Cumbria CA20 1PG, United Kingdom

ABSTRACT

International collaboration and partnerships have become a reality as markets continue to globalize. This is the case in nuclear sector where over recent years partnerships commonly form to bid for capital projects internationally in the increasingly contractorized world and international consortia regularly bid and lead Management and Operations (M&O) / Parent Body Organization (PBO) site management contracts. International collaboration can also benefit research and technology development. The Idaho National Laboratory (INL) and the UK National Nuclear Laboratory (NNL) are internationally recognized organizations delivering leading science and technology development programmes both nationally and internationally. The Laboratories are actively collaborating in several areas with benefits to both the laboratories and their customers. Recent collaborations have focused on fuel cycle separations, systems engineering supporting waste management and decommissioning, the use of misting for decontamination and in-situ waste characterisation. This paper focuses on a case study illustrating how integration of two technologies developed on different sides of the Atlantic are being integrated through international collaboration to address real decommissioning challenges using fogging technology.

INTRODUCTION

The globalization of world markets has led to increasing international cooperation and partnering to deliver large scale projects. The nuclear industry has many examples of organizations from different continents joining forces to deliver major projects, from construction of new power reactors through to decommissioning and cleanup of shutdown plants.

Technology development is another area where collaboration between international organizations with common goals and complimentary capabilities can lead to significant benefits. The Idaho National Laboratory (INL) and UK National Nuclear Laboratory (NNL) have collaborated internationally over many years. Key areas for collaboration have included research on fuels cycles, nuclear graphite and the application of systems engineering approaches to support waste management and decommissioning programmes. A more recent collaboration has been established in 2012 to develop fogging (or misting) as a technology that can support decommissioning operations. This international collaboration case study and the first phase of the development work is the focus of this paper

BACKGROUND

One important challenge during the decommissioning of radioactive facilities is the prevention of the spread of airborne contamination. This is more serious for areas where large accumulations of radioactive dust and lint are present, such as disposal site exhumation, laundry facilities, exhaust ventilation ducting and exhaust stacks.

In a recent demolition of large ventilation ducting (about 3m cross section and 30m long) at Brookhaven National Laboratory a spray coating was applied to the duct from inside using a painter dressed in anti-contamination clothing and an airline respirator system. Other examples abound where a large quantity of personal-protective-equipment is required to mitigate airborne contamination hazards in the D&D arena. The estimated loss of productivity typically exceeds fifty percent on most projects requiring respiratory protection, not to mention the use of costly equipment and controls.

In separate efforts, both the Idaho National Laboratory and the National Nuclear Laboratory have developed compatible technologies to solve this difficult problem. The INL team, under a U. S. Department of Energy research grant developed a new type of contamination capture coatings that could be fogged into dusty areas and ductwork. This fog, dubbed FX1, behaves similarly to a gas; it can be introduced into ductwork at low pressure and low velocity. It is a sophisticated solution containing a sticky base and a surfactant which increases the penetration and capture of dust and lint.

The NNL team has been working on the application of atomization technology to develop a superior fog-based delivery system for decontamination reagents, and coatings. These two technologies, though developed independently, have been brought together through a desire by both organizations to maximize the benefits of collaborative research and development.

DEVELOPMENT OF FX1 AND PREVIOUS EXPERIENCE

Laboratory tests performed on FX1 compared the criteria of wetness, stickiness, dustiness and penetration, and compared performance with the conventional glycerin fogging technique. A field demonstration of FX1 was performed late in February 2007 at the INL in a 6 ft x 6 ft x 4 ft (approximately 1.8m x 1.8m x 1.2m) waste container. A 6 hr test was planned, but was cut short to 1.5 hrs because of problems with the currently available, ultrasonic powered fogging equipment. Whist ultrasonic equipment is apparently not capable of long term use with high solids, aqueous solutions; the results showed that the solution produced a good fog with good penetration of dust coupons. Similar laboratory testing of this solution at 1.5 hrs, 4 hrs, 8 hrs and 16 hrs confirmed the short test results and showed that longer periods, of at least 4 hrs, produce superior penetration, binding and dust control compared to the baseline glycerin based solutions.

The potential benefits associated with establishing an effective mechanism for delivery is a significant increase in worker safety and a reduction in worker controls through reducing the risk of suspended or resuspended airborne contamination. It would also eliminate the time consuming need to pre-clean or coat ductwork with multiple applications; it accomplishes more in a shorter time with less work and cost than the baseline coating/capture techniques.

ATOMISATION TECHNOLOGY DEVELOPMENT

The atomization technology available via the UK National Nuclear Laboratory offers a 'game changing' delivery mechanism for reagents, fixatives and decontaminants. This potential was identified through the National Nuclear Laboratories work within the Chemical, Biological, Radiological and Nuclear (CBRN) response arena, where the laboratory has been using its expertise in waste characterization, waste management, and decontamination to inform on potential post terrorist-incident recovery.

The atomization technology has its roots in the development of marine drive systems, and was subsequently developed by the technology owners *PDX Limited* for applications including sterilization, decontamination, and health care. The NNL recognized the potential for the technology to have numerous hazard mitigation applications within the nuclear industry, notably the knock-down and tie-down of airborne and other particulates which present significant hazards during both routine operations and decommissioning activities.

The technology utilizes the convergence of compressed air, and the solution (e.g. a decontamination reagent) through the atomizer head, within which rapid acceleration and impact of the two streams occurs, leading to atomization of the solution into an ultra-fine mist. The geometry of the unit is configured to provide a planar 360 degree exit, through which the mist exits at speed (Figure 1). In operation, the mist is initially projected laterally, in a cascade.

The maintenance of the high air flow generates a turbulence that maintains the movement and buoyancy of the mist. It is this turbulence that ensures the droplets disperse throughout a space and interact with both the line of sight and non-line of sight surfaces. Non-line of sight surfaces are those which in a typical spray scenario would not be wetted, e.g. the underside of horizontal surfaces, the reverse sides of objects from the spraying location. It is this ability to effect such non-line-of-sight coverage/delivery that makes this technology such a step-change in capability.

A single atomizer can be placed within a cell and within minutes deliver an ultra fine coating to all surfaces. An activity which would otherwise require a manned-entry, the erection of scaffolding to reach ceiling and upper walls, the movement of objects to permit access to the reverse and undersides of objects.

Figure 1:360° atomizer

TESTING PROGRAMME

A two phase testing programme was established with the initial intent to determine FX1 compatibity with the PDX™ atomisation technology based upon a series of spraying trials at NNL facilities in the UK in 2012-13. Following confirmation and optimization, an active trial is scheduled within an INL facility in the future. The initial tests are described below.

On the assumption that the viscosity of FX1 is similar to that of water under ambient conditions, initial trials were performed using water as a substitute for FX1 to optimize the test facility and to establish the correct protocols for atomizing with the FX1. Using a single PDX 360° nozzle, three trials were carried out to assess its ability to effectively fill a pre-defined volume within the test chamber shown in Figure 2

Figure 2- The 180m^3 fogging test chamber

- The entire chamber (180 m3) 10 x 6 x 3 m
- Half the chamber (90 m3) – the chamber divided into two, using PVC sheeting to create two halves, measuring 5 x 6 x 3 m.
- A quarter of the chamber (45 m3) – one of the two halves divided into two using PVC sheeting to create two halves measuring 5 x 3 x 3 m.

For each test, the PDX 360° nozzle was placed in the centre of the chamber section, approximately 0.3 m below the ceiling to maximize the benefit of the Coanda effect (ability of the mist to adhere to the ceiling before falling to the floor) between the gas and atomized water exiting the nozzle and the chamber ceiling. Typically, the water/air ratio to the nozzle was 1:1. During atomization of the water trials, the ventilation was set at the maximum to determine whether the mist created by the atomizer would remain stable.

Further trials were performed using FX1 in the 45m^3 chamber to test performance of the coating various targets, both line of sight and non-line of sight. The targets including metal, plastic, wood and brick were arranged to allow in-line and non-line of sight surfaces to be tested (Figure 3 and 4). To assess tie-down of particulate, a tray containing fine particulate (powder <100 µm) was placed on the floor. Pre-weighed Petri dishes were also placed around the enclosure to assess distribution of FX1 by mass.

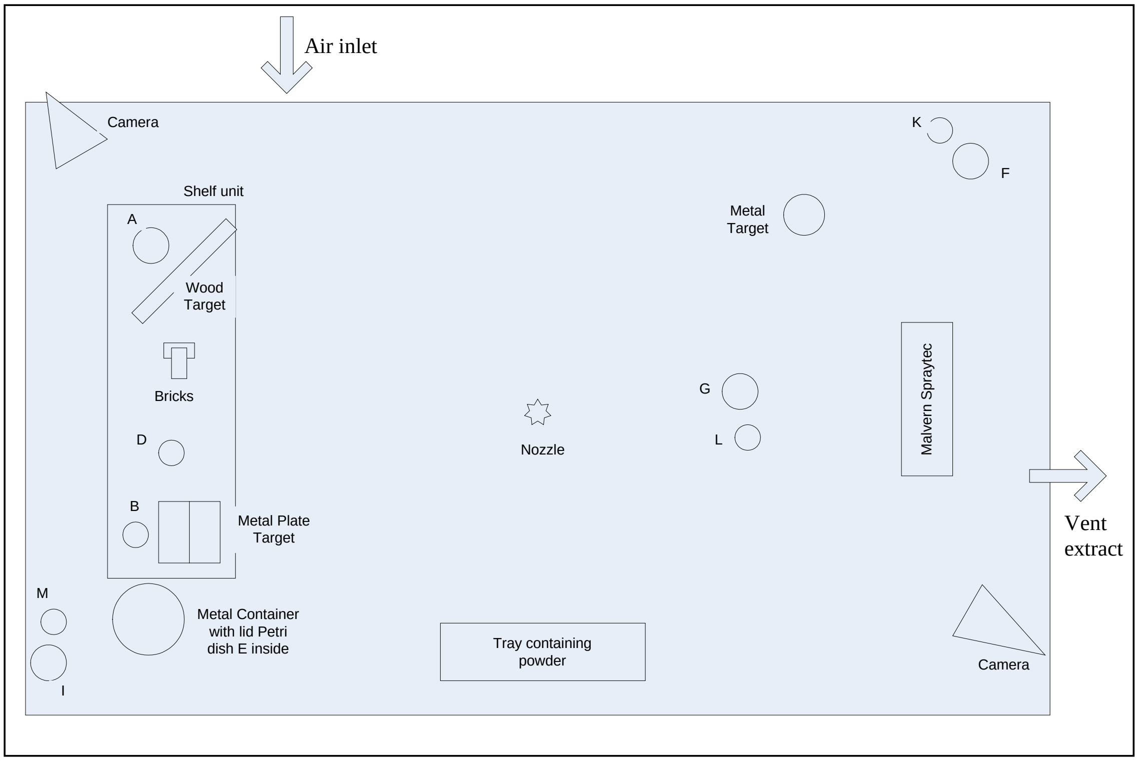

Figure 3: Plan of enclosure showing position of equipment and targets

Figure 4: Objects for line of sight / non-line of sight testing

INITIAL RESULTS

The water trials demonstrated that the technology was capable of filling a room up to 180 m3 (under forced ventilation up to 4m^3/min) with a stable mist within one minute of operation. The PDX 360° nozzle was effective in atomizing the FX1 and forming a stable mist filling a 45m^3 room within a minute of starting operation which demonstrates its compatibility with FX1.The mist that formed was stable under forced ventilation and a significant mist remained in suspension at least 5 minutes after switching off the nozzle.

Fine particulate (powder <100 μm) placed in trays on the floor were effectively tied down to a solid with the FX1 (Figure 6).These initial results have demonstrated that there is potential in further development and optimization of this technology. This will be conducted in the next phase of the programme.

Figure 5 Images of the chamber after 10s and 90s fogging

Figure 6 Tray of powder coated with FX1 during fogging chambers trials

CONCLUSIONS

The initial trails of this combination of two technologies have confirmed their compatibility and the potential to offer a new approach to the management of airborne contamination during some decommissioning operations. The associated benefits to operations and safety of remotely applying these coatings are significant.

Having confirmed the approach in the initial trials, the phase of the development will focus on the optimization of the system, in terms of composition, operation and deployment. Beyond this the plan is for an active trial at INL.

International collaboration on this project has worked well and is allowing both organizations to progress with the technology development at pace and build on the strengths of both organizations and with a strong focus on both US and UK decommissioning challenges.