

SENSOR TECHNOLOGY INTEGRATION FOR EFFICIENT AND COST-EFFECTIVE D&D

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ABSTRACT

The deactivation and decommissioning of radiologically contaminated facilities require the use of a multitude of technologies to perform characterization, decontamination, dismantlement, and waste management. Current baseline technologies do not provide adequate tools to perform this work in an efficient and cost-effective manner. Examples of such tasks that can be modified to enhance the D&D work include: floor and wall decontamination, pipe decontamination, and surveillance and monitoring. FIU-HCET's Technology Development, Integration and Deployment (TDID) group aims to enhance the D&D process by integrating sensor technology to existing decontamination and remote surveillance tools. These integrated systems have been demonstrated throughout the DOE Complex and commercial nuclear facilities undergoing decommissioning. Finding new ways of integrating technologies utilized in the decommissioning and surveillance & monitoring process has been a goal of this group during the past several years. Current and previous integration projects include: Mobile Integrated Piping Decontamination and Characterization System, On-Line Decontamination and Characterization System, In-Situ Pipe Decontamination and Unplugging System, Remote Hazardous Environment Surveyor (RHES), and the Online Handheld grit blasting decontamination system

As a result of integrating sensors with D&D tools, the resulting technologies have removed the downtime currently found in baseline processes by allowing operators and project managers to have real-time contamination data during the specified D&D process. This added component allows project managers to verify that full decontamination and surveillance has been conducted. Through successful demonstration and deployments of the TDID-developed technologies, FIU-HCET has provided tools that can impact the cost, schedule and health and safety of D&D operations in a positive way, leading to shorter downtimes and significant cost-savings. This paper will discuss the development of technologies currently modified with sensor technology by the TDID group, from conceptual design to Deployment at a DOE or commercial nuclear facility. Cost information associated with the respective technology will also be discussed.

INTRODUCTION

The deactivation and decommissioning of 10,000 buildings in the U.S. Department of Energy (DOE) complex will require the disposition of miles of pipe and millions of cubic meters of concrete. These situations require systems capable of decontaminating as well as characterizing pipes and concrete. Current systems require individual application of characterization and decontamination, which in turn requires cessation of decontamination while characterization surveys are carried out. HCET aims to find innovative solutions to D&D problems encountered throughout the DOE complex and commercial nuclear facilities undergoing decommissioning. To date, several tools and sensors have been integrated by HCET to the technologies listed below:

- Mobile Integrated Piping Decontamination and Characterization System
- Integrated Floor Decontamination and Characterization System
- Integrated Vertical and Overhead Decontamination and Characterization System
- Handheld Integrated Grit Blasting and Monitoring System

During the last three years, HCET researched new tools and sensors that have become part of various technologies that have been, or will ultimately be, deployed at facilities such as Los Alamos National Laboratory, Connecticut Yankee, Rancho Seco and other DOE and commercial utilities sites.

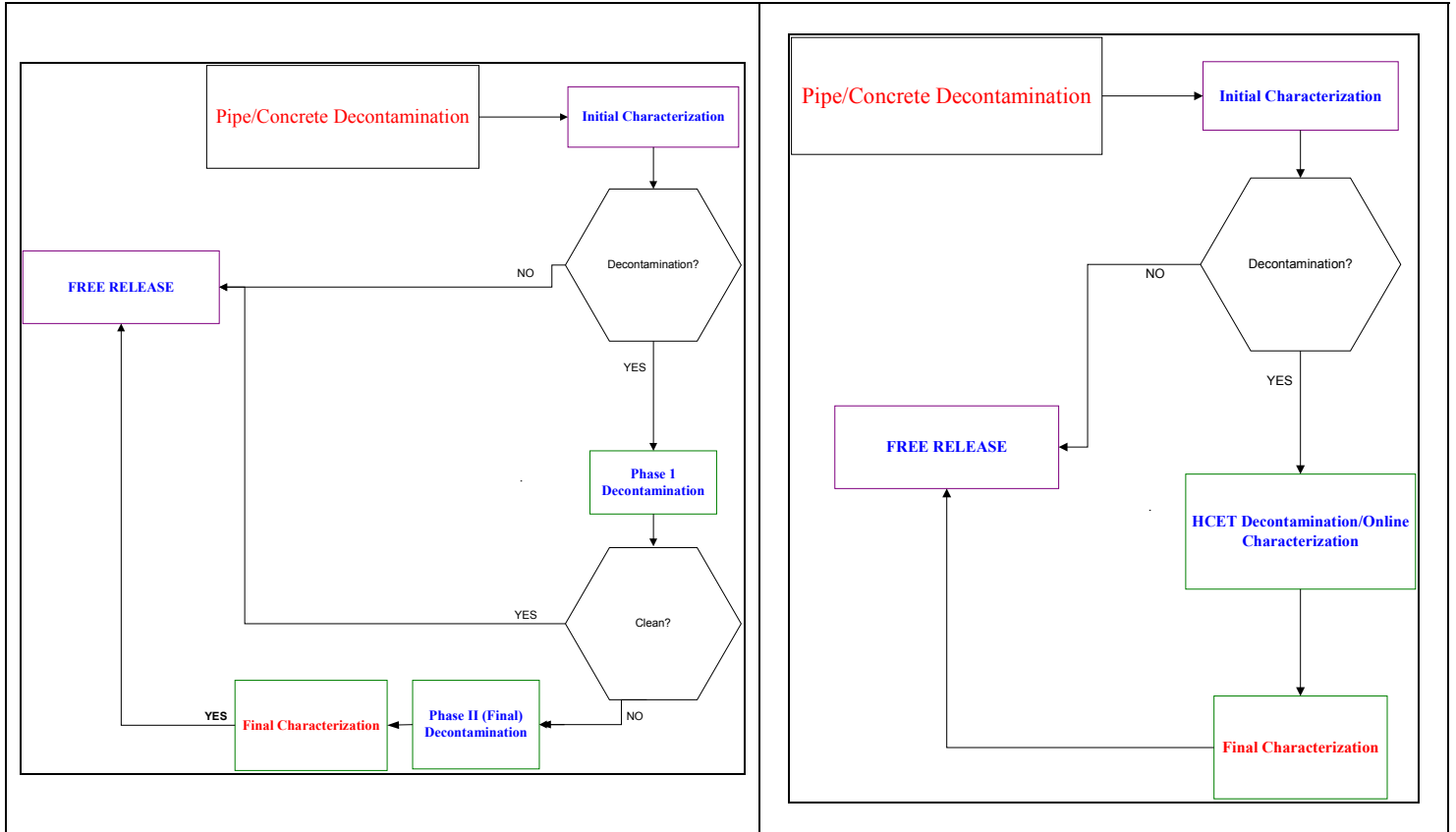


Table I. Decontamination Flow Diagram for Concrete and Piping. Right: With the use of HCET-developed technologies time and cost-savings are immediately reduced.

TECHNOLOGY INTEGRATION PROJECTS

Mobile Integrated Pipe Decontamination and Characterization System (MIP-DCS)

The Mobile Integrated Pipe Decontamination and Characterization System (MIP-DCS) can decontaminate, characterize, and segregate piping and structural steel with little or no human interaction. Since most of the pipes are contaminated both internally and externally, there was no existing decontamination system usable as a solution. The MIP-DCS is capable of decontaminating pipes internally and externally. Thus, MIP-DCS avoids the other options of disposal of contaminated piping, which are labor-intensive and involve large costs. The MIP-DCS developed at HCET is composed of decontamination, ventilation, characterization, and off-loading modules. The system was demonstrated at Consumer Energy’s Big Rock Point Facility (BRP) in Michigan on April 7, 2000, as part of the cooperative efforts between the utility industry and the DOE.

Figure 1 indicates the layout of the different modules of the MIP-DCS.



Fig 1 MIP-DCS System – Module Layout

The pipes or structural elements to be cleaned are loaded onto the entrance conveyor of the decontamination module, which forwards the contaminated pipe to a centrifugal wheel grit blast chamber for external pipe decontamination.

A ventilation module equipped with a dust collector and nuclear-rated HEPA filtration system supports the decontamination module, ensuring operations are performed under negative pressure. The conveyor then transfers the pipe or structural element to a second station where the pipe is lifted, rotated, and blasted by using a compressed air lance for internal pipe decontamination. The pipe or structural element is then transferred to a characterization module capable of measuring reactor and uranium contaminants [2]. The module also detects whether the pipe is completely clean and sends the signal to the off-loading module.

The last of the modules is the off-loading system that receives the pipes from the characterization module and segregates the pipes based on signal received from the characterization module.

Integrated Floor Decontamination and Characterization System (IF-DCS)

The Integrated Floor Decontamination and Characterization System (IF-DCS) is a prototype system consisting of decontamination technology capable of cleaning concrete floor and a characterization technology capable of carrying out in-process measurement of the extent of the decontamination. The IF-DCS is composed of a decontamination technology, characterization system, and waste collection vacuum system. Figure 2 shows the IF-DCS. The decontamination technology used is the electrically powered, self-propelled, portable centrifugal shot-blasting unit. The unit has a blast area of 13.8 inches (350mm) and is capable of removing 1/4 inch of concrete by mechanical abrasion. The characterization system consists of two large-area (6in × 4in) gas proportional detectors, with one in front of the shot blast chamber and the other behind the chamber, all mounted at a distance of 2" from the floor. The detectors have an efficiency of 1% for γ , 10%-30% for β , and 0-100% for α radiations. A computer and a flat panel display, mounted on the machine, display the count rate from both detectors for a real-time measurement of decontamination. A custom software application developed by HCET controls the supporting modules and calibrates the detectors based on the work area.



Fig 2 IF-DCS Side View

Integrated Vertical and Overhead Decontamination and Characterization System (IVODS)

FIU-HCET has designed and developed an integrated decontamination and robotic deployment system for removing layers of concrete from wall, ceiling and floor surfaces as well as removal of coatings from metal surfaces, combined with a real characterization information system. A decontamination system (a remote-controlled free-climbing robot) was designed using a shrouded concrete shaving decontamination unit. The decontamination system employs a self-propelled remote joystick-operated robotic deployment system. Adhesion to the surface is achieved by using negative pressure, enabling the robot to perform on vertical, horizontal and overhead surfaces. This system is also equipped with a waste collection and handling system rated for nuclear use. This waste system is a closed loop system able to capture the waste scabbled from the surface. The captured waste is sent to a waste collection system equipped with an ultra-high performance HEPA vacuum system. A controlled seal drum fill system allows the operator to fill, seal, remove and replace the waste drum under controlled vacuum conditions, thus minimizing the risk of releasing airborne contamination and exposing the workers to possible contamination. The decontamination, robotic deployment and waste collection systems are integrated to perform decontamination activities on vertical, horizontal and overhead concrete, brick and metal surfaces.



Fig 3 IVODS View

Handheld Integrated Grit Blasting and Monitoring System

This work focused on redesigning and improving LTC America's existing vacuum blasting technology including blasthead nozzles, ergonomic handling of the blasthead by reducing its weight, brush-ring design, vacuum level regulator, efficiency of the dust separator, and operational control sensors. The redesign is expected to enhance the productivity and economy of the vacuum blasting system by at least 50 percent over current vacuum blasting systems. The actual cost of decontaminating a given area will, of course, be dependent upon the coating being removed, the shape of the surface, and the accessibility afforded to the operators of the vacuum blasting equipment.



Fig. 4 Blasthead with radiological and proximity sensors

TECHNOLOGY INTEGRATION DEMONSTRATIONS/DEPLOYMENTS

Big Rock Point

The MIP-DCS was demonstrated using contaminated 8-inch-diameter carbon steel and 17-inch-diameter stainless steel pipes. The pipes processed ranged between 5 feet to 7 feet in length. A total of 90 linear feet of pipe was processed with a total surface area of 655 ft². The total weight of the pipes cleaned by the system was approximately 10,000 pounds.

Pre-decontamination and post-decontamination radiological surveys were collected by BRP's Health Physics (HP) personnel using a hand-held frisker and by taking smears for gamma analysis in the laboratory. Pipe contamination data were also collected by MIP-DCS's characterization module and compared to the manual swipe collection.

The production rate obtained for the 8-inch-diameter carbon steel pipes averaged 0.17 ft/min. (pipe length considered is double the actual length since the pipes were decontaminated both externally and internally). The production rate obtained for 17-inch stainless steel pipes averaged 0.14 ft/min.

The total radioactivity readings varied among the different pipes processed. Total radioactivity levels for a carbon steel pipe were 10,000 dpm/100cm² (hand-held frisker) before decontamination and <5,000 dpm/100cm² after decontamination. The corresponding readings taken by MIP-DCS's characterization module averaged 16,000 dpm/100cm² before decontamination and 326 dpm/100cm² after decontamination

Total activity for stainless steel pipes was 750,000 dpm/100cm² (hand-held frisker) before decontamination and 60,000 dpm/100cm² after decontamination. For the same pipe, the MIP-DCS recorded an average of 54,464 dpm/100cm² after decontamination. The decontamination factors (DF) computed from the characterization data are 50 and 14, respectively, for the above-mentioned pipes.

Rancho Seco

The IF-DCS was demonstrated in the turbine-generator building of the Rancho Seco Nuclear Power facility in California from May 8 to 18, 2000, as part of cooperative effort between DOE-NETL, EPRI, and some other commercial companies. HCET personnel trained Rancho Seco staff in the operation of various subsystems during the first week of demonstration. The actual demonstration commenced during the second week, with trained Rancho Seco personnel handling the system operations. Figure 5 shows the demonstration of IF-DCS in progress at the Rancho Seco nuclear facility.

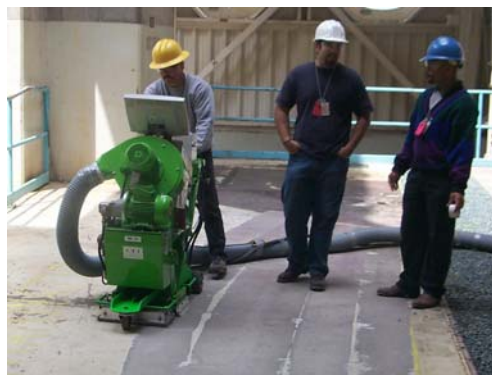


Fig 5 IF-DCS Demo at Rancho Seco

The demonstration was to be carried out by decontaminating concrete floor in the turbine-generator building of the Rancho Seco facility, where the contamination was caused due to leaks of slightly radioactive steam and/or water during plant operations. Data pertaining to the surface contamination levels in the demonstration area were collected through a pancake frisker survey carried out by the Rancho Seco HP personnel. The depth of the contamination was estimated to be within the range of 1/16 – 1/8 inch.

The Rancho Seco HP personnel collected surface contamination levels in the demonstration area through a pancake frisker survey before and after decontamination. The contamination levels were in the range of 200-1600 cpm/ft² before decontamination. The post-decontamination survey by Rancho Seco personnel showed readings less than background level, which is set to 60cpm/ft². The IF-DCS also collected the pre-decontamination and post-decontamination surface contamination levels from its characterization subsystem. The IF-DCS measured contamination levels ranging 144-1440 cpm/ft² before decontamination and 36cpm/ft² after decontamination for the areas cleaned.

The survey data collected from the demonstration site by the frisker and the IF-DCS before and after decontamination were compared, and the comparison is depicted in the form of a graph shown in Figure 6.

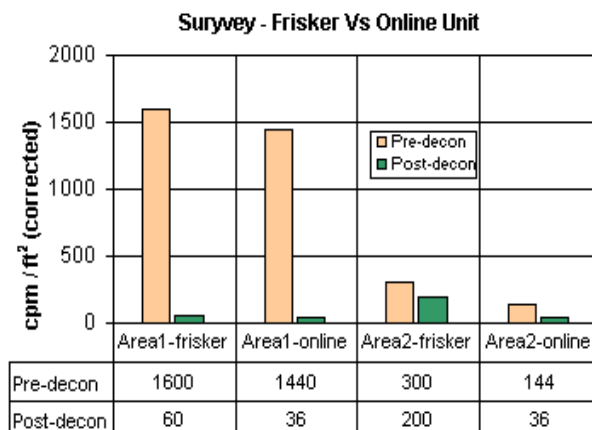


Fig 6 IF-DCS Survey Analysis

The survey data in the graph are corrected counts per minute per the respective probe area in feet squared. The DFs as computed from the data obtained from the IF-DCS are 40 and 4, whereas those computed from the frisker survey data are 3 and 1.5.

COST/PROCESS BENEFITS

Pipe Decontamination vs. Disposal Services

A preliminary cost analysis conducted after the demonstration held at Big Rock Point proved the system to be a viable option, where it can be setup onsite and provide a reduction in waste classification for scrap metal pipes remaining for disposal. If no onsite disposal facility is available, these materials must be transferred to decontamination/waste packaging and disposal service companies where processing costs run at approximately \$3 per pound (as per verbal communication with Big Rock Point Representative). An analysis conducted for 100,000 lbs of pipe (8") to be decontaminated using the MIP-DC system resulted in a cost of approximately \$1.53 per pound. This, plus an assumed packaging and transportation to an offsite disposal facility charge of \$1 per pound, would provide sites with a 16% cost-savings in processing. This percentage would increase as the quantity of pipe increased in a specific site. The cost-savings would also be greater where material must be transfer to offsite facilities not within that sites' geographic region.

Another potential cost-benefit that this technology provides from a complex-wide perspective is where a reduction in the waste volume can be achieved from free-releasing some of this material, and possibly recycling and selling the scrap metal. This is viewed from a long-term perspective associated with the reduction of waste volumes at DOE-used disposal facilities, where onsite or otherwise.

Concrete/Paint Decontamination Cycle

The advantage of the IFDCS and the handheld blaster are their ability to provide real-time data on the contamination levels of the area you are deconing. This allows operations personnel, as well as the D&D project manager onsite, to have data on the conditions being faced and make a determination as to the best course of action ("Go, No Go"). These technologies provide other definite benefits in the areas of waste volume reduction. When comparing the IFDCS to baseline scabbling systems, the cost benefit is taken from a multitude of factors. First, the IFDCS can control the amount of concrete that is removed from the surface. Integrated with the sensors, this allows user to remove exactly what is necessary to clean the area. In comparison to a concrete scabblers that cannot control the depth of removal, at a decontamination cost of approximately \$9.37 per square foot, the centrifugal shot blasting technology runs at about \$8.10 per square foot. 53% of the cost associated with the scabblers is spent on decontamination where the shot blaster consumes the largest monetary amount in demobilization work. The obvious drawback of other scabblers to the IFDCS is that it lacks any sensors for detection. Another cost benefit of the technology is that as the frequency of personnel into the contaminated area decreases, the cost-savings increase in the areas of personnel and personnel protective equipment (PPE).

CONCLUSIONS

HCET staff assessed the performance of the integrated decontamination and characterization systems through demonstrations carried out at Big Rock Point and Rancho Seco nuclear power facilities. As observed from the demonstration results, the integrated systems justify their capabilities.

The MIP-DCS reduces the quantity of disposable waste if the contaminated pipes were to be disposed instead of being cleaned and reused. The IF-DCS demonstrated the advantage of having an online characterization system that allows the operator to monitor the amount of decontamination during the process. The demonstrations further provided valuable information as feedback and evaluations from observers regarding possible modifications toward more effective and efficient systems.

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