BULK BUILDING MATERIAL CHARACTERIZATION AND DECONTAMINATION USING A CONCRETE FLOOR AND WALL CONTAMINATION PROFILING TECHNOLOGY

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ABSTRACT

The concrete profiling technology, RadPro™ has four major components: a drill with a specialized cutting and sampling head, drill bits, a sample collection unit and a vacuum pump. The equipment in conjunction with portable radiometric instrumentation produces a profile of radiological or chemical contamination through the material being studied. The drill head is used under hammer action to penetrate hard surfaces. This causes the bulk material to be pulverized as the drill travels through the radioactive media efficiently transmitting to the sampling unit a representative sample of powdered bulk material. The profiling equipment is designed to sequentially collect all material from the hole. The bulk material samples are continuously retrieved by use of a specially designed vacuumed sample retrieval unit that prevents cross contamination of the clean retrieved samples. No circulation medium is required with this profiling process; therefore, the only by-product from drilling is the sample. The data quality, quantity, and representativeness may be used to produce an activity profile from the hot spot surface into the bulk building material. The activity data obtained during the profiling process is reduced and transferred to building drawings as part of a detailed report of the radiological problem. This activity profile may then be expanded to ultimately characterize the facility and expedite waste segregation and facility closure at a reduced cost and risk.

INTRODUCTION

The DOE is in the process of Decontamination and Decommissioning (D&D) many of its nuclear facilities throughout the United States. These facilities must be dismantled and the demolition waste sized into manageable pieces for handling and disposal. The facilities undergoing D&D are typically chemically and/or radiologically contaminated. To facilitate this work, DOE requires a tool capable of profiling the bulk building materials to depth. Operating requirements for the tool include production of representative samples of the material being characterized, simple and economical operation, the capability of operating in ambient temperatures, and the ability to be easily decontaminated. The tool also must be safe for workers.

The objective of the Mound Tritium Facilities Large-Scale Demonstration and Deployment Project (LSDDP) was to demonstrate, and evaluate a concrete radiochemical sampling and profiling tool. Radioactive material characterization and remediation of various nuclear processing facilities to be decommissioned at the DOE-MEMP in Ohio were assessed for the presence of radionuclides throughout the concrete floor matrix. By using the rapid profiling approach activity and volume reduction of various segregated waste streams were achieved. All operations were conducted in compliance with applicable nuclear site regulations.

TECHNICAL FIELD

The intent of the demonstration was to compare the portable concrete profiling technology system used in conjunction with a portable liquid scintillation counting (LSC) system with the baseline technology. The baseline technology is an electrically powered coring drill operated in dry conditions to remove a core from the concrete surface to depth. The retrieved core is then sent to a laboratory for slicing, sub-sample preparation and analysis.

There is a need to detect tritium at depth within the building material matrix in real time, for it will allow immediate response to contamination and increased worker safety awareness. The accepted method for detecting tritium is liquid scintillation counting of field swipes or digestion of sub-sampled cores. This method takes place in a counting laboratory that is removed from the area of measure and often backlogged with work. This baseline methodology is removed from the contamination area, which causes delays in turn-around time from minutes to hours or even days and weeks. The downtime associated with these delays reduces productivity, increases costs, and most importantly, delays worker awareness of the area of contamination.

This technology is a specialized bulk material radiochemical profiling drilling technology and has four major components: a drill with a specialized cutting and sampling head, drill bits, a sample collection unit and a vacuum pump as shown in figure 1. The equipment in conjunction with portable radiometric instruments produces a profile of radiological or chemical contamination through the material being studied. The drill head is used under hammer action to penetrate hard surfaces. This causes the bulk material to be pulverized as the drill travels through the radioactive media efficiently transmitting to the sampling unit a representative sample of bulk material. The equipment is designed to sequentially collect all material from the hole. The bulk material samples are continuously retrieved by use of a specially designed vacuumed sample retrieval unit that prevents cross contamination of the clean retrieved samples. No circulation medium is required with this profiling process; therefore, the only by-product from drilling is the sample.

The activity data produced by the calibrated radiometric instruments is assessed for quality, quantity, and representativeness which is then used to produce an activity profile from the hot spot surface into the bulk building material. The activity data obtained during the profiling process is reduced and transferred to building drawings as part of a detailed report of the radiological problem. This activity profile is then expanded to ultimately characterize the facility and expedite waste segregation and facility closure at a reduced cost and risk.

Fig.1. Use of RadPro^{TM} To Sample & Characterize Concrete Floors of Nuclear Facilities

PROFILING OBJECTIVES

Profiling the concrete floor of room SW-142 at Mound Plant, Ohio to depth included the following desired capabilities and design features of the equipment:

- An ability to remove samples of concrete using a specialized tungsten carbide drilling technology.
- Collection of all concrete particulate from sampling operations into a specialized filter unit.
- To be powered with commonly available electric power.
- Able to remove 1/8-in. depth of potentially contaminated concrete sequentially from depths of less than an inch to 8 feet.
- Produce representative samples in a powdered form for optimal counting efficiency by a portable LSC system.
- Able to operate in an ambient temperature environment.

The room being sampled required a wide range of depths between 1/8-in. and 1-in. samples to be taken from three predetermined sampling points through the concrete slab. The concrete floor was covered in hard vinyl tiling that needed to be removed before core sampling commenced.

METHODOLOGY

Sections of vinyl tiles were removed from the concrete surface with a hammer and chisel at the predetermined areas of Room SW-142. No contamination was found beneath the tile surface. A core was drilled dry from the concrete slab as the baseline technology approach to characterization. A 1.75-inch core to a depth of 4 inches was achieved but the core had broken into several pieces and produced approximately 100 grams of dust. These dusts were vacuumed away and the broken pieces of core numbered and marked to the best of the operators' ability. It was not known precisely which order the pieces needed to be assembled to form the core. This procedure took approximately 40 minutes to obtain the core and clean up the dispersed dusts from the operation of the cutting bit. This procedure was not clean cut, did not produce a representative sample, and did not give analytical confidence for further sub-sampling operations at the laboratory.

The concrete profiling technology was set up to take samples of the concrete adjacent to where the fragmented core had been taken. The concrete slab was profiled at 1/8-in increments at several points on the surface for the first 6 samples. This increased the mass of sample acquired, 0.1g to 0.25g was all that was needed for the portable liquid scintillation counter, the rest of the concrete dust was produced for the onsite laboratory to compare the tritium profile results and analyze for possible alpha activity. Sample 7 was 0.25-in. and samples 8 and 9 were a further inch each into the concrete floor. Discussions prior to sampling had indicated that there was a possibility that a 3-in. concrete pour had occurred over an existing 6-in. concrete slab, possibly the action to cover historical spills of radioactivity. To analyze for this slab interface, samples 10 and 11 were 0.25-in.

each. However on drilling 0.25-in. for sample 12 the drill penetrated 5-in. into soft material, passing right through the slab.

The first inch of sampling took approximately 40 minutes, and the samples acquired at inch increments took 10 seconds each. A known mass of each incremental depth of dust sample was weighed out on a calibrated balance. 2 mls of distilled water and 2 mls of Instagel LSC cocktail were added to a 20 mls LSC vial and shaken thoroughly to evenly disperse the concrete dusts throughout the volume of LSC cocktail. The dusts were homogeneously distributed throughout the matrix to present the best sample geometry. The dusts constituted a mass of very fine particulate so minimizing self-absorption of any activity present. Each sample was placed in the counting chamber of the tritium calibrated LSC and analyzed for tritium activity for 10 minutes. From the start of sampling to the completion of analysis, a total time of 20 minutes per sample was observed. This is a vast improvement in time and cost over the baseline technology and a more representative sample was acquired in a safer and more precise manner.

The concrete profiling mechanism was moved to position two and samples were acquired for the first inch of depth to the predetermined depths as described for Hole 1 above. Samples 8 and 9 were sampled as 1-in. increments. Samples 10 to 13 were sampled at 0.5-in. increments down to the 5-in. level within the concrete slab. Sampling past the first inch of depth was very speedy.

The concrete profiling mechanism was moved to position three a few inches from Hole 2 and samples were acquired at five incremental depths of 1-in. each. To reach the predetermined 5-in. limit of sampling of the concrete slab took less than 20 minutes. Each hole was filled with latex cement and leveled to the surrounding vinyl floor tiles.

RESULTS

As shown in Table I below there was no high tritium contamination level within the concrete slab at the points sampled, although certain samples were calculated to be above background activity levels. Samples that have calculated activities less than the background are shown as less than (<) the limit of detection of the LSC.

Table I: Tritium Activity With Depth of The Concrete Slab of Room SW-142, Mound Plant, Ohio

Depth (inches)	pCi/g		
	Hole 1	Hole 2	Hole 3
0.125	2.006	0.438	NA
0.25	1.156	3.523	NA
0.375	0.814	0.611	NA
0.5	0.444	1.435	NA
0.625	0.684	0.722	NA
0.75	2.213	0.685	NA
1	2.510	1.359	0.532
2	2.071	0.756	1.545
3	1.195	1.268	0.636
3.5	0.532	<0.129	NA
4	4.094	0.235	<0.129
4.5	NA	<0.129	NA
5	<0.129	<0.129	0.767

Figures 2, 3 and 4 show the results graphically. These graphs show that there was no high tritium activity at any depth.

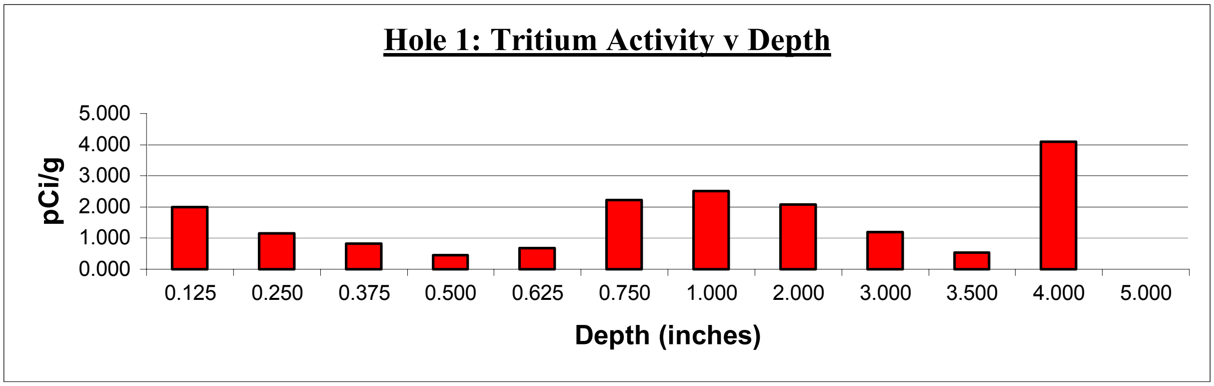

Fig. 2. Hole 1 Tritium Activity Profile From Surface to 5-in. Depth

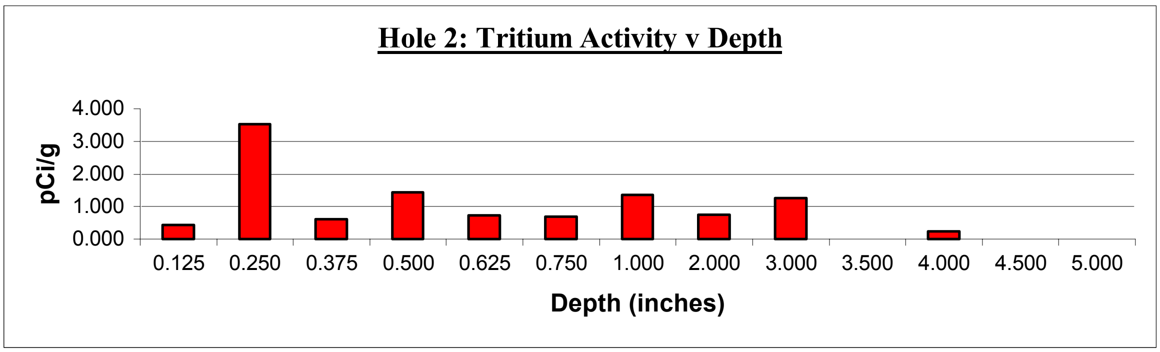

Fig. 3. Hole 2 Tritium Activity Profile From Surface to 5-in. Depth

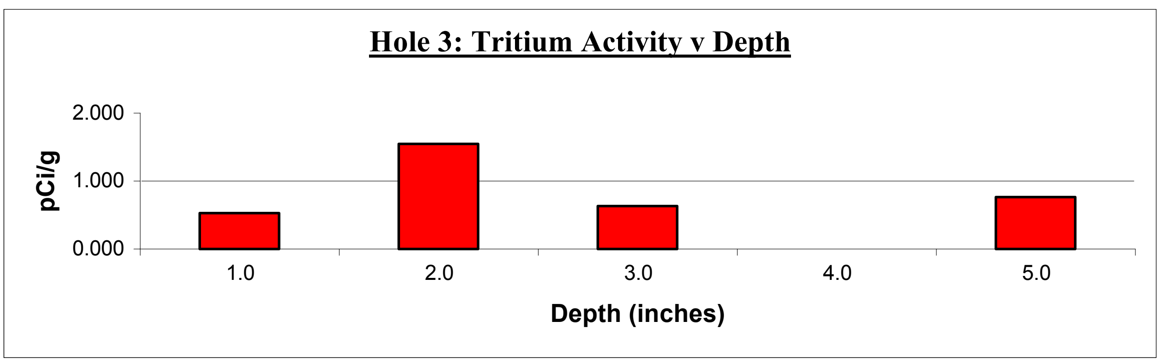

Fig. 4. Hole 3 Tritium Activity Profile From Surface to 5-in. Depth

RADIOCHEMICAL PROFILING

There was a need to detect tritium at depth within the building material matrix in real time. The approach to sample acquisition and use of portable radioanalytical measuring equipment is key to achieving these needs. This technology employed a heavy duty 110 V hammer action drill that rapidly penetrates the concrete surface to precise predetermined depths. The powder generated at the depth of penetration into the bulk building material was immediately extracted away from the specialized tungsten carbide drill bit by high vacuum and collected in an inline filter unit for radioanalysis. The sample was in a powder form and was therefore easier to place in the correct geometry for optimal calculation of the matrix activity. The reduced downtime associated with sampling and characterization increases productivity, decreases costs, and most importantly, increases worker awareness of the radiological area.

This technology demonstrated the ability to prove concrete floors in Room SW-142 had no tritium contamination of consequence throughout the concrete building matrix at the positions sampled.

This technology produced high quality and representative samples very speedily, so that the radioanalysis is reliable. The concrete sampling and profiling technology produced samples from the concrete in a form that could be analyzed within twenty minutes by a calibrated tritium liquid scintillation counter within the sampling area.

This technology has a high sampling tolerance and depth resolution and significantly reduces the chance of cross contamination of samples.

Table II shows the comparison between RADPRO™ technology and the baseline technology of coring.

Table II. Comparison between RADPRO™ Technology and Coring

RADPRO™	CORING
Cost Effective Equipment (~$1,000)	Expensive Equipment (~$5,000)
Produces Representative Sample	Core to be Sub-sampled
No Cross-contamination	Cross-contamination Dry or Wet
30 Samples In 3 Hours or a One Increment In 10 Seconds	1 Core In 40 Minutes or More Depending On Depth
Analysis at Work Area, 5 Minutes	Analysis at Lab, One Week or More
No Secondary Waste	Disposal of Core
Less Sample Handling and hence Reduced Worker Radiation Exposure	Sample & Sub-sampling Handling and hence Increased Radiation Worker Exposure
Removes 1/8-in. Depth Samples Sequentially at Depths of Less Than an Inch to 8 Feet in any Direction.	Removes Solid One Piece Core That Requires Sub-sampling & Produces Secondary Wastes.
Increased Radiological Safety by Resolving Understanding of Previous Undeterminable Historical Unknowns in Real time	Time Delay Of Radioanalysis, Increased Operator Exposure to Undeterminable Historical Unknowns
Increased Speed & Confidence in Deployment of Decontamination Technologies	Time Delay Between Radioanalysis & Decontamination

CONCLUSIONS AND RECOMMENDATONS

Based on the samples evaluated, the following conclusions and recommendations can be made:

- There was no high tritium contamination within the concrete slab at the points sampled, although certain samples were calculated to be above background activity levels.
- A more detailed and extensive sampling regime is needed to prove adjacent areas are free of tritium contamination.
- The concrete sampling and profiling technology produced high quality, representative samples, so that the radioanalysis is reliable.
- Confidence is greatly increased in radiological safety and in D&D operations by eliminating previously undeterminable historical unknowns.
- The concrete sampling and profiling technology in conjunction with the LSC increases productivity, decreases costs, and most importantly, significantly improves worker awareness of the area for a safe and concerned radiation worker.
- The sampling and profiling technology and approach therefore proves that a bulk building material is clear for free release or reuse in real time. That the bulk building material waste streams can be radiologically fingerprinted to depth and so enhance the ability to decontaminate the material more efficiently and effectively, thus providing more controlled segregation of radwaste streams saving considerable time and money.