SAND2009-2615C

RDD Decontamination

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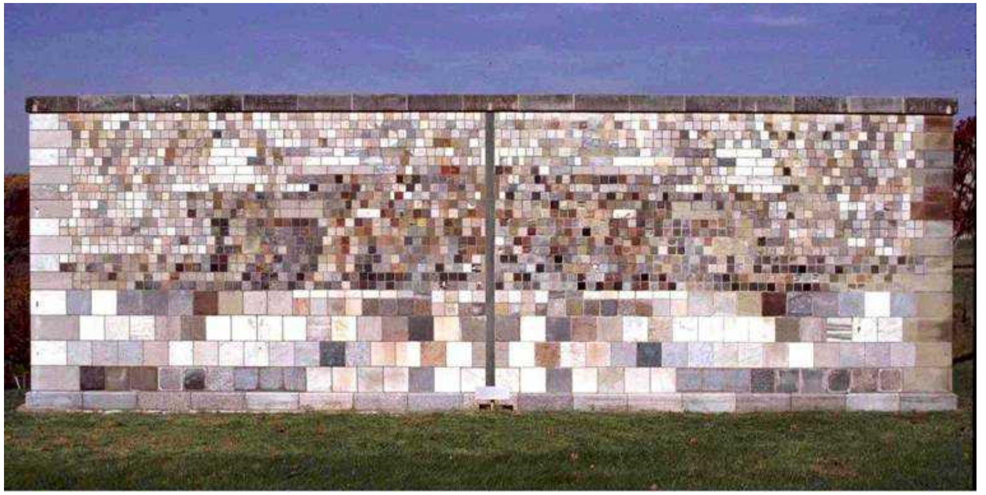
The Problem

- **Radiological Decontamination Testing**
  - **No ASTM methods exist**
  - **Current methods rely on highly conservative methods – often not reflecting results that may be obtained in the field**
  - **Exposed surfaces have much different properties than those studied in the lab**

Isotope interactions and surfaces

	Concrete				Granite		Marble	Wood				Glass		Rubber		Ceramic tile	Brick				Paint			Slate	Metal		Sandstone	Caulk
	Silicates	C-S-H gel	Hydroxides	Carbonates	Oxides	Silicates	Carbonates	Hydroxides	Nitrides	Carboxylates	Bromides	Silanol bonds	Silicates	Carboxylates	Nitrides	Silicates	Silicates	Sulfides	Chlorides	Fluorides	Selenides	Amines	Fluorides	Hydroxides	Oxides	Iron oxides	Silicates	Silanol bonds
Cs-137	X	X	X	X	X	X	X	X			X		X		X	X	X	X	X	X	X	X	X	X	X		X	
Co-60	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X
Ir-192	X		X	X	X	X					X	X	X			X	X	X	X	X	X	X	X	X	X		X	X
Sr-90			X	X	X		X	X		X	X			X				X	X	X	X	X	X		X	X		
Pu-238			X	X	X		X	X			X							X	X	X	X		X	X	X			
Am-241			X		X																			X	X			
Ra-226					X						X							X	X	X			X		X			
Cf-252			X		X			X											X					X	X			

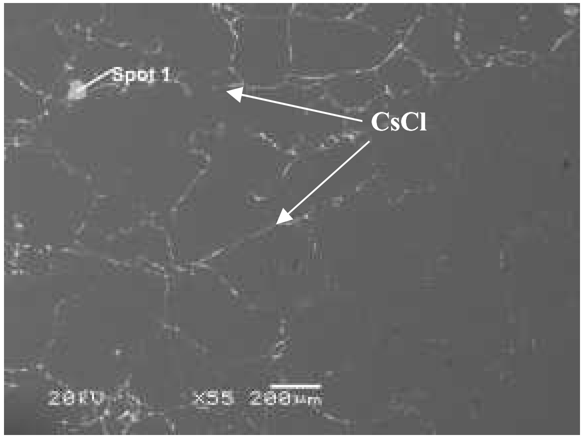
NIST Stone Test Wall

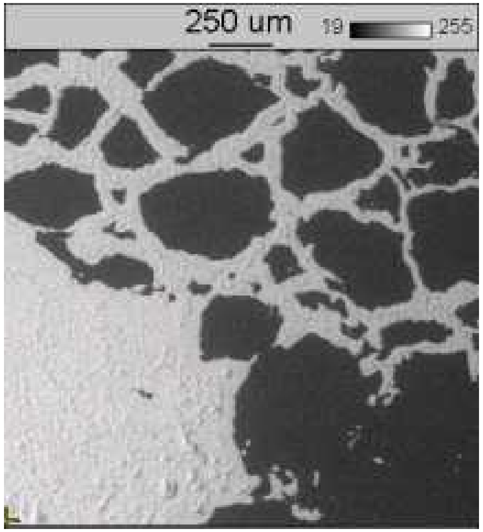


- Constructed in 1948 to study the weathering effects of stones.
- Contains 2352 individual samples of stone, of which 2032 are domestic stones from 47 states, and 320 are stones from 16 foreign countries.
- Includes many varieties of common types of stone used in buildings (i.e., marble, limestone, sandstone, and granite).
- Examining program building stones provides a unique opportunity to generate a subset of weathering and aging effects data that otherwise did not exist.
- Data will aid in the understanding of possible radionuclide/surface interactions.

Surface Chemistry, Grime and other Features

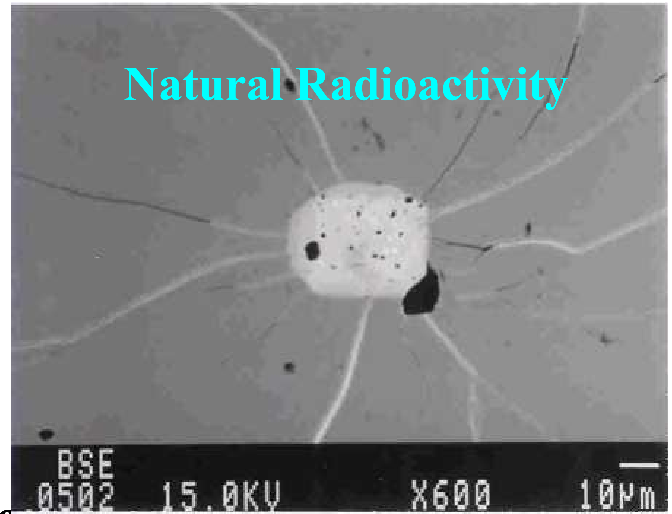
- **Marble**
  - Grain boundaries
  - Contaminant solutions travel cm-scale distances in marble
  - Overcoming this can be very difficult
- **Grime**
  - Many surfaces have oily grime layers
  - Interaction of radionuclides with organics
  - Require surfactants

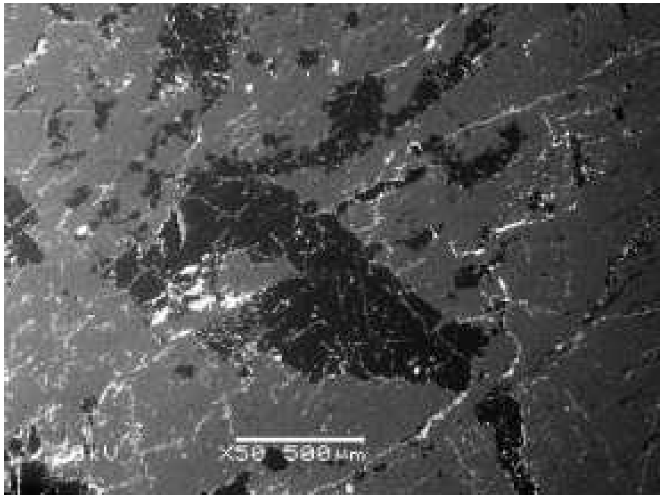


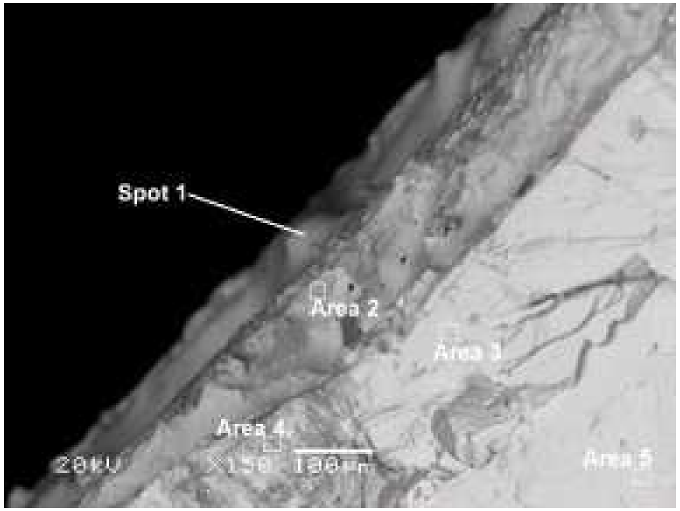


Surface Chemistry, Grime and other Features

- **Milford Granite**
  - High U-content Zircons present
  - Contain multiple geologic phases
    - K-feldspar
    - Quartz
    - Albite
  - Grain boundary migration – cm scale







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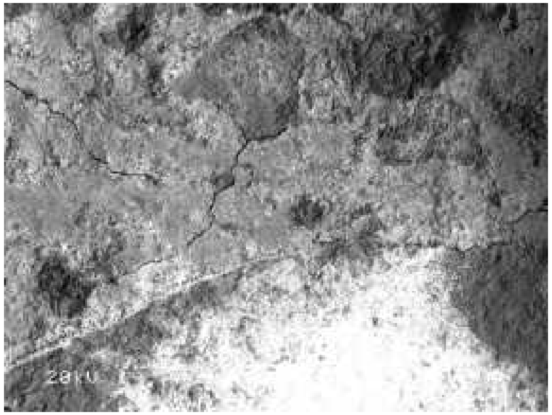
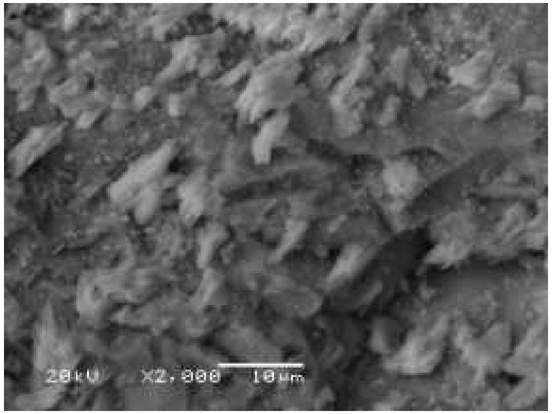
Surface Chemistry, Grime and other Features

- **Concrete**
  - Solutions only travel 100 µm
  - Highly reactive surface
  - Concrete equilibrium
    - Based on hydration
    - May take up to 15 years



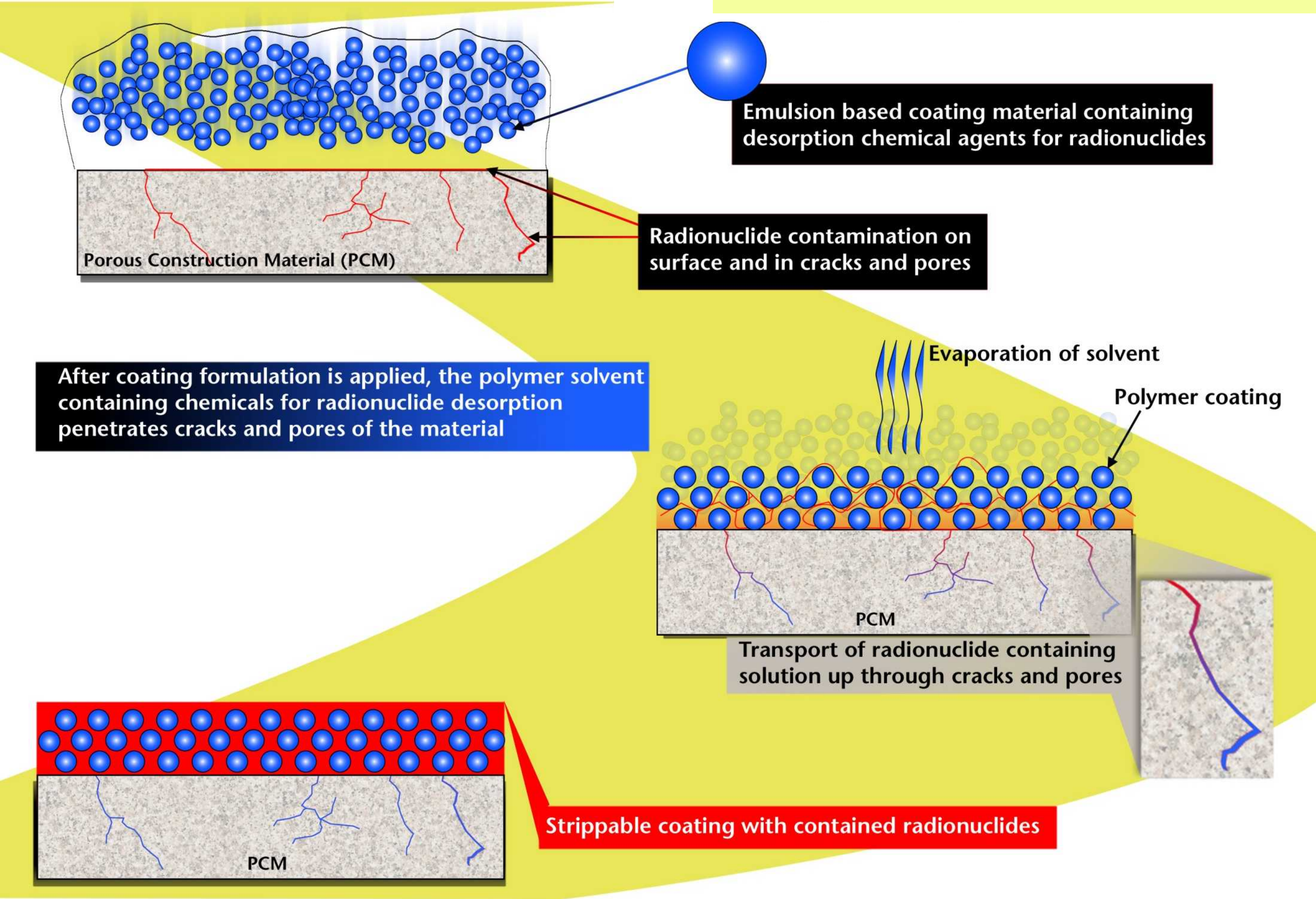


Surface Decontamination

Easily Decontaminated	Difficult to Decontaminate
Glass, a nonporous surface with little affinity for radionuclides	Wood, highly porous surfaces and many carboxyl groups able to complex radionuclides
Ceramic Tile, glazes provide a glassy non-porous surface with little affinity for complexing radionuclides.	Sandstone, more porous than other rocks being considered, may contain a variety of constituents with affinity for radionuclides of concern.
Slate, relative non-porous rock with little chemical affinity for most radionuclides except Cs.	Brick, very porous rough surfaces
Metals, non-porous substrates with relatively thin oxide coatings which can be removed with relative ease by chemical or mechanical methods.	Paint, may weather to form porous coatings and have very complex chemistry able to sequester many radionuclides. Note: numerous technologies exist for removing paint in bulk, however.
Caulk, Rubber, relatively low porosity with a largely hydrophobic surface chemistry	Concrete, quite reactive toward a number of radionuclides as well as moderately porous
	Marble, Granite, modestly porous and modestly reactive to some radionuclides

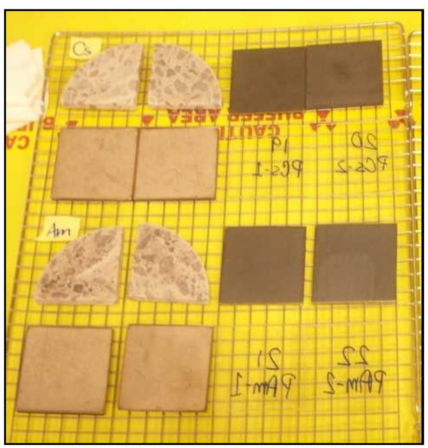
How do you clean a non-accessible surface?

One Step Strippable Coating for Radionuclide Decontamination

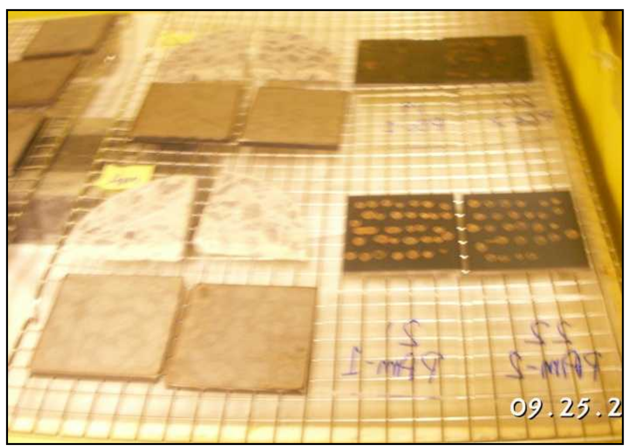


Method

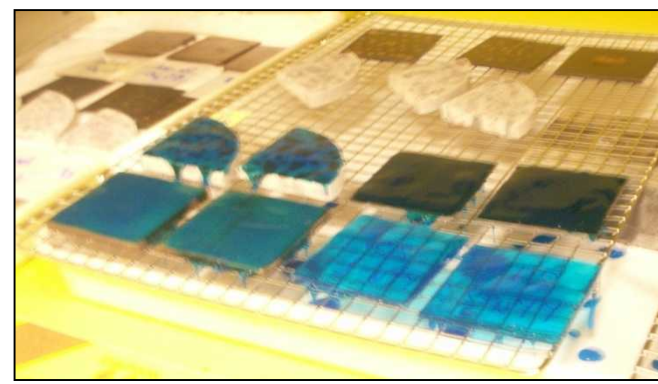
- Contaminate coupons with liquid solution (typically slightly acidic to keep nuclides in solution)
- Apply coating and let dry
- Remove coating and count by gamma spectroscopy



Initial Coupons



Coupons after contamination



Coupons after coating

Results for Commercial off the Shelf Coatings

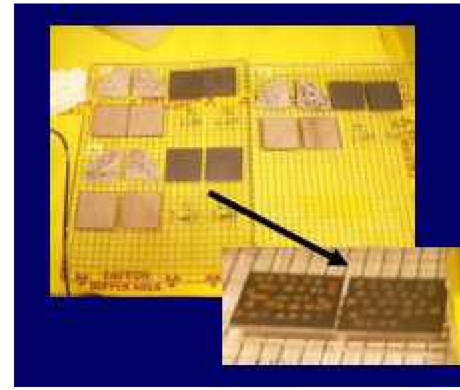
		Initial contamination	% radionuclide removed from surface	
Radionuclide	Material	µrem/hr @ 1 inch	ALARA*	Stripcoat TLC*
cesium	marble	100	32%	30%
	granite	100	48%	46%
	concrete	100	25%	20%
cobalt	marble	300	14%	13%
	granite	300	25%	22%
	concrete	300	50%	49%

These tests were performed using a hand held detector to give us some baseline data.

Decon Testing of DG 1101 Radionuclide Solutions (Cellular Bioengineering)

- **Radionuclide Solutions**
  - NIST traceable
  - Prepared 1uCi/ml from stock solutions
  - Am-241: AmCl3 in 1N HCl
  - Pu-239: Pu(NO3)4 in 4M HNO3
  - Cs-137: CsCl in 0.1M HCl
- **Coupon Materials**
  - Construction grade concrete cores, uniformly sectioned
  - Carbon steel 3” x 3” x 1/8”
  - 300-series Stainless steel 3” x 3” x 1/4”
  - PlexiGlas 3” x 3”

Decontamination Testing of DG 1101



- **Coupon Contamination**
  - Placed on wire racks
  - ~1 µCi each deposited using pipettor
  - Carbon steel showed visible corrosion
- **Coupon Coating Application and Removal**
  - Initial counts measured
  - Coupons coated with DG1101, spread with spatula and excess allowed to drip off
  - 24 hr. dry time
  - All coupons easy to peel, most difficult was concrete
  - Coatings all removed in single sheet with no fracture
  - Carbon steel no longer had visible corrosion on surface

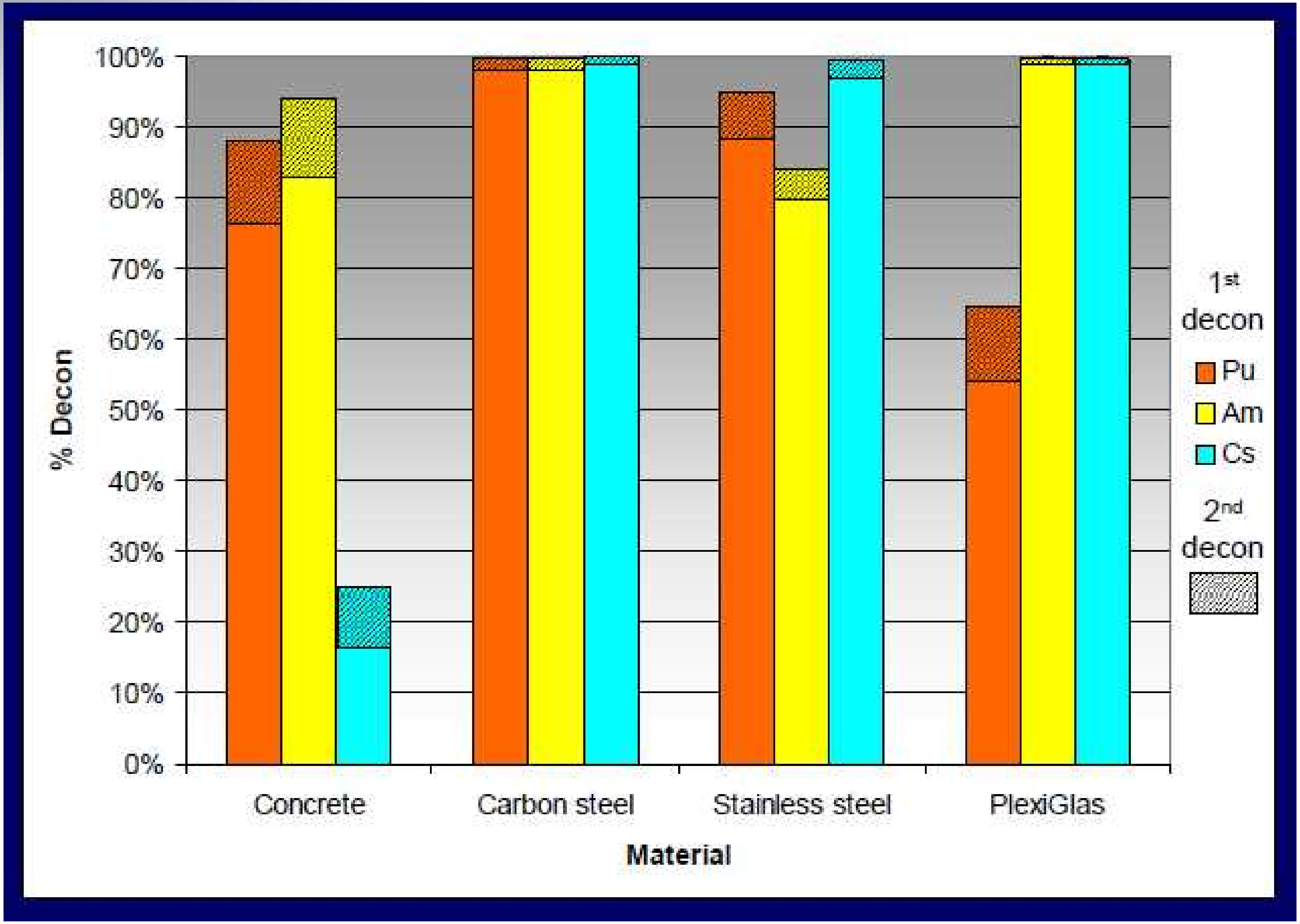
Decontamination Testing of DG 1101

- **Analytical Method and Data Workup**
  - Cs-137 counted for 1000 s with Canberra HPGe detector, peak area used to calculate activity
  - Am-241 and Pu-239 counted for 120 s w/Ludlum 43-1 and Eberline E600
  - Calibration coupons used for all cases
  - $\% \text{ Decon} = \dfrac{\text{Initial Activity} - \text{Final Activity}}{\text{Initial Activity}} \times 100$

Gamma detector with Plexiglas sample holder to keep a uniform distance between the sample and the detector.

Ludlum detector

DG 1101 Results for 1st and 2nd Decon



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Questions?

- **For copies of the Cellular Bioengineering reports, please contact Mike O'Neill at moneill@cellularbioengineering.com**