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Decontamination of Cs-137, Pu-239, and Am-241 from Hard Surfaces using a Peelable Polymer-based Hydrogel

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Decon Gel 1101 – What is It?

Apply → Dry → Peel

- Near neutral-pH, low-odor polymer hydrogel
- Utilizes surfactants to lift contaminants
- Soluble chelators bind contaminants for transport
- Contaminants pulled into polymer upon drying
- Entrapped in rehydratable polymer matrix

Sandia National Laboratories

Operated for the U.S. Department of Energy by Sandia Corporation

October 2007 –

CBI commissioned efficacy testing for DG1101 on:

- Concrete (C)
- Carbon steel (CS)
- Stainless steel (SS)
- Plexiglas (P)

Contaminated with:

- Pu-239
- Am-241
- Cs-137

Coupon Name	Initial Activity (µCi)	Activity after 1st Decon (µCi)	Activity after 2nd Decon (µCi)
C Pu-1	1.005	0.176	0.078
C Pu-2	0.902	0.257	0.146
CS Pu-1	0.983	0.009	0.001
CS Pu-2	0.977	0.021	0.002
SS Pu-1	1.045	0.181	0.082
SS Pu-2	0.978	0.056	0.021
P Pu-1	0.859	0.403	0.320
P Pu-2	0.903	0.405	0.310
C Am-1	0.980	0.169	0.063
C Am-2	0.888	0.149	0.050
CS Am-1	0.994	0.012	0.001
CS Am-2	0.949	0.031	0.003
SS Am-1	0.961	0.210	0.172
SS Am-2	0.947	0.171	0.135
P Am-1	1.002	0.011	0.001
P Am-2	0.913	0.012	0.001
C Cs-1	1.006	0.834	0.737
C Cs-2	0.974	0.822	0.745
CS Cs-1	0.998	0.010	0.002
CS Cs-2	1.002	0.014	0.002
SS Cs-1	0.998	0.039	0.008
SS Cs-2	0.986	0.019	0.003
P Cs-1	0.912	0.005	<MDA
P Cs-2	0.953	0.004	<MDA

December 2007 –

- Sandia applied 2nd coat of DG1101 to same test coupons that had been deconned in October.
- Results show 2nd decon efficacies as good or better than 1st application.

Notes: MDA = Minimum detectable activity

C Pu = concrete, plutonium; CS Am = carbon steel, americium; SS = stainless steel; P = Plexiglas; etc

Decontamination Testing of DG 1101

Radionuclide Solutions

- NIST traceable
- Prepared 1uCi/ml from stock solutions
- Am-241: $AmCl_3$ in 1N HCl
- Pu-239: $Pu(NO_3)_4$ in 4M HNO_3
- Cs-137: CsCl in 0.1M HCl

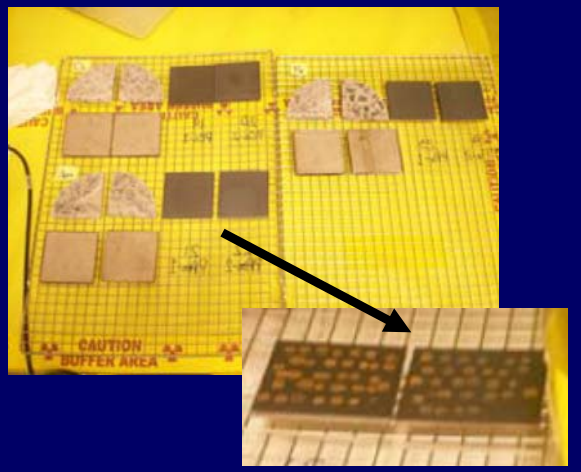
Coupon Materials

- 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

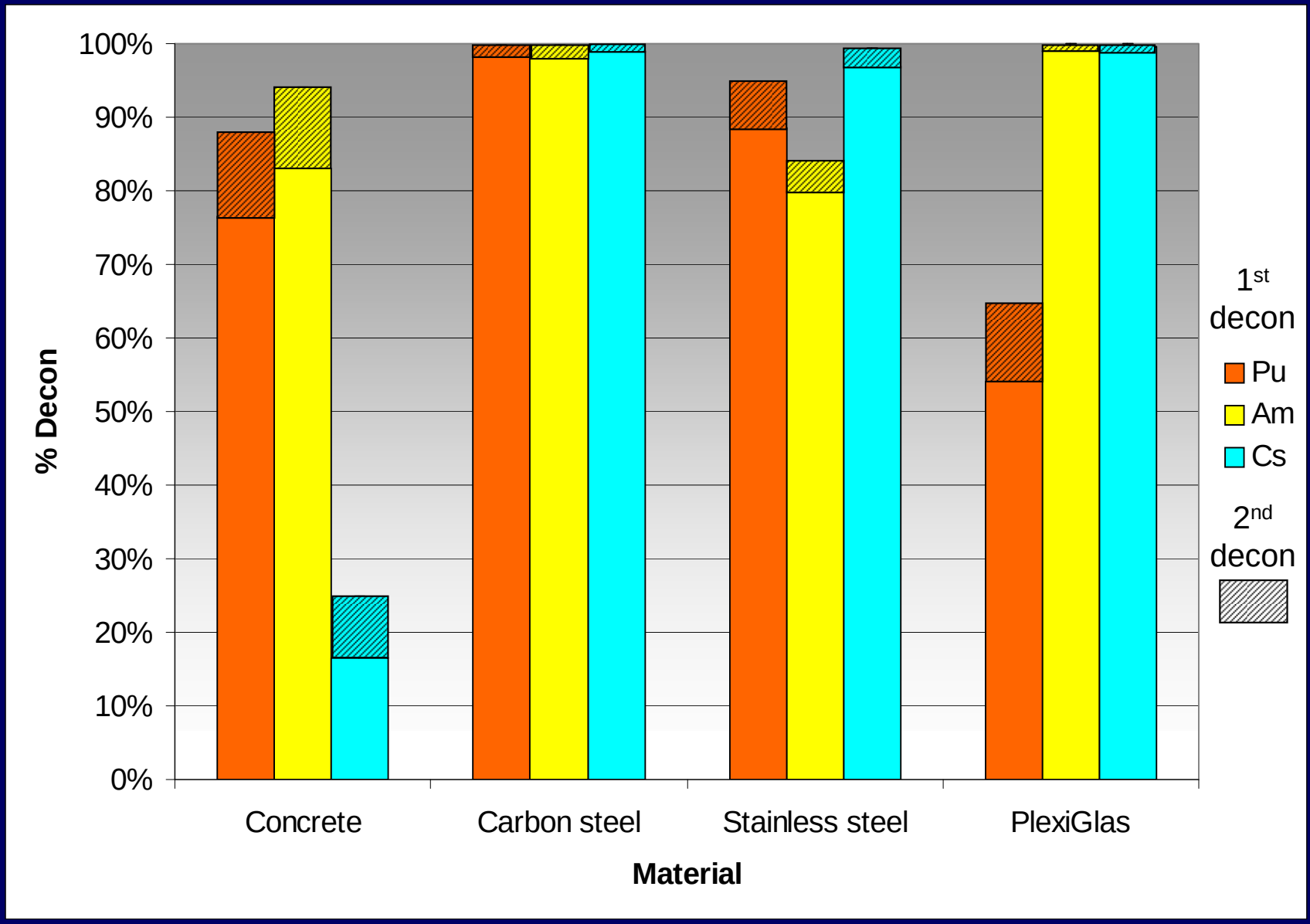
Decontamination Testing of DG 1101

Analytical Method and Data Workup

- Cs-137 counted for 1000 s w/Canberra Ge 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
- % Decon = $\frac{\text{Initial Activity} - \text{Final Activity}}{\text{Initial Activity}} \times 100$

Results


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% Decon
Concrete
Carbon steel
Stainless steel
PlexiGlas
Material
1st decon
Pu
Am
Cs
2nd decon

Pu Glovebox Decon at LLNL

Glovebox (~ 4 ½ ft x 8 ft x 9 ft)

- Cast steel floor, Al walls, Lexan® windows and Hypalon® gloves
- Commissioned in 1964 to cold roll Pu metal
- In 1996 a spill of Pu-238 occurred
- Measurements at < 1 inch >>1,000,000 cpm (off-scale)
- Previous unsuccessful decontamination efforts involved a commercially available strippable film coating

Figure 1. Exterior and interior of glove-box. Note rolling mill inside glove-box was removed prior to decontamination and the floor of the glove-box was swept.

Figure 3. Glove-box floor (steel and aluminum) before and after application of Decon Gel 1101.

Field Test

DG 1101 Application

- Applied with trowel, allowed to dry overnight
- Lexan® window deconned 2x, Steel floor and Al siding 3x
- DFs measured as ratio of original alpha activity at 1.5 inch stand-off to activity measured after each decon
- Initial contamination levels averaged
  - 74,000 dpm for cast steel horizontal floor
  - 56,000 dpm for aluminum siding
  - 54,000 dpm for Lexan window

Table 2. Measured Radioactivity Levels for Each Quadrant.

Aluminum Wall	**Measured Radioactivity, cpm**						
Location	*Initial*	*Thru Gel*	*Shielding*	*1st Decon*	*Initial Efficiency*	*Last Decon*	*Total Efficiency*
	cpm	cpm	%	cpm	%	cpm	%
A2	27000	3000	89	NA	NA	120	100
A3	28000	3000	89	NA	NA	120	100
B1	28000	3000	89	NA	NA	140	100
B5	28000	3000	89	NA	NA	100	100
C1	28000	4000	86	NA	NA	160	99
C5	26000	3000	88	NA	NA	200	99
D1	28000	2000	93	NA	NA	220	99
D5	26000	4000	85	NA	NA	220	99
E1	30000	3000	90	NA	NA	240	99
E5	28000	3000	89	NA	NA	160	99
F1	32000	4000	88	NA	NA	NA	NA
F5	32000	3000	91	NA	NA	140	100
Average	*28417*	*3167*	*89*	*NA*	*NA*	*165*	*99*
2 Sig Fig Ave	*28000*	*3200*	*89*	*NA*	*NA*	*170*	*99*
SD	*1975*	*577*	*2*	*NA*	*NA*	*47*	*0.2*
RSD	*7*	*18*	*2*	*NA*	*NA*	*29*	*0.2*

Figure 5. Removal of cured Decon Gel 1101 as a strippable film from cast steel glove-box floor.

Results

One application

- Activity on steel floor was reduced by 57% (SD=7%) and on the Lexan window by 37% (SD=8%)

Additional applications

- Lexan window after 2nd application overall 99.5% removal (SD=0.1%)
- Steel floor after 2nd and 3rd application overall 99.4% (SD=0.3%)
- After 2 and 3 applications of DG 1101, activity was reduced to <400 dpm in almost all cases
- Given the highly contaminated nature of the surfaces within the glove-box, this decontamination efficiency is considered excellent

Cast Steel	Measured Radioactivity, cpm						
Location	*Initial*	*Thru Gel*	*Shielding*	*1st Decon*	*Initial Efficiency*	*Last Decon*	*Total Efficiency*
	cpm	cpm	%	cpm	%	cpm	%
B2	34000	4000	88	18000	47	200	99
B3	34000	3000	91	18000	47	220	99
B4	38000	2000	95	15000	61	140	100
C2	50000	3000	94	16000	68	520	99
C3	42000	1000	98	14000	67	320	99
C4	34000	2000	94	16000	53	180	99
D2	42000	1000	98	16000	62	700	98
D3	32000	3000	91	15000	53	180	99
D4	30000	2000	93	15000	50	140	100
E2	40000	3000	93	15000	63	400	99
E3	32000	3000	91	14000	56	140	100
E4	38000	2000	95	16000	58	160	100
Average	*37167*	*2417*	*93*	*15667*	*57*	*275*	*99*
2 Sig Fig Ave	*37000*	*2400*	*93*	*16000*	*57*	*280*	*99*
SD	*5686*	*900*	*3*	*1303*	*7*	*179*	*0.4*
RSD, %	*15*	*37*	*3*	*8*	*13*	*65*	*0.4*
Average Decontamination Factor (DF): 2 after first application, 57 after second and third application combined, 130 total including all three applications.							

Continued - Table 2. Measured Radioactivity Levels for Each Quadrant.

Lexan Window	Measured Radioactivity, cpm						
Location	*Initial*	*Thru Gel*	*Shielding*	*1st Decon*	*Initial Efficiency*	*Last Decon*	*Total Efficiency*
	cpm	cpm	%	cpm	%	cpm	%
WA3	27000	3000	89	20000	26	100	100
WA4	27000	2000	93	17000	37	120	100
WA5	24000	2000	92	17000	29	140	99
WB1	26000	1000	96	17000	35	110	100
WB2	28000	3000	89	18000	36	120	100
WB5	27000	2000	93	19000	30	120	100
WC1	26000	1000	96	14000	46	180	99
WC2	28000	1000	96	13000	54	120	100
WC5	28000	3000	89	20000	29	140	100
WD1	28000	1000	96	18000	36	180	99
WD2	27000	1000	96	16000	41	120	100
WD5	26000	3000	88	15000	42	120	100
Average	*26833*	*1917*	*93*	*17000*	*37*	*131*	*100*
2 Sig Fig Ave	*27000*	*1900*	*93*	*17000*	*37*	*130*	*100*
SD	*1193*	*900*	*3*	*2216*	*8*	*25*	*0.1*
RSD, %	*4*	*47*	*4*	*13*	*22*	*19*	*0.1*
Average Decontamination Factor (DF): 2 after first application, 130 after second application, 210 total after two applications.							

Operational Perspectives

- The Nuclear Materials Processing and Technology Program personnel conducting the decon activities reported that the material had a good workability and allowed sufficient working time before drying.
- In general the material adhered to the sides of the glove-box without an excessive amount of dripping being observed.
- DG 1101 was able to penetrate crevices and was easily removed from all surfaces with the exception of the Hypalon® gloves.
- While hand application was used for the study, personnel commented that spray application might be advantageous for future applications.
- [Comment from CBI: DG 1120 is now available for spray applications.]

Summary

- Lab Environ
  - Decon Gel 1101 demonstrated effective on Pu-239, Am-241, and Cs- 137 radioisotopes
  - 2^{nd} decon factors as good or better than 1^{st} application
  - Cs on concrete most difficult case, R&D in progress
- Field Application
  - Application of DG 1101 to Pu decon of highly contaminated glovebox at LLNL demonstrated excellent efficacy overall
- Full Reports Available
  - Sandia and LLNL reports available upon request at CBI booth or contact M. O'Neill, CTO, CBI
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