Evaluation of Engineering Controls Implemented to Mitigate Godiva Contamination

Joetta Goda, John Bounds, Dave Hayes

ANS Winter Conference 2016

Introduction

- Godiva bursts commenced in 2013 following reassembly and startup in 2012.
- Air sampling was performed during initial bursts
- There were 32 burst performed in 2014 (all without “Top Hat”)
- Access to the building following a burst was made by personnel wearing respirators
- Despite these precautions, there was higher than desired levels of surface contamination and indication of potential personnel uptakes of uranium which prompted discussions of engineering controls.

Airborne and Surface Contamination

- Airborne contamination consists of both uranium and fission products.
  - The uranium comes from the HEU fuel that has oxidized and is expelled from the surface of the core due to the shock wave generated during a burst.
  - Volatile fission products generated during the operation also become airborne. As they decay, non-volatile daughter products can be captured on air filters.
- Surface contamination consists primarily of HEU settling out of the air and onto surfaces in the building..

Engineering Controls

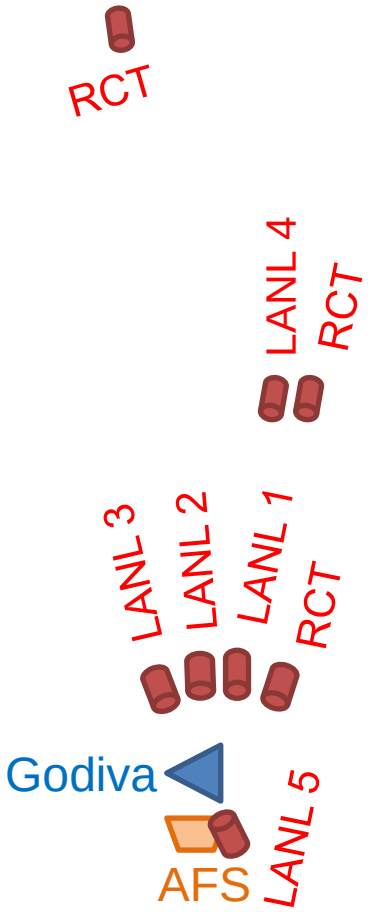
- Passive Engineering Control--"Top Hat" cover to physically contain contamination and the
- Active Engineering Control--Air Filtration System (AFS). The AFS is a large HEPA filtered air collection system mounted with the intake adjacent to the area above the Godiva core.

Burst Info

- 9 bursts performed,
- Controls evaluated
  - Top Hat -- passive
  - Air Filtration System -- active
  - Both Controls Combined

	"60"	"150"	"200"
Top Hat and AFS	#2000	#2002	#2003
	24Sep15	27Oct15	28Oct15
	66 C	128 C	265 C
Top Hat only	#2004	#2005	#2006
	16Nov15	17Nov15	18Nov15
	62 C	155 C	269 C
AFS Only	#2007	#2008	#2009
	15Dec15	16Dec15	17Dec15
	53 C	130 C	197 C

Location of Air Samplers



"Giraffe" air sampler

Air Samplers, Location and Timing

1 meter from HCA (1 m from Godiva)

- LANL 1 – ON at 30 min following burst, 2.5 cfm
- LANL 2 – continuous, 2.5 cfm
- LANL 3 – ON at 80 min following burst, 2.5 cfm
- RCT – continuous, 2.5 cfm

Hotline (entrance to room)

- LANL 4 – continuous, 2.5 cfm
- RCT – continuous, 2.5 cfm

AFS Exhaust

- RCT – continuous, 2.5 cfm

AFS Filter (at top of AFS, facing Godiva)

- LANL 5 – continuous, 2.5 or 2.0 cfm

Air filters counted LANL count room (alpha spec and gamma spec)
Counted later by NSTec RCTs (gross alpha/beta)

LA-UR-16-21407

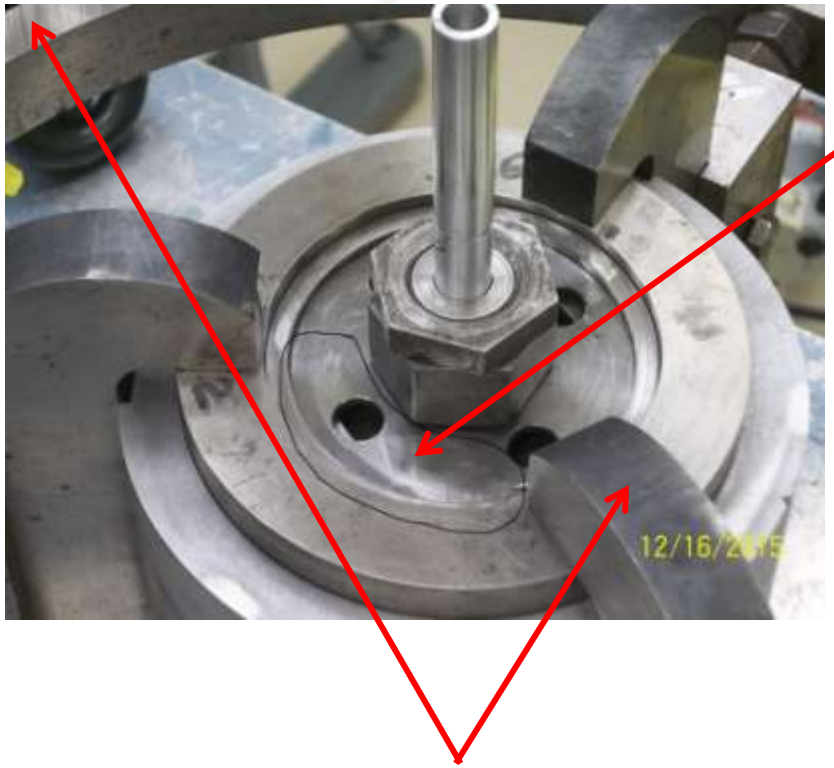
Contamination Survey Results

- Numbers in red are the numbers used for Table 1

Group	Sample ID	Location	THA60 Alpha (dpm)	THA150 Alpha (dpm)	THA250 Alpha (dpm)	TH60 Alpha (dpm)	TH150 Alpha (dpm)	TH250 Alpha (dpm)	A60 Alpha (dpm)	A150 Alpha (dpm)	A250 Alpha (dpm)
HCA	A1	Top Hat (closest to AFS)	90	848	1834	239	243	1399	176000*	5000*	1000*
	A2	Top Hat (away from AFS)	20	347	97	47	510	256	87000*	4000*	70000*
	A4	AFS Inlet Screen	43	340	4868	717	197	14000*	20000*	15000*	15000*
CA/floors	A5	1 foot from assembly, each side (floor)	33	219	200	41	47	47	17	13	357
	A6	1 foot from assembly, each side (floor)	38	38	192	41	232	52	77	13	4
	A7	1 foot from assembly, each side (floor)	31	120	54	49	44	65	15	3	40
	A9	2 m from assembly, each side (floor)	9	541	237	257	184	230	10	18	25
	A10	2 m from assembly, each side (floor)	9	22	17	15	56	211	-1	3	21
	A11	2 m from assembly, each side (floor)	25	42	33	101	115	213	5	2	19
CA/walls	A13	Green strut on south side of room	7	25	15	28	13	154	-3	-2	8
RBA	A15	Room 110 entrance (large doorway)	0	9	12	5	34	31	-3	-3	-1
	A17	Personnel doorway	2	6	4	2	5	22	9	-3	1
	A19	Downstream from AFS exhaust	9	7	1	8	7	4	-1	-2	6
CA/walls	A21	Wall closest to Godiva	-	14	9	16	13	18	2	2	-2
Other	A23	Facility Task Ventilation (screen)	-	-	-	-	1940	4905	48	59	122

*Counted with Electra

Contamination Survey Location Photos



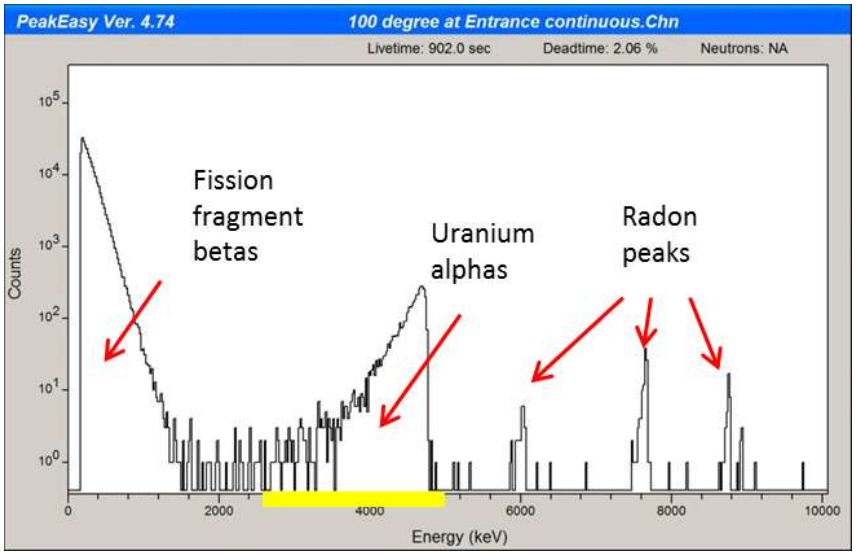
176k dpm (16DEC15): not cleaned during top hat removal

4k-5k dpm (17DEC15): cleaned during top hat removal

LA-UR-16-21407

Alpha Spectroscopy

- Used to determine amount of HEU on air filters
- Counted 1 day post burst.
- 300 second count. The MDA for the detector setup is 5 dpm.
- Background counts taken before and after each filter.
- Alpha spectroscopy allows for Radon activity to be discriminated.
- 2013 data reanalyzed for consistency



Air Filter Alpha Spectrum, 108 ºC Burst, No Controls

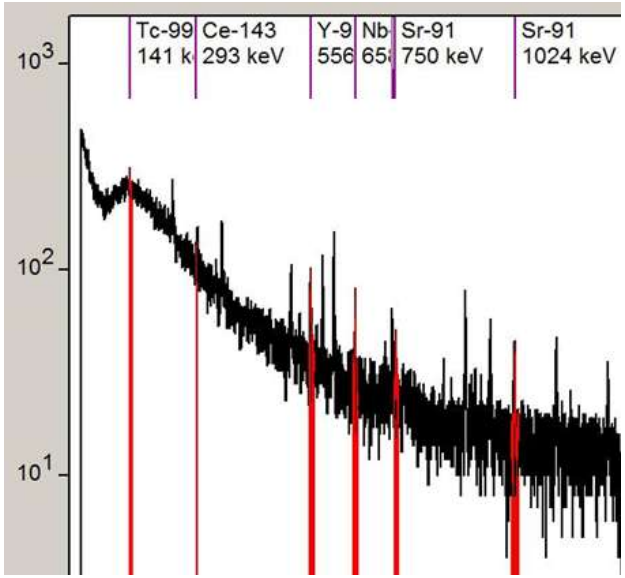
Alpha Spectroscopy Data

“200” degree Burst Data (dpm)

		12Sep2013	28Oct2015	18Nov2015	17Dec2015
Filter		200°, no controls	265°, Top Hat + AFS	269°, Top Hat	197°, AFS
LANL 1	ON at 30	7395	6	818	14
LANL 2	Continuous	53173	183	18300	329
LANL 3	On at 80	-	<MDA	21	8
LANL 4	CA Boundary	35271	30	5810	24
LANL 5	AFS	-	135	42200	301

Gamma Spectroscopy

- To determine fission products on air filters
- Counted 1 day post burst
- 30 minute gamma spectra
- Identifies peaks of fission fragments
- Old data reanalyzed for consistency



Air Filter Gamma Spectrum, 66 ºC Burst, with TopHat and AFS Controls.

Gamma Spectroscopy Data

197 degree Burst Data (Bq at Time of Measurement) by Location

	ON at 30	Continuous	ON at 80	CA Boundary	AFS
Isotope	LANL 1	LANL 2	LANL 3	LANL 4	LANL 5
Mo-99	<MDA	5.2	<MDA	1.5	4.5
Ce-143	<MDA	13.7	<MDA	1.7	8.6
I-133	<MDA	9.0	<MDA	1.4	6.4
Nb/Zr-97	<MDA	15.0	<MDA	2.0	11.4
Sr-91	4.4	132	<MDA	156	126

Gamma Spectroscopy Comparison by Control

- Comparison of Data for “LANL 2” Continuous Air Filter

“200” degree Burst Data (Bq at Time of Measurement) by Control

	12Sep2013	28Oct2015	18Nov2015	17Dec2015
Isotope	200°, no controls	265°, Top Hat + AFS	269°, Top Hat	197°, AFS
Mo-99	409	3.7	188	5.2
Ce-143	471	7	253	13.7
I-133	488	4.1	318	9.0
Nb/Zr-97	913	9	510	15.0
Sr-91	2240	28	1250	132

HEU and Fission Product Contribution to Total Airborne Dose Rates

- As burst size increases, the contribution from airborne HEU increases faster than the contribution from fission products.

	Name	Burst Size deg C	Fission Prod. DAC.hr	HEU DAC.hr	Total DAC.hr
No Controls	60	60	1.08	0.46	1.54
	150	108	2.30	7.70	10.00
	200	200	6.20	79.00	85.00
Top Hat + AFS	60 THA	66	0.004	0.000	<0.005
	150 THA	128	0.02	0.03	<0.1
	200 THA	265	0.05	0.27	0.32
Top Hat only	60 TH	62	0.46	0.41	0.87
	150 TH	155	1.20	5.80	7.00
	200 TH	269	3.10	27.40	30.50
AFS only	60 A	53	0.03	0.03	0.06
	150 A	130	0.05	0.06	0.11
	200 A	197	0.11	0.49	0.60

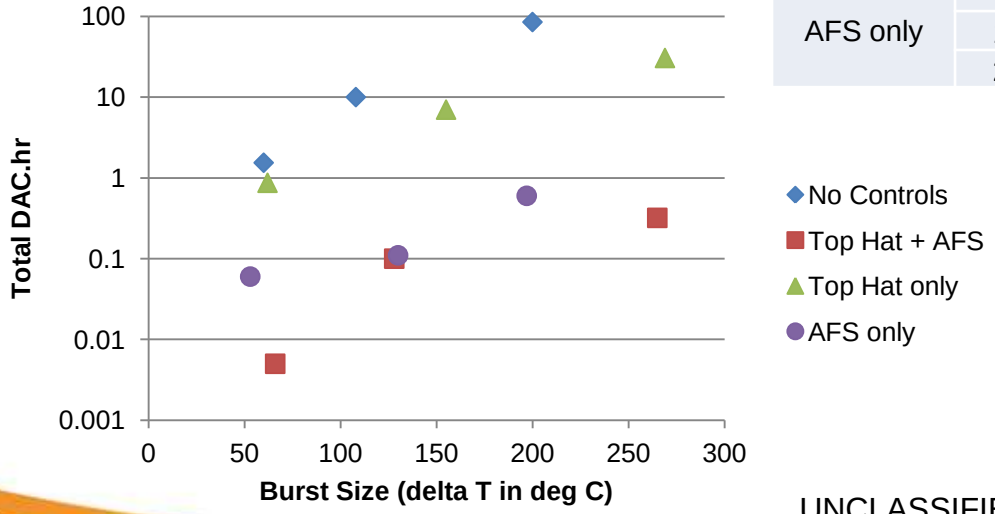


Table 1: Engineering Control Effectiveness Determination Table

Control	Nominal Burst del T	1 meter air sampling station		Highest Swipe in each Area [dpm/100cm^2]								Control Effective? Y/N
		DAC-h	<10 DAC-h? Y/N	HCA	< 100,000? Y/N	CA Floor	< 5,000? Y/N	CA Walls/Cables	< 2,000? Y/N	RBA	< 200? Y/N	
NONE	60	1.5	Y	-		-		-		-		
	150	10	Y	-		-		-		-		
	>200	85 12.4	N*	-		-		-		-		
Top Hat and AFS	60	<0.005	Y	90 α/ 507 β	Y	43 α/ 509 β	Y	7 α/ 25 β	Y	2 α/ 10 β	Y	Y
	150	<0.1	Y	848 α/ 2363 β	Y	541 α/ 79 β	Y	25 α/ 11 β	Y	9 α/ 6 β	Y	Y
	>200	0.32	Y	4868 α/ 28377 β	Y	237 α/ 86 β	Y	15 α/ 36 β	Y	12 α/ 24 β	Y	Y
Top Hat	60	0.87	Y	717 α/ 256 β	Y	257 α/ 23 β	Y	28 α/ 7 β	Y	5 α/ 3β	Y	Y
	150	7.0	Y	510 α/ 80 β	Y	231 α/ 23 β	Y	28 α/ 7 β	Y	5 α/ 3β	Y	Y
	>200	30.5 1.4	N* Y	1399 α/ 3277 β	Y	230 α/ 235 β	Y	154 α/ 603 β	Y	31 α/ 115 β	Y	Y
AFS	60	0.06 0.02	Y	176,000 α	N**	77 α/ 40 β	Y	2 α/ 7 β	Y	9 α/ 11 β	Y	Y
	150	0.11 <0.01	Y	15,000 α	Y	18 α/ 3 β	Y	2 α/ 3 β	Y	-2 α/ 4 β	Y	Y
	>200	0.6 0.02	Y	70,000 α	Y	357 α/ 1052 β	Y	8 α/ 2 β	Y	6 α/ 11 β	Y	Y

Conclusions

- The highest airborne contamination levels were found on the air samplers closest to Godiva and running continuously.
- Contamination levels increase with burst size.
- Airborne radioactivity levels drop off quickly in time following a burst.
- The “Top Hat” was effective at reducing surface contamination and airborne levels of HEU.
- The AFS was more effective at reducing the airborne levels of fission products.
- The combination of both controls provided additional reduction over the effect of any single control.

This work is supported by the DOE Nuclear Criticality Safety Program, funded and managed by the National Nuclear Security Administration for the Department of Energy.