Health Physics Support for High Specific Activity TRU Waste Processing Project

Presented by

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,
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Project Purpose

- Prepare Waste for Ultimate Disposal at WIPP
- Remove Liquids identified by RTR
- Characterize and treat Liquids
- Retrieve $^{244/243}Cm$ which had potential commercial value

Waste Knowns

- Drums Stored for ~ 20 years
- Originators of waste assumed direct burial
- Content :
  - >7 Ci of alpha emitting TRU (~ 4 Ci $^{244/243}Cm$, ~ 1 Ci ^{241}Am, 0.5 Ci ^{238}Pu and the balance being $^{239/240}Pu$). Also ~ 7 Ci ^{241}Pu (LEB).
  - Engineered metal oxide with an ~ 1 micron AMAD
  - General lab trash

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TRU Facts for Inhalation Considerations

Nuclide	Sp. Act	DAC	Sol. Type	Inverse ED coef.
	Ci/g	uCi/ml		dpm/mrem
Pu-240	0.23	5.00E-12	(M)	12.8
		6.00E-11	(S)	40
Pu-239	0.062	5.00E-12	(M)	12.8
		6.00E-11	(S)	40
Pu-238	17	6.00E-12	(M)	13.9
		5.00E-11	(S)	40
Cm-244	81	9.00E-12	(M)	23.8
Cm-243	52	7.00E-12	(M)	20.8
Am-241	3.6	5.00E-12	(M)	15.4
Pu-241	103	2.00E-10	(M)	714
		2.00E-09	(S)	3704

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Waste Handling Options

Based on the knowns, engineered controls were deemed necessary. Options were:

- Use of an existing general duty glovebox.
- Modify the existing glovebox for TRU rating.
- Handle the waste using a glove bag.

Glovebox/Ventilation Modifications

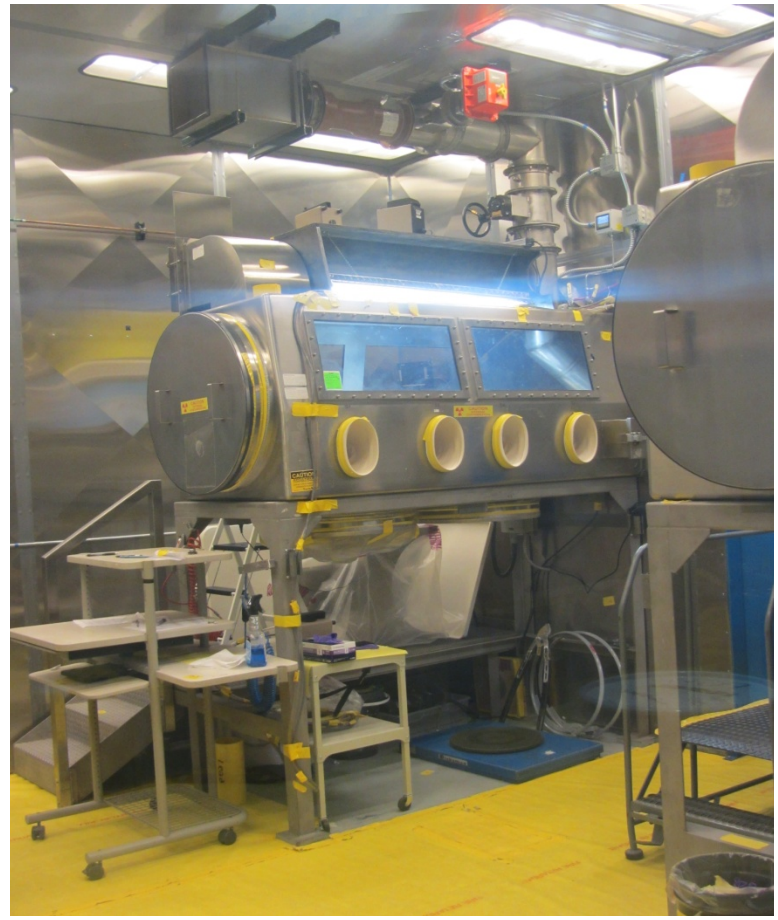
Modifying the existing glovebox was ultimately chosen to handle this waste due to:

- **TRU curie content.**
- **High specific activity of the material.**
- **Potential respirability of the material.**
- **Significant likelihood of sharps in the waste.**
- **Nature of overall work activities.**
- **Limited experience with high specific activity TRU**

Glovebox/Ventilation Modifications

- Replaced ductwork so everything is 8” OD SS.
- Installation of HEPA @ exhaust from glovebox.
- Installation of isolation valves to focus process ventilation.
- Rebalancing both process and room flow ventilation.

Glovebox Before/Post Upgrades



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Resultant Ventilation Characteristics

Changes align with ASTM C852-09

- Glovebox differential pressure: 0.4 ->0.6 inches H_2O gauge
- 125 lfm inflow at largest opening.
- Added HEPA filter to interior of box.
- Building air flow:

  Primary room negative w/r secondary work area, negative w/r highbay.

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Additional Measures Taken

In addition to the above noted changes:

- Removals from & introductions to the glove box either via isolatable pass through or using bag-in/bag-out techniques.
- Special over-gloves when handling potential sharps.
- Egress/entrances via a contamination reduction corridor.
- PAPR respirators during bag-in/bag-outs & glove changes.
- Local ventilation applied during removals.
- Special monitoring conducted during these activities.

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Potential Internal Dose Evaluation

- Using NUREG 1400 criteria to evaluate potential dose assuming work was carried out without upset conditions:

$$I_p = Q * 1E\text{-}06 * R * C * D$$

where

I_p = potential intake (pCi)

Q = throughput (7.25E+12 pCi)

R = release fraction (0.01)

C = confinement factor (0.001)

D = dispersibility (2)

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Potential Internal Dose Evaluation

I_p = 7.25E+06 * 1E-06 * (0.01) * (0.001) * (2)

I_p = 3.6E-04 uCi = 3.6E+02 pCi = 805 dpm

Using a sum of ratios method, an overall effective dose coefficient is determined to be 4.0E-02 mrem/dpm, therefore, effective CED for the project would be as follows:

(805 dpm) * (4.0E-02 mrem/dpm) ~ 32 mrem

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Initial Screening for Air Sampling

Initial screen is given as:

$$Q_i > 2.4E+13 * DAC_i * t_y$$

Where Q_i = total activity of radionuclide "i" handled during time t_y (7.25E+06 Ci)

t_y = work duration as a fraction of a work-year (2 wks=0.04)

DAC_i = Job appropriate DAC as uCi/ml (2E-11 uCi/ml)

- **If Q_i </= the product of initial screening, air sampling is not required.**
- **If Q_i > the product of initial screening, detailed screening required.**

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Initial Screening for Applicability

$$Q_i > 2.4E+13*DAC_i*t_y$$

7.25E+06 > 23 is true, therefore, detailed screening is required.

Detailed Screening

Detailed Screening:

$$v_i = [(4.17E\text{-}14)*(Q*R*C*D)] / (DAC*t_y)$$

where: **values are given as for the internal dose evaluation and initial screening calculation. The level of sampling/monitoring depends on how high the value is as summarized in the Airborne Hazard Decision Matrix. In this case:**

$$v_i = [(4.17E\text{-}14)*(7.25E{+}06*0.01*0.001*2] /(2E\text{-}11*0.04)$$

$$v_i = 7.6$$

Airborne Hazard Decision Matrix

Air Sampling Threshold Coefficients	Required Air Sampling Actions	Potential Requirements, Best-Practice Air Sampling Actions
<1	Not Required Generally, see Potential Requirements	General Area Sampling
		Assessment of Engineered Controls Required
1 to <2	General Area Sampling	BZ (May be required for very short jobs, E.G. <1 h)
	Assessment of Engineering Controls	Bioassay

Airborne Hazard Decision Matrix

Air Sampling Threshold Coefficients	Required Air Sampling Actions	Potential Requirments, Best-practice Air Sampling Actions
2 to <30	General Area Sampling	Continuous Air Monitoring
	BZ/ Bioassay	Evaluate need for additional Work controls (ARA consideration of Resp. Protection and air sampling for down-post)
	Assessment of Engineered Controls	
30 or Greater	General Area Sampling	
	BZ/ Bioassay	
	Respiratory Protection	
	Continuous air monitoring (potential for 40 DAC hr/week)	
	Evaluate need for additional Work Controls	
	Post as ARA (air sampling for down-post)	

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Air Sampling

- Personal air sampling chosen for:
  - Dose evaluation (bioassay as warranted)
  - Area conditions
  - Engineered controls integrity
  - Posting (air concentrations relative to DAC)
- CAMs chosen for:
  - Engineered controls integrity
  - Warn workers of airborne threat
- High Vol. sampling chosen for:
  - Posting/release of respiratory protection
- CAM locations were chosen based on likely breach points in conjunction with qualitative smoke testing

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Air Monitoring Challenge

- **CAMs are typically set up for plutonium, a ROI upper boundary set at ~ 5.5 MeV (channel 121).**
- **^{244}Cm, significant for this work, has primary alpha emission at 5.8 MeV (channel 129).**
- **The first ^{222}Rn daughter, ^{218}Po, has an alpha energy of 6.0 MeV (channel 134).**
- **Setting up the ROIs to discriminate between the tail of the ^{218}Po and a true ^{244}Cm release was problematic.**

Upper boundary of ROI 1 (detection region) set at channel 129, the lower end of ROI 2 (^{218}Po region) at 132.

Air Monitoring Challenge

A concern remained about potential false positives.

- **CAMs operated ~3 weeks prior to project during mock-ups.**
- **CAM filters collected daily, equivalent to expected work iterations then a separate filter for the balance of a 24 hour period.**
- **Each filter field counted then later, to assess typical radon levels on the filters- thus establishing background.**
- **Same analysis process carried out for lapel samples.**
- **With each CAM filter collection, data values from ROI 1 through ROI 5 logged and data in those ROIs zeroed out.**

Air Monitoring Challenge

Based on the background data collected:

- **Range for background values known w/r CAM filters and PAS filters based on an initial field counts.**
- **Assessment of ROI data provided correlations for field identification of release precursor conditions:**

"we may be on the brink of containment failure if…"

ROI 1/ROI 2 ratio > 2

ROI 3/ROI 1 ratio < 3

ROI 1 count rate > 5 cpm

Additional CAM Headaches

- Archaic CAM software didn’t allow algorithm adjustments that would better assure proper response to a curium release.
- False alarms clearly not related to airborne radioactivity conditions.

False alarms were moderated by placing CAMs on dedicated UPS systems & minimizing radio communications.

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General Summary and Comments

- **Engineered upgrades value added considering:**
  - **Worker confidence,**
  - **Project outcome,**
  - **Upgraded facility for future operations.**
- **Modified NUREG 1400 approach instrumental for:**
  - **Determining air sampling needs,**
  - **Providing a reasonable "a priori" dose estimate.**
- **Dealing with nuclides such as isotopes of curium offer special challenges for the HP professional.**

General Summary and Comments

- No airborne radioactivity alarms during the job
- Monitor readouts never approached conditions that we believed to be a leading indicator of a release.
- None of the field counts of air filters exceeded the “a priori” derived background values.
- Surface/air survey data were consistent, indicating that we had no airborne releases.
- Validation of the ROI method to predict impending releases not confirmed by actual airborne conditions.
- The affect of a wetter climate is also an unknown.

Summary and Comments

NUREG 1400

- For this project, we used off-table values for C and D.
- From our experience, confinement for a general duty metal/plexiglass glovebox tracks with a C = 0.01.
- With the upgrades of our glovebox consistent with ASTM guidance, using cut resistent gloves and bag-in/bag-out techniques, we justified C = 0.001.
- Also relevant was the fact that respiratory protection was used for higher risk activities (PAPR).
- Based on mobility of high specific alpha TRU, D = 1 probably non-conservative so we doubled it, D = 2.

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Summary and Comments

NUREG 1400

- All air sampling indications as well as swipe results for the project were negative.
- Based on MDAs for filter analysis, likely worker CED < 1 mrem. Calculated potential CED was 32 mrem.
- Due to inner packaging and powder versus solid assumptions (a priori uncertainties), a true release fraction “R” is likely 1-2 orders of magnitude high.
- The true confinement factor may be somewhat better than C = 0.001, considering the upgrades made.

Summary and Comments

NUREG 1400

- NUREG methodology provides a defensible basis and a useful cornerstone upon which to frame an air sampling program.

- A revision is, however, strongly recommended and supported by Sandia National Laboratories.

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Summary and Comments

NUREG 1400 "Needs"

- Address discontinuous, short term and evolving operations, not just production line work.
- More detail regarding the use of the modifying factors, and more value options.
- Discussion of use and justification for applying off-table values along with examples of their application.
- Discussion of "representativeness" in sampling
- More detail regarding sampler placement w/r purpose.
- Updating discussions on air sampling systems.