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**WASTE DRUM GAS GENERATION SAMPLING PROGRAM
AT ROCKY FLATS DURING FY 1989**

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SUBJECT DESCRIPTORS

G Values
Gas Generation
Hydrogen Permeability
Transuranic (TRU) Waste

EG&G ROCKY FLATS, INC.
ROCKY FLATS PLANT
P. O. BOX 464
GOLDEN, COLORADO 80402-0464

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WASTE DRUM GAS GENERATION SAMPLING PROGRAM AT ROCKY FLATS DURING FY 1989

D. K. Roggenthen and R. G. Nieweg

ABSTRACT

Rocky Flats Plant transuranic waste drums were sampled for gas composition. Glass, metal, graphite, and solidified inorganic sludge transuranic waste forms were sampled. A vacuum system was used to sample each layer of containment inside a waste drum, including individual waste bags. G values were calculated for the waste drums. $G(H_2)$ was below 0.6 and $G(Total)$ was below 1.3 for all waste forms discussed in this report.

INTRODUCTION

Rocky Flats Plant (RFP) transuranic (TRU) waste will be shipped in the TRUPACT-II container to the Waste Isolation Pilot Plant. The Nuclear Regulatory Commission issued a Certificate of Compliance for TRUPACT-II in August 1989 to allow shipment of waste. This report provides additional documentation for questions arising about gas generation of the waste material.

To answer questions about the concentration and composition of gas generation from waste material, actual gas compositions were requested to establish minimum and maximum values for hydrogen and organic solvents. Waste drums used in this study were RFP-generated waste drums stored at Idaho National Engineering Laboratory (INEL) and returned to RFP for examination. The waste forms are identified by item description code (IDC). The waste forms sampled contained glass, metal, graphite, and solidified inorganic sludge. Each containment layer inside the waste drum was punctured with a needle, and a gas sample was collected in gas-tight bottles and analyzed by mass spectrometry for inorganic and organic gases. The

G value was calculated; the G value estimates the amount of gas generated per 100 eV of absorbed energy.

EXPERIMENTAL PROCEDURE

Gas generation sampling was performed inside each layer of containment, including individual waste bags, in RFP-generated waste drums. The TRU waste was RFP-generated waste stored at INEL and returned for examination. The TRU waste consisted of metal, glass, graphite, and solidified inorganic sludges. All sampling was performed in the airlock of the Size Reduction Facility. A vacuum pump and sampling device (Figure 1) were used to obtain the samples. The sampling device was connected to the vacuum pump approximately 24 hours before beginning waste drum sampling. The sampling device was checked for leaks and repaired before sampling.

Sludge Waste Drum Sampling Procedure

The typical solidified sludge (IDC 001 and 007) waste drum contains a rigid liner, a polyethylene (PE) round-bottom bag, and a polyvinylchloride (PVC) bag. The sludge was inside the PVC bag. Figure 2 shows a sectioned diagram of a sludge drum and the sampling points. To sample the sludge waste drum, two people wearing full-face masks and protective clothing stood inside the SRF airlock. The waste drum was moved into the airlock and the drum lid was removed. The lid of the PVC rigid liner was punctured with an awl. The awl was removed as the needle on the sampling device was lowered into the same hole. A gas sample was then taken inside the rigid liner.

FIGURE 1. Sampling Device

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Next, the rigid liner lid was removed, exposing the round-bottom PE (outer) bag. The outer bag was pulled up and isolated to allow a gas sample to be taken between the outer bag and the PVC (inner) bag. The needle on the sampling device punctured the outer bag, and a gas sample was taken. Two-inch tape was placed over the area of the needle puncture to reseal the bag and prevent contamination of personnel. The outer and inner bag were pulled up and isolated to allow a gas sample to be taken between the inner bag and the waste material. The needle on the sampling device punctured both bags, and a gas sample was taken. Two-inch tape was placed over the area of the needle puncture on the outer bag. The needle hole on the inner bag was not sealed.

Normally, the rigid liner lid and drum lid would be replaced, and the drum would be sealed and returned to the waste custodian. However, plastic

FIGURE 2. Solidified Sludge Waste Drum

bag material was also taken from three different areas for each drum for hydrogen permeability measurements. The three areas were: (1) top half of the polyethylene bag, (2) air-contacted polyvinylchloride, and (3) sludge contacted polyvinylchloride. The plastic bag material was sampled inside the Size Reduction Facility. The sludge, rigid liner, and remaining bag material were repacked into different drums and then sealed and returned to the waste custodian.

The hydrogen permeability results were reported previously (RFP-4377).¹ This report also gives results for bag material sampled from drums discussed in another report (RFP-4311).²

Individual Waste Bag Sampling Procedure

The individual waste bag sampling procedure was used for all but two code types (IDC 001 and 007). The waste drums sampled usually contained a PE

round-bottom (outer) bag, a PVC (inner) bag, and individual packages of waste material wrapped inside small bags. For some of the waste forms, a rigid liner or cardboard liner was required before the PE round-bottom bag. For some waste forms, a PVC bag was not used. The individual waste bag sampling procedure followed the sludge waste drum sampling procedure except: (1) the outer bag was cut open after the gas sample was taken, and (2) the inner bag was cut open after the gas sample was taken. With the outer and inner bags open, individual waste bags were removed from the drum one at a time. The waste was usually contained within two plastic bags. The plastic bag's material varied, depending on origin of the waste.

The individual waste bags removed from the drum had an outer waste bag and an inner waste bag. The waste material was inside the inner waste bag. Figure 3 shows a sectioned diagram of the waste drum containing individual waste bags and the gas sampling points. A gas sample was collected between the outer waste bag and the inner waste

bag using the sampling device. The needle of the sampling device punctured the outer bag, and a gas sample was taken. Two-inch tape was placed over the area of the needle puncture. A gas sample was also collected between the inner bag and the waste. Two-inch tape was placed over the area of the needle puncture on the outer bag. The needle hole in the inner bag was not sealed.

Each individual waste bag was placed into a special 55-gallon drum for assay. The special 55-gallon drum was prepared by placing a cardboard box and a round cardboard piece inside the plastic-lined drum. The special 55-gallon drum was closed and assayed at the passive/active neutron (PAN) counter or the segmented gamma scanner (SGS) counter. With such small amounts of waste per drum, by positioning the individual waste bag in the center third of the drum, an assay with less reflective background was obtained. The above procedure was followed for each waste bag sampled.

FIGURE 3. Sectioned Combustible Waste Drum

Gas Sampling Procedure

A gas sample was collected inside a 10-mℓ evacuated sampling bottle. The sampling device shown in Figure 1 consisted of a Cajon VCO^R connection to a 10-mℓ valved sampling bottle, a valved pressure gauge, a 0.5-micron sintered metal filter, a valve before the vacuum pump, and a valved syringe needle. The sampling device was connected to the vacuum pump before sampling any waste drum and evacuated to <30 microns of mercury. The sampling device was evacuated to <50 microns of mercury between samples. The gas sample was taken using the needle of the sampling device to puncture the plastic bag.

For sampling, the valves on the sampling manifold (Figure 1) were positioned in the following order:

1. Pressure gauge valve (V2) was open
2. Vacuum valve (V3) was shut
3. Needle was inserted through the plastic bag
4. Needle valve (V4) was opened
5. Sample bottle valve (V5) was opened

The gas sample was collected once the sample bottle was filled. The valves were positioned in the following order to replace the filled sample bottle with an empty sample bottle:

1. Needle valve (V4) was closed
2. Sample bottle valve (V5) was closed
3. Vacuum valve (V3) was closed
4. Filled sample bottle was removed
5. Empty sample bottle was attached
6. Sample bottle valve (V5) was opened
7. Pressure gauge valve (V2) was closed
8. Vacuum valve (V3) was opened
9. Pressure gauge valve (V2) was reopened approximately one to two minutes after opening V3.

The vacuum evacuated the sampling device and bottle to <80 microns of mercury. The sample bottle valve (V2) was closed. The sampling device was then prepared for the next sample

Drum Assay and G Value Calculation Requirements

To calculate the drum assay and the G value for each waste drum, the following information was required. If the waste form was a sludge or did not contain individual bags of waste, the entire waste drum was assayed in the PAN or SGS counter. The individual waste bags were weighed on a platform scale. Individual waste bag dimensions of circumference and length were also taken. If the waste drum contained individual waste bags, the bags were sampled and repackaged into a 55-gallon drum for assaying at the PAN or SGS counter. Any unsampled waste bags in the original waste drum were also repackaged and assayed in the PAN or SGS counter.

The PAN drum counter gives results in passive and active mass (grams). The active mass was usually the value used in the drum assay calculations. The SGS drum counter gives results in grams of radioactive element per gram of waste.

Sludge drums were measured for the amount of free space available inside the rigid liner. The type

of rigid liner was also determined. For filtered drums, the carbon composite filters have a minimum diffusion coefficient of 1.9×10^{-6} moles/sec/mole fraction of hydrogen. The minimum diffusion coefficient for hydrocarbons was six orders of magnitude lower and considered insignificant. The minimum diffusion coefficient was determined at standard pressure and 23 °C (Reference 3). Information about the waste drums is summarized in Table 1 for sludges and Table 2 for packaged waste.

Using information from above, the drum assay was calculated. The drum assay is the total alpha activity from inside a drum or the sum of all individual waste bags inside a drum. The total alpha activity was calculated by multiplying the specific activity of each radioactive element by the weight of each radioactive element. The specific activity (curie per gram) is a constant. The specific activity values were taken from the Solid Waste Information Management System data base. For the PAN counter, the weight of each radioactive element was calculated from the active mass value reported by the PAN counter. For the SGS counter, the weight of each radioactive element was calculated from the grams of radioactive element per gram of waste multiplied by the weight of the waste. The active mass value was assumed to be only plutonium unless an analysis of the waste form or the origin of the waste gave additional information on americium or uranium content.

The waste drum void volume was also calculated. The total drum void volume includes:

- Space between the rigid liner and the 55-gallon drum
- Inside the rigid liner, the space above the sludge or outside of the individual waste bags
- Void space inside the individual waste bags.

RFP specifications were used to obtain dimensional information for the rigid liners and the 55-gallon drum. Knowing the type of rigid liner (I, II, or III), the void space between the inside of the 55-gallon drum and the outside of the rigid liner was

TABLE 2. Packaged Waste Gas Sample

DRUM NUMBER	IDC CODE	SAMPLING DATE	DATE DRUM FILLED	GROSS WEIGHT (kg)	DRUM VENTED	DRUM ASSAY			PACKAGE DIMENSIONS (CIR. X WIDTH) (inch X inch)	LINER VOID SPACE (DEPTH) (inch)	GAS SAMPLE ANALYSIS						
						Pu (gm)	Am (gm)	U (gm)			CO2 (VL%)	N2 (VL%)	Ar (VL%)	O2 (VL%)	H2 (VL%)	CH4 (VL%)	NOx (VL%)
002800658	440	11-3-88	9-28-82	79.5	YES	14.0 7.2					0.2	77.9	0.9	20.6			
				2.08					21 x 12		0.2	77.8	0.9	20.7	TRACE		
				1.485					23 x 9.5		0.2	77.6	0.9	20.8	TRACE		
				1.38					18 x 11		0.2	77.4	0.9	21.1			
				2.17					22 x 9		0.2	77.6	0.9	21.0	TRACE		
				2.745					21 x 15		0.1	78.1	0.9	20.7			
				1.595					22 x 15		0.1	77.4	0.9	21.4			
				1.52					22.5 x 11		0.1	77.6	0.9	21.1	TRACE		
				1.58					18 x 10		0.1	77.2	0.9	21.5			
				1.88					21 x 12		0.2	78.0	0.9	20.5			
				2.85					24 x 11		0.1	77.5	0.9	21.2			
				3.9					21 x 12		0.2	77.5	0.9	20.8	0.1		
				3.105					24 x 16		0.1	77.8	0.9	20.9			
				1.52					14 x 8.5		0.2	78.0	0.9	20.5			
				2.085					21 x 12		0.2	77.9	0.9	20.7			
				1.5					24 x 10		0.2	77.0	0.9	21.4	0.1		
				0.705					15 x 9		0.1	77.9	0.9	20.9			
				1.83					22.5 x 18		0.2	77.6	0.9	20.9			
				2.16					23 x 11		0.1	77.5	0.9	20.8	TRACE		
				2.615					26 x 10		0.2	77.8	0.9	20.6	TRACE		
				4.38					19 x 9; 13 x 10 17 x 11; 18 x 10; 13.5 x 8		0.2	77.4	0.9	21.0	TRACE		
											0.2	77.4	0.9	21.1			
											0.1	77.5	0.9	21.3			
											0.2	77.2	0.9	21.4	0.1		
											0.2	77.6	0.9	20.9	TRACE		
											0.1	78.0	0.9	20.7			
											0.2	77.7	0.9	20.9	0.1		
											0.2	77.4	0.9	21.1			
											0.2	77.7	0.9	20.8			
											0.2	77.2	0.9	21.3	TRACE		
											0.2	77.8	0.9	20.8	TRACE		
											0.2	77.4	0.9	21.0			
											0.1	77.8	0.9	20.9	TRACE		
											0.2	77.5	0.9	21.1	TRACE		
											0.1	77.4	0.9	21.2	0.1		
											0.2	78.0	0.9	20.5	TRACE		
											0.1	77.4	0.9	21.3			
											0.2	77.6	0.9	20.9	TRACE		
											0.2	77.6	0.9	20.9	TRACE		
242533	480	11-10-88	2-21-84	92.7	NO	30 26					4.0	88.5	1.1	1.7	3.7	0.2	0.2
											4.1	89.4	1.0	0.5	3.9	0.3	0.2
				1.02					17.5 x 9		4.1	90.0	1.1	1.3	3.8	0.3	0.1
				1.84					18 x 10		4.4	89.1	1.1	1.3	3.6	0.3	0.1
				1.915					21 x 20		4.3	89.4	1.1	0.4	3.8	0.3	0.2
				0.86					21 x 10		2.1	83.5	1.0	11.3	1.6	0.1	0.1
				1.39					20 x 10		3.7	89.0	1.1	2.2	3.4	0.2	0.1
				0.56					20 x 6		3.6	87.4	1.0	4.3	2.8	0.2	0.1
				1.685					17.5 x 9		4.2	89.2	1.1	0.5	3.9	0.3	0.2
				1.035					27.5 x 9		2.6	84.9	1.0	8.9	2.0	0.1	0.1
											4.3	89.4	1.1	0.5	3.9	0.3	0.1
											1.7	83.1	1.0	12.2	1.4	0.1	0.2
											4.2	89.2	1.1	0.9	3.9	0.3	0.1
											4.1	89.3	1.1	1.0	3.7	0.3	0.1
											4.3	89.8	1.1	0.2	3.8	0.3	0.1
											1.6	81.8	1.0	13.9	1.4	0.1	TRAC
											4.3	89.0	1.1	1.3	3.6	0.3	0.1

BLE 2. Packaged Waste Gas Sample

GAS SAMPLE ANALYSIS										SAMPLE LOCATION	WASTE BAG CONTENTS	GENERAL COMMENTS
?	N2 (VL%)	Ar (VL%)	O2 (VL%)	H2 (VL%)	CH4 (VL%)	NOx (VL%)	CO (VL%)	TRIC (VL%)				
2	77.9	0.9	20.6					0.4		RIGID LINER		TYPE 11 RIGID LINER
2	77.8	0.9	20.7	TRACE				0.4		OUTER BAG		
2	77.6	0.9	20.8	TRACE				0.5		OUTER WASTE BAG		
2	77.4	0.9	21.1					0.4		INNER WASTE BAG	LEAD TAPED GLASSWARE	WASTE BAG REPACKAGED
2	77.6	0.9	21.0	TRACE				0.3		OUTER WASTE BAG		
1	78.1	0.9	20.7					0.2		INNER WASTE BAG	LEAD TAPED GLASSWARE	WASTE BAG REPACKAGED
1	77.4	0.9	21.4					0.2		OUTER WASTE BAG		
1	77.6	0.9	21.1	TRACE				0.3		INNER WASTE BAG	LEAD TAPED GLASSWARE	WASTE BAG REPACKAGED
2	77.2	0.9	21.5					0.3		OUTER WASTE BAG		
2	78.0	0.9	20.5					0.4		INNER WASTE BAG	LEAD TAPED GLASSWARE	WASTE BAG REPACKAGED
1	77.5	0.9	21.2					0.3		OUTER WASTE BAG		
2	77.5	0.9	20.8	0.1				0.5		INNER WASTE BAG	LEAD TAPED GLASSWARE	WASTE BAG REPACKAGED
2	77.8	0.9	20.9					0.3		OUTER WASTE BAG		
2	78.0	0.9	20.5					0.4		INNER WASTE BAG	LEAD TAPED GLASSWARE	WASTE BAG REPACKAGED
2	77.9	0.9	20.7					0.3		OUTER WASTE BAG		
2	77.0	0.9	21.4	0.1				0.4		INNER WASTE BAG	LEAD TAPED GLASSWARE	WASTE BAG REPACKAGED
1	77.9	0.9	20.9					0.2		OUTER WASTE BAG		
2	77.6	0.9	20.9					0.4		INNER WASTE BAG	GLASS VIALS	WASTE BAG REPACKAGED
1	77.5	0.9	21.4					0.1		OUTER WASTE BAG		
1	77.8	0.9	20.8	TRACE				0.4		INNER WASTE BAG	CLOSED PLASTIC BOTTLE	WASTE BAG REPACKAGED
2	77.5	0.9	20.9					0.5		OUTER WASTE BAG		
3	77.7	0.9	20.6	TRACE				0.5		INNER WASTE BAG	LEAD TAPED GLASSWARE	WASTE BAG REPACKAGED
2	77.6	0.9	21.0	TRACE				0.3		OUTER WASTE BAG		
2	77.4	0.9	21.1					0.4		INNER WASTE BAG	CLOSED PLASTIC BOTTLE	WASTE BAG REPACKAGED
1	77.5	0.9	21.3					0.2		OUTER WASTE BAG		
2	77.2	0.9	21.4	0.1				0.2		INNER WASTE BAG	LEAD TAPED GLASSWARE	WASTE BAG REPACKAGED
2	77.6	0.9	20.9	TRACE				0.4		OUTER WASTE BAG		
1	78.0	0.9	20.7					0.3		INNER WASTE BAG	LITTLE GLASS BOTTLES	WASTE BAG REPACKAGED
2	77.7	0.9	20.9	0.1				0.2		OUTER WASTE BAG		
2	77.4	0.9	21.1					0.4		INNER WASTE BAG	CLOSED PLASTIC BOTTLE	WASTE BAG REPACKAGED
2	77.7	0.9	20.8					0.4		OUTER WASTE BAG		
2	77.2	0.9	21.3	TRACE				0.4		INNER WASTE BAG	10 ML TEST TUBES	WASTE BAG REPACKAGED
CE	77.8	0.9	20.8	TRACE				0.4		OUTER WASTE BAG		
2	77.4	0.9	21.0					0.5		INNER WASTE BAG	10 ML TEST TUBES	WASTE BAG REPACKAGED
1	77.8	0.9	20.9	TRACE				0.3		OUTER WASTE BAG		
2	77.5	0.9	21.1	TRACE				0.3		INNER WASTE BAG	10 ML TEST TUBES	WASTE BAG REPACKAGED
1	77.4	0.9	21.2	0.1				0.3		OUTER WASTE BAG		
2	78.0	0.9	20.5	TRACE				0.4		INNER WASTE BAG	LITTLE GLASS BOTTLES	WASTE BAG REPACKAGED
1	77.4	0.9	21.3					0.3		OUTER WASTE BAG		
2	77.6	0.9	20.9	TRACE				0.4		INNER WASTE BAG	10 ML TEST TUBES	WASTE BAG REPACKAGED
2	77.6	0.9	20.9	TRACE				0.4			3 PKGS 10 ML TEST TUBES & 2 PKGS SMALL GLASS BOTTLES	ALL 5 WASTE BAGS REPACKAGED
10	88.5	1.1	1.7	3.7	0.2	0.2	0.5	0.1		RIGID LINER		TYPE 11 RIGID LINER
1	89.4	1.0	0.5	3.9	0.3	0.2	0.5	0.1		OUTER BAG		ALL WASTE BAGS REPACKAGED
										INNER BAG		NOT SEALED COMPLETELY-NO SAMPLE
1	90.0	1.1	1.3	3.8	0.3	0.1	0.3	TRACE		ONLY WASTE BAG	VACUUM GAUGE	
4	89.1	1.1	1.3	3.6	0.3	0.1		0.1		OUTER WASTE BAG		
3	89.4	1.1	0.4	3.8	0.3	0.2	0.4	0.1		INNER WASTE BAG	LOOSE METAL PIECES	
1	83.5	1.0	11.3	1.6	0.1	0.1	0.3	TRACE		OUTER WASTE BAG		
7	89.0	1.1	2.2	3.4	0.2	0.1	0.2	0.1		INNER WASTE BAG	1/2 INCH TUBING	
6	87.4	1.0	4.3	2.8	0.2	0.1	0.5	0.1		OUTER WASTE BAG		
2	89.2	1.1	0.5	3.9	0.3	0.2	0.5	0.1		INNER WASTE BAG	ALUMINUM PAN	
6	84.9	1.0	8.9	2.0	0.1	0.1	0.3	0.1		OUTER WASTE BAG		
3	89.4	1.1	0.5	3.9	0.3	0.1	0.3	0.1		INNER WASTE BAG	UNKNOWN-TOO MUCH TAPE	
7	83.1	1.0	12.2	1.4	0.1	0.2	0.3	TRACE		OUTER WASTE BAG		
2	89.2	1.1	0.9	3.9	0.3	0.1	0.2	0.1		INNER WASTE BAG	ALUMINUM BALANCE PANS	
1	89.3	1.1	1.0	3.7	0.3	0.1	0.3	0.1		OUTER WASTE BAG		
3	89.8	1.1	0.2	3.8	0.3	0.1	0.3	0.1		INNER WASTE BAG	1/4 INCH METAL PLATE	
6	81.8	1.0	13.9	1.4	0.1	TRACE	0.2	TRACE		OUTER WASTE BAG		
3	89.0	1.1	1.3	3.6	0.3	0.1	0.2	0.1		INNER WASTE BAG	CRUSHED CANS	

TABLE 1. Solidified Sludge Waste Gas Sampling

DRUM NUMBER	IDC CODE	SAMPLING DATE	DATE DRUM FILLED	GROSS WEIGHT (kg)	DRUM VENTED	DRUM ASSAY			LINER VOID SPACE (DEPTH) (Inch)
						Pu (gm)	Am (gm)	U (gm)	
741204577	001	10-6-88	3-26-85	246	NO	6.4 6.	1.4		6.5
74703446	007	11-3-88	1-7-85	264	NO	.147 0	.05		6.5

DRUM NUMBER	GAS SAMPLE ANALYSIS						SAMPLE LOCATION	GENERAL COMMENTS
	CO2 (VLX)	N2 (VLX)	Ar (VLX)	O2 (VLX)	H2 (VLX)	H2O (VLX)		
741204577	0.1	69.9	0.8	28.6	0.5	0.1	RIGID LINER	TYPE II LINER
		66.4	0.8	31.7	0.9	0.2	OUTER BAG	
	0.1	78.1	0.9	20.9			INNER BAG	BROWNISH-RED TO BROWN COLORED SLUDGE
74703446	TRACE	88.2	1.1	10.6	0.1		RIGID LINER	TYPE II LINER
	TRACE	89.8	1.1	9.0	0.1		OUTER BAG	
		91.7	1.1	7.0	0.2		INNER BAG	CEMENT BETWEEN TWO BAGS

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TABLE 2. Packaged Waste Gas Sample Cor

DRUM NUMBER	ID CODE	SAMPLING DATE	DATE DRUM FILLED	GROSS WEIGHT (kg)	DRUM VENTED	DRUM ASSAY			PACKAGE DIMENSIONS (CIR. X WIDTH) (inch X inch)	LINER VOID SPACE (DEPTH) (inch)	GAS SAMPLE ANALYSIS					
						PU (pm)	Am (pm)	U (pm)			CO2 (VL%)	N2 (VL%)	A ^a (VL%)	O2 (VL%)	H2 (VL%)	CH4 (VL%)
				5.355					27.5 x 9		3.1	86.0	1.0	6.6	2.6	0.2
				2.285					17 x 13		3.4	86.9	1.0	4.4	3.4	0.2
				7.585					20.5 x 15		3.6	87.4	1.0	4.9	2.9	0.2
				3.195					21 x 12		3.9	88.1	1.1	2.3	3.5	0.3
				0.48					15 x 9		2.3	84.1	1.0	10.2	1.9	0.1
				0.79					17 x 6		3.2	86.5	1.0	6.0	2.7	0.2
				0.985					16 x 9		2.9	86.0	1.0	6.7	2.6	0.2
				3.02					24 x 13		4.0	88.3	1.1	2.2	3.5	0.3
				1.00					12 x 9		2.0	83.2	1.0	11.6	1.5	0.1
				2.265					20 x 7		4.1	89.0	1.1	2.3	3.1	0.2
				1.635					16.5 x 9		2.3	84.8	1.0	9.9	1.3	0.1
				1.655					17 x 11		4.2	89.8	1.1	1.1	3.2	0.3
				17.93					17 x 6; 20 x 11 20 x 11; 10 x 8 13 x 5.5;		2.6	84.7	1.0	8.9	2.1	0.2
											2.8	90.7	1.1	2.5	2.3	0.2
											2.6	85.1	1.1	8.5	2.1	0.1
											4.1	88.6	1.1	1.5	3.7	0.2
											1.6	81.7	1.0	14.3	1.1	0.1
											4.0	89.4	1.0	1.5	3.4	0.2
											2.3	84.4	1.0	10.2	1.5	0.1
											3.9	90.1	1.1	0.7	3.5	0.3
											1.8	83.1	1.0	12.8	0.9	0.1
											4.4	89.3	1.1	1.0	3.6	0.3
											2.4	84.9	1.0	9.9	1.3	0.1
											4.2	89.6	1.1	0.8	3.6	0.3
234906	480	1-27-89	2-21-84	49	NO	11.0	0.0				0.3	77.9	0.9	20.9		
						6.0					0.3	78.2	0.9	20.6		
				5.365					33 L x 50 CIR		0.3	78.0	0.9	20.8		
				7.495					20 L x 52 CIR		0.3	78.2	0.9	20.6		
											0.4	78.6	0.9	20.1		
											0.4	78.0	0.9	20.7	TRACE	
											0.4	78.6	0.9	20.0	0.1	
3201073	300	1-27-89	12-5-83	80.7	NO	15.0	0.0			19.0	0.6	81.2	0.9	16.8	0.5	
											0.7	80.9	0.9	17.0	0.5	
											0.6	80.8	0.9	17.3	0.4	
											0.7	81.2	0.9	16.7	0.5	

* TRIC = 1,1,1 Trichloroethane

BLE 2. Packaged Waste Gas Sample Concluded

ID	GAS SAMPLE ANALYSIS									SAMPLE LOCATION	WASTE BAG CONTENTS	GENERAL COMMENTS
	CO2 (V/L)	N2 (V/L)	Ar (V/L)	O2 (V/L)	H2 (V/L)	CH4 (V/L)	NOx (V/L)	CO (V/L)	TRIC (V/L)			
3.1	86.0	1.0	6.6	2.6	0.2	0.1	0.3	0.1	0.1	OUTER WASTE BAG	HEAVY CASTING	WASTE MARKED WITH 330 IDC
3.4	86.9	1.0	4.4	3.4	0.2	0.2	0.4	0.1	0.1	INNER WASTE BAG		
3.6	87.4	1.0	4.9	2.9	0.2	0.1		0.1	0.1	OUTER WASTE BAG	UNKNOWN - TAPED	
3.9	88.1	1.1	2.3	3.5	0.3	0.2	0.5	0.1	0.1	INNER WASTE BAG		
2.3	84.1	1.0	10.2	1.9	0.1	0.1	0.2	0.1	0.1	OUTER WASTE BAG	UNKNOWN - TAPED	
3.2	86.5	1.0	6.0	2.7	0.2	0.1	0.2	0.1	0.1	INNER WASTE BAG		
2.9	86.0	1.0	6.7	2.6	0.2	0.1	0.4	0.1	0.1	OUTER WASTE BAG	POLY BOTTLE/W METAL	
4.0	88.3	1.1	2.2	3.5	0.3	0.2	0.3	0.1	0.1	INNER WASTE BAG		
2.0	85.2	1.0	11.6	1.5	0.1	0.1	0.5			OUTER WASTE BAG	UNKNOWN	
4.1	89.0	1.1	2.3	3.1	0.2	0.1		0.1	0.1	INNER WASTE BAG		
2.3	84.8	1.0	9.9	1.3	0.1	0.1	0.4	0.1	0.1	OUTER WASTE BAG	PINT CONTNER/W METAL	
4.2	89.8	1.1	1.1	3.2	0.3	0.2		0.1	0.1	INNER WASTE BAG		
2.6	84.7	1.0	8.9	2.1	0.2	0.1	0.3	0.1	0.1	OUTER WASTE BAG	UNKNOWN - TAPED	
2.8	90.7	1.1	2.5	2.3	0.2	0.1	0.2	0.1	0.1	INNER WASTE BAG		
2.6	85.1	1.1	8.5	2.1	0.1	0.1	0.3	0.1	0.1	OUTER WASTE BAG	UNKNOWN - TAPED	
4.1	88.6	1.1	1.5	3.7	0.2	0.1	0.6	0.1	0.1	INNER WASTE BAG		
1.6	87.7	1.0	14.3	1.1	0.1	TRACE	0.2	TRACE	0.1	OUTER WASTE BAG	METAL TUBE	
4.0	89.4	1.0	1.5	3.4	0.2	0.1	0.3	0.1	0.1	INNER WASTE BAG		
2.3	84.4	1.0	10.2	1.5	0.1	0.1	0.3	0.1	0.1	OUTER WASTE BAG	CRUSHED CAN	
3.9	90.1	1.1	0.7	3.5	0.3	0.3		0.1	0.1	INNER WASTE BAG		
1.8	85.1	1.0	12.8	0.9	0.1	0.1	0.1	0.1	0.1	OUTER WASTE BAG	METAL RINGS-FLATTENED	
4.4	89.3	1.1	1.0	3.6	0.3	0.1	0.1	0.1	0.1	INNER WASTE BAG		
2.4	84.9	1.0	9.9	1.3	0.1	0.1	0.2	0.1	0.1	OUTER WASTE BAG	METAL RINGS-FLATTENED	DOUBLE REPACKAGING
4.2	89.6	1.1	0.8	3.6	0.3	0.1	0.2	0.1	0.1	INNER WASTE BAG		
VACUUM GAUGE, 3 PKGS UNKNOWN-TAPED, 2PKGS PLASTIC BOTTLE/W KNIVES, 3 PKGS 1/2IN. METAL TUBING THIN METAL STRIP, FLOOR DRAIN FLANGE, DOOR CLOSING MECHANISM, 2 BOLTS INSIDE 2 GLOVES, PRESSURE GAUGE, PRESSURE REGULATOR, METAL RINGS, ALPHA MET BACKS, "HOT METAL" LABELLED TAPE, PIPE PLUG, UNKNOWN, KNIFE, FLATTENED METAL RINGS											TYPE III RIGID LINER	
0.3	77.9	0.9	20.9							RIGID LINER		
0.3	78.2	0.9	20.6							OUTER BAG		
0.3	78.0	0.9	20.8							INNER BAG		
0.3	78.2	0.9	20.6							OUTER WASTE BAG		
0.4	78.6	0.9	20.1							INNER WASTE BAG		
0.4	78.0	0.9	20.7	TRACE						OUTER WASTE BAG		
0.4	78.6	0.9	20.0	0.1						INNER WASTE BAG		
RIGID LINER												
0.6	81.2	0.9	16.8	0.5						OUTER BAG		
0.6	80.8	0.9	17.3	0.4						INNER BAG		
0.7	81.2	0.9	16.7	0.5						O-RING BAG		
LARGE GRAPHITE CHUNKS												
TRIC = 1,1,1-Trichloroethane												

* TRIC = 1,1,1 Trichloroethane

calculated. The three types of rigid liners have approximately the same outside volume, but the lid closure method varied. The inside dimensions of each rigid liner type was obtained for purposes of calculating the void space outside the individual waste bags or above the sludge. When individual waste bags were combined into one drum for assay, the package dimension was used and totaled.

The solidified sludge waste was assumed to contain no void space. The void space for the individual waste bags was determined by subtracting the volume of the individual waste bag from the volume of waste. Individual waste bags were assumed to be right circular cylinders for volume calculations. The volume of waste was determined dividing density of the waste into the weight of an individual package or the net weight of the drum. A density was calculated for lead-taped glassware assuming the lead tape was 25% by weight. A density was also calculated for metal objects inside paper or plastic containers by assuming a weight for the container from previous measurements.

The G value was calculated from the above information. G values are obtained by dividing the amount of gas generated per 100 eV of absorbed energy. All calculations used standard pressure and room temperature (23 °C, 74 °F). Moles of gas generated were calculated from the ideal gas law based on void volume of the drum, diffusion rate of hydrogen from filtered drums, and analytical results. The moles of gas were calculated for hydrogen, carbon dioxide, and the total of all nonchlorinated compounds except nitrogen, argon, and oxygen. Except for individual waste bags, the highest total analytical results were used. Changes in oxygen concentration were not accounted for in these calculations. Absorbed energy is calculated from the total alpha activity calculations and the length of time since the drum had been sealed. G values for each drum were calculated from:

$$G = \frac{\text{moles gas} \times (6.02 \times 10^{23} \text{ molecules/mole})}{[(\text{curie Pu}) \times (5.23 \times 10^4 \text{ 100 eV/dist}) + (\text{curie Am}) \times (5.64 \times 10^4 \text{ 100 eV/dist})] \times (\text{days drum sealed}) \times (3.7 \times 10^{10} \text{ dist/s-Ci}) \times (8.64 \times 10^4 \text{ s/day})}$$

RESULTS AND DISCUSSION

Six drums of waste were sampled for gas generation composition. They included one drum each of glass (IDC 440), graphite (IDC 300), and two drums each of metal (IDC 440) and inorganic solidified sludge (IDC 001 and 007). G values were not calculated for a graphite drum because of incomplete assay information.

G value limits have been set for the materials being shipped inside TRUPACT-II. The upper bounding G values for flammable gas are 3.1 and 4.1 for the TRUPACT-II.⁴ The flammable gas G value includes hydrogen, methane, and ethane. The maximum G (Flam Gas) calculated was 3.1 for solid organic materials packaged in cardboard and plastic. Materials with a calculated G (Flam Gas) greater than 4.1 are not allowed in quantities greater than 1 wt % for TRUPACT-II shippable waste.

The G(H₂) and G(Total) values for the inorganic solidified sludge ranged from 0.001 to 0.002 and 0.001 to 0.002, respectively. The G(H₂) and G(Total) values for the metal, glass, and graphite waste drums ranged from 0.036 to 0.553 and 0.181 to 1.289, respectively. The G value would not prevent shipment of any of these drums even though most were not vented. All calculated values for the waste drums are shown in Table 3. The inorganic solidified sludge G values compare favorably to previously reported values G(H₂) from 0.005 to 0.019 and G(Total) from 0.006 to 0.020.²

Possible assumptions that could introduce some error into the G value calculation are:

- All gases remained inside a non-filtered sealed drum with a semi-permeable gasket.
- Gas composition remained the same from the day the drum was closed until sampled.
- Individual waste bags were accumulating in the drum before closing.
- All the radiologic decay on the waste inside individual waste bags contacted the plastic material.⁵

TABLE 3. Waste Drum Gas Sampling Results

DRUM NUMBER	IDC CODE	SAMPLING DATE	DATE DRUM FILLED	DRUM VENTED	CALCULATED DRUM ASSAY (Ci/drum)	CALCULATED VOID VOL (liter)	CALCULATED G VALUE		
							G(H ₂)	G(CO ₂)	G(TOT)
741204577	001	10-6-88	3-26-85	NO	30.78	60.3	0.002	0.0	0.0019
74703446	007	11-3-88	1-7-85	NO	7.4122	60.5	0.001	0.0	0.001
002800658	440	11-3-88	9-28-82	YES	0.37	196.30	0.226	0.01	0.236
242533	480	11-10-88	2-21-84	NO	1.01	203.99	0.553	0.595	1.289
234906	480	1-27-89	2-21-84	NO	0.3717	200.17	0.036	0.145	0.181
3201073	300	1-27-89	12-5-83	NO	NA	179.5		NA	

Error can also be introduced into the G value calculation because of analytical and PAN or SGS drum assay error.

CONCLUSIONS AND RECOMMENDATIONS

The information in this report covers gas generation by RFP waste. RFP-generated waste has varying concentrations of hydrogen, carbon dioxide, various hydrocarbons, and nitrogen oxides in the headspace and individual waste bags in the six drums sampled. The calculated G(H₂) and G(Total) values for the six drums did not exceed any bounding G value. The G(Total) for inorganic solidified sludge ranged from 0.001 to 0.002. The G(H₂) for inorganic solidified sludge ranged from 0.001 to 0.0019. The G(Total) for metal, glass, and graphite waste drums ranged from 0.181 to 1.289. The G(H₂) for waste bag drums ranged from 0.036 to 0.553. The G values for inorganic solidified sludge compare favorably to previously reported values.²

Possible assumptions that could introduce some error into the G value calculation are:

- All gases remained inside a non-filtered sealed drum with a semi-permeable gasket.
- Gas composition remain the same from the day the drum was closed until sampled.
- Individual waste bags were accumulating in the drum before closing.
- All the radiologic decay on the waste inside individual waste bags contacted the plastic material.⁵

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3. *Safety Analysis Report for the TRUPACT-II Shipping Package Docket Number 71-9218, Appendix 3.6.9 - Gas Release Assessment, Nuclear Packaging, Inc., Seattle, WA, February 1989.*
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