276
12-14-77

Lh. 1669

MLM-2463

MLM-2463

MASTER

Volume Reduction System for Solid and Liquid TRU Waste from the Nuclear Fuel Cycle: April-June 1977

Don F. Luthy and William H. Bond

November 30, 1977

ef

Monsanto

MOUND FACILITY

Miamisburg, Ohio

operated by

MONSANTO RESEARCH CORPORATION

a subsidiary of Monsanto Company

for the

U. S. DEPARTMENT OF ENERGY

Contract No. EY-76-C-04-0053

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

PRINTED IN THE UNITED STATES OF AMERICA

Available from
National Technical Information Service
U. S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161
Price: Printed Copy \$4.00; Microfiche \$3.00

Volume Reduction System for Solid and Liquid TRU Waste from the Nuclear Fuel Cycle: April-June 1977

Don F. Luthy and William H. Bond

Issued: November 30, 1977

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

MOUND FACILITY

Miamisburg, Ohio 45342

operated by

MONSANTO RESEARCH CORPORATION

a subsidiary of Monsanto Company

for the

U. S. DEPARTMENT OF ENERGY

Contract No. EY-76-C-04-0053

REA

Abstract

The Cyclone Incinerator development this quarter was concentrated on testing a particular liquid feed and burn system. The liquids tested were limited to tributyl phosphate in kerosene and oil-based vacuum pump oil. The tests established that the system worked as designed and built; that tributyl phosphate (TBP), as much as 30% by weight in kerosene, would burn readily; and that the scrubber system collects and neutralizes phosphoric acid which results from the combustion of TBP.

Ash immobilization studies included determinations of leach rates for cemented ash. Plutonium-238 was used as a doping agent for the detection of leaching.

Continuous Feed

One of the commitments under the TRU Waste Cyclone Drum Incinerator and Treatment System Project is to investigate the advantages and disadvantages of continuous feed to the incinerator burn chamber and to compare it with the batch (in situ) method. The feed system was designed, and fabrication is in progress. The principal areas of interest are the quantity of hydrocarbons and other by-products in the off-gas stream and the overall throughput of waste.

Liquid Feed

A major effort during the quarter was directed toward the addition and testing of a liquid burning capability to the cyclone incinerator system.

A commercial oil burner designed to burn all types of fuel oil was chosen as the

primary combustion unit. The cyclone air flow used for solid-batch incineration was not removed in order to provide for extended retention time in the high-temperature zone so that any necessary secondary combustion could be completed.

Some equipment changes were considered necessary or desirable. The steel-drum combustion chamber was modified with the installation of a castable refractory liner and an oil burner at the base of the drum. (See Figure 1) The resulting combustion chamber is much heavier to move than the solid waste chambers, but it will still permit an interchangeability of chambers, and thereby multiple fuel burning capabilities, with a minimum of effort. No changes were considered to be necessary in the off-gas handling system.

FIGURE 1 - Steel drum combustion chamber with oil burner at base.

A number of safety devices were installed to protect against a possible local concentration of flammable vapors. A propane pilot flame with autoignition was installed to initiate liquid burning. In the event that the oil flame is extinguished through blowout, feed cutoff, etc., an ultraviolet sensor automatically reignites this pilot flame.

Backup protection was provided by an H.N.U. Systems, Inc., photoionization gas monitor. (See Figure 2) This very sensitive instrument was used to close a valve on the liquid feed line in the event that a fraction (0.25) of the lower explosive limit of a combustible gas in the flue gas stream was detected.

An extraction solvent used extensively in the nuclear fuel cycle, 30% tributyl phosphate (TBP) in kerosene, was chosen for initial testing of the liquid burning system. Difficulties were anticipated in two areas when burning TBP: 1) TBP does not burn easily because of its high flash point and low vapor pressure and 2) the generation of phosphoric acid in the combustion reactions necessitates caustic scrubbing to prevent corrosive attack on the off-gas equipment.

Test burns showed that the TBP-kerosene mixtures burned readily in the percentages used. The only difficulty experienced was in cold ignition. It was found that igniting kerosene alone prior to feeding the

FIGURE 2 - Liquid feed system.

mixture resulted in a smoother initial burning of the mixture. The feed rate after ignition was 4 gal/hr.

A solution of potassium hydroxide was used in both the deluge tank and venturi scrubber to remove phosphates from the flue gas stream. As can be seen in Table 1, the scrubber system effectively removed phosphates from the off-gas.

Waste Container Compaction

A conceptional sketch (Figure 3) was prepared to illustrate the integration of the drum compaction process into the Cyclone Incinerator System. The concept concentrates upon waste stored in drums which cannot be recycled. Subsequent to incineration in the storage drum and ash removal, the drum is compacted to reduce volume and packaged for storage.

The drum compactor has been selected and is scheduled for purchase and installation in fiscal year 1978.

Selection of an Ash Immobilization Technique

During this quarter, efforts were concentrated on further studies of cemented incinerator ash and of ash fixation in pressed pellets.

Leach Rates

Seven concrete samples were doped with plutonium-238 for the measurement of plutonium leach rates (see Table 2). The samples were prepared by mixing Portland type 1A cement and distilled water with incinerator ash. The doping was accomplished by adding plutonium nitrate solution to the dry ash and heating to convert

Table 1 - TEST BURNS WITH TBP-KEROSENE MIXTURES

Run	PO ₄ ⁻³ Flue Gas (g)	PO ₄ ⁻³ Exhaust Gas (ppm)	Feed Material	Time (min)	Feed Flow Rate (gal/hr)	Total Per Run (gal)	PO ₄ ⁻³ Burned (g)
1	---	---	Kerosene	180	4	12	
2	---	---	Kerosene	20	4	1.33	
			70% Kerosene-30% TBP	70	4	4.67	1841
3	---	---	Kerosene	20	4	1.33	
			70% Kerosene-30% TBP	25	4	1.67	658
4	3.88	0.31	Kerosene	20	4	1.33	
			70% Kerosene-30% TBP	190 ^a	4	12.67	4997
5	31.05	1.28	Kerosene	20	4	1.33	
			70% Kerosene-30% TBP	370	4	24.67	9731
6	46.57	2.09	Kerosene	20	4	1.33	
			70% Kerosene-30% TBP	340	4	22.67	8942
7	31.05	2.15	Kerosene	10	4	0.67	
			70% Kerosene-30% TBP	220	4	14.67	5786
8	7.76	1.18	Kerosene	20	4	1.33	
			70% Kerosene-30% TBP	100	4	6.67	2630
9	7.76	0.91	Kerosene	20	4	1.33	
			70% Kerosene-30% TBP	130	4	8.67	3419
10	---		Kerosene	10	4	0.67	
			25% Kerosene-75% Dil (Vac)	230	4	15.33	
^a Based on 735.6 ft ³ per min.							38,004

FIGURE 3 - Mound Cyclone Incinerator concept.

Table 2 - COMPOSITION OF LEACH RATE SAMPLES

Sample	Waste (g)	Cement (g)	H ₂ O (g)	²³⁸ Pu
DCA-1	Ash III - 3.8	9.11	6.80	5.3 µg
DCA-2	Ash I - 4.0	16.0	8.00	1.12 mg
DCA-3	Ash I - 4.2	9.8	7.30	1.12 mg
DCA-4	Ash II - 4.0	16.0	8.00	1.12 mg
DCA-5	Ash II - 4.2	9.8	7.40	1.12 mg
DCA-6	Ash III - 4.0	16.0	8.00	1.12 mg
DCA-7	Ash III - 4.2	9.8	7.35	1.12 mg

the plutonium nitrate to an oxide. After cooling, the doped ash was mixed with cement and water. The samples were cast in plastic vials and sealed. After a 28-day cure, the samples were removed from the vials; measured for diameter, height, and weight; and then suspended in distilled water for leaching. The water was changed after 24 hr and weekly thereafter. The plutonium leach rates are shown in Table 3.

Table 3 - PLUTONIUM LEACH RATES

Sample	Rate [g/(cm ² -day) x 10 ⁻⁷]		
	1 Day	4 Weeks	8 Weeks
DCA-1	5.39	2.29	0.762 ^a
DCA-2	9.76	1.32	0.213
DCA-3	12.50	1.31	5.724
DCA-4	1.68	3.49	1.680
DCA-5	19.50	11.10	3.960
DCA-6	40.40	5.43	1.207
DCA-7	9.63	14.80	1.046

^aLeach rate at end of 12 weeks for this sample only.

The surface of the samples was not rinsed prior to the beginning of the leach tests. Consequently, a relatively large amount

of plutonium was leached in the first 24 hr compared to that leached in subsequent periods (Table 4).

Table 4 - COMPARISON OF PLUTONIUM LEACHED PER DAY

	Plutonium Leached (g Pu/day x 10 ⁻⁹)		
	Day 1	Day 2 Through Day 28	Day 29 Through Day 56
		Day 1	Day 28
DCA-2	6.29	0.89	0.27
DCA-3	5.59	1.66	1.00
DCA-4	7.71	0.76	0.40
DCA-5	9.64	1.68	8.78
DCA-6	19.10	1.88	0.73
DCA-7	4.43	2.01	1.63

Geometric surface areas were used for calculating the leach rates shown in Table 4. Surface areas of four samples were determined by gas absorption (Table 5). Table 6 shows plutonium leach rates of 30 wt % ash - 70 wt % cement concrete samples, using surface areas as determined by gas absorption. Additional surface area data, as determined by gas absorption, will be collected next quarter from samples of both concrete and pressed pellets.

Table 5 - SURFACE AREA
BY GAS ABSORPTION

Sample	Surface Area (m ² /g)
Concrete - 30 wt % Ash	13.00
Concrete - 50 wt % Ash	16.43
Pressed Pellet - 30 wt % Ash ^a	5.44
Pressed Pellet - 40 wt % Ash ^a	4.92

^aPressed at 20,000 psi.

Table 6 - PLUTONIUM LEACH RATES USING
SURFACE AREA AS DETERMINED BY GAS
ABSORPTION

Sample	Leach Rate [g/(cm ² -day) x 10 ⁻¹²]		
	1 Day	4 Weeks	8 Weeks
DCA-3	38.45	11.40	5.18
DCA-5	66.00	11.48	13.42
DCA-7	30.21	13.88	3.28

Pressed Pellets

Comparative tests will be conducted on concrete vs. pressed pellets. Portland type 1A cement and Lumnite* cement are mixed with incinerator ash in cement weight percents of 20 through 80 in increments of 10%. The resulting mixtures are either cast into concrete samples or cold pressed into pellets. The samples of concrete and pressed pellets will be compared with respect to leachability, density, crush strength, mechanical strength, and waste loading factors. Data were collected for the waste loading factors of several concrete and pressed pellet ash mixtures (Table 7). Thirty weight percent ash appears to be the maximum loading for concrete fixation if a reasonable crush strength is to be maintained. A much higher weight percent ash loading can be obtained with pressed pellets. Pressed pellets are virtually void of water which reduces the problem of gas build-up caused by radiolysis of water. Crush strength data will be presented next quarter.

*Trade mark of Atlas Cement Company

Table 7 - LOADING RATES - CONCRETE vs PRESSED PELLETS^a

Weight % Ash	Concrete (g ash/cm ³ waste)	Pressed Pellets (g ash/cm ³ waste)
20	0.30	0.50
30	0.44	0.62
40	0.56	0.82
50	0.71	1.0
60	-	1.15
70	-	1.33
80	-	1.50

^aPellets pressed at 20,000 psi.

Distribution

EXTERNAL

TIC, UC-70 (277)

J. A. Chacon, DAO (2)
D. Davis, ALO (2)
D. W. King, ALO
R. A. Wolfe, URE
T. K. Keenan, LASL
J. O. Blomeke, ORNL
R. E. Lerch, HEDL
G. H. Daly, WPR
J. M. Morrison, OWI
R. K. Flitcraft, MRC
J. A. Leary, WPR (2)

INTERNAL

B. A. Alexander
A. G. Barnett
W. H. Bond
W. T. Cave
J. W. Doty
T. C. Elswick
K. V. Gilbert
L. V. Jones
L. M. Klingler
J. W. Koenst
B. R. Kokenge
E. L. Lewis
D. F. Luthy
J. R. McClain
D. L. Prosser
L. B. Stevens
J. E. Todd
R. E. Vallee
H. L. Williams
Library (15)
Publications