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**TRU Waste Cyclone Drum Incinerator
and Treatment System:
April-June 1978**

**Larry M. Klingler, Dana H. Batchelder
and Edward L. Lewis**

July 28, 1978

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Miamisburg, Ohio

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MONSANTO RESEARCH CORPORATION

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U. S. DEPARTMENT OF ENERGY

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

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Foreword

Under the sponsorship of the DOE Division of Waste Management, Production and Reprocessing, Mound is responsible for the development of a volume reduction system to treat TRU combustible waste generated at DOE sites. Milestones for this project are shown on the following page.

This report is submitted by W. T. Cave, Nuclear Operations, and B. R. Kokenge, Manager, Nuclear Technology, from contributions prepared by members of the Nuclear Waste Technology Section, K. V. Gilbert, Manager, the Volume Reduction Technology group, W. H. Bond, Leader, and the Waste Immobilization Group, J. W. Doty, Leader, and with the technical guidance of J. W. Koenst.

Previous reports of this and the related project, Volume Reduction System for Solid and Liquid TRU Waste from the Nuclear Fuel Cycle, are listed below:

TRU Waste Cyclone Drum Incinerator and Treatment System:

April-June 1977	MLM-2482
July-September 1977	MLM-2496
October-December 1977	MLM-2510
January-March 1978	MLM-2516

Volume Reduction System for Solid and Liquid TRU Waste from the Nuclear Fuel Cycle:

April-June 1977	MLM-2463
July-September 1977	MLM-2498
October-December 1977	MLM-2509
January-March 1978	MLM-2517

DEFENSE INCINERATOR MILESTONES

Activity	FY-1978	FY-1979
1. Demonstration of Cyclone Incinerator		▲
2. Selection of Method to Treat Liquids	▲	
3. Demonstration of Liquid Treatment Technology	▲	▲
4. Upgrade Incinerator System		▲
5. Identification of Potential Offsite Applications		▲
6. Operational Reliability Studies for Mound Wastes		▲
7. Operational Reliability Studies for Other DOE Applications		▲
8. Determine Potential Application of the Cyclone Incinerator to Special Wastes (Sludges, etc.) Generated at DOE Sites		▲
9. Quality Control	▲	▲

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Summary

The cyclone incinerator was operated throughout the quarter utilizing the new lid assembly. Burning rates averaged 35.1 kg/hr. Early indications are that equipment life expectancies may also have lengthened. Efforts continue on selection of a system to dry sludges generated in the off-gas treatment system.

A quality control program was started this quarter.

The ash/cement matrix studies were completed. The 65/35 mixture proved to be the best for dry-cure pellets, and the 80/20 mixture produced the best wet-cured pellets. Experimental incinerator ash was successfully sintered; the final carbon content was less than 0.1 wt%.

Task 1: Cyclone Incinerator Development

L. M. Klingler

Demonstration of the cyclone incinerator

The cyclone incinerator was operated throughout the quarter to obtain additional data on burning characteristics, equipment life, and by-product generation.

Low-specific-activity waste of the <10 nCi/g category served as fuel for the runs. All waste of this type generated at Mound Facility was burned. The total weight of the waste was 1530 kg (3,379 lb). Data collected from the runs are listed in Table 1.

Most of the incinerator runs this quarter were made after installation of a new lid assembly and slip joint described previously [1] and thus provided a rather thorough testing of the new equipment.

Several improvements in the system characteristics were evident. Burning rates averaged 35.1 kg/hr for runs made after installation of the new system. The average combustion rate for runs made last quarter was 26.1 kg/hr.

Early observations indicate that equipment life expectancies may also have lengthened. The outlet baffling of the new lid assembly is showing no sign of warpage or excessive corrosion. The "clamped-together" construction of the lid assembly has already proven of value in simplifying experimentation and maintenance. In addition, the slip joint which replaced the expansion joint in the exhaust system has performed as intended, permitting expansion and contraction of the exhaust line.

Selection of methods to treat scrubber system by-products

Work is proceeding toward selection of a system to process the incinerator scrubber system solution and filter cake.

Table 1 - SUMMARY OF CYCLONE INCINERATOR RUNS FOR MARCH, APRIL, AND MAY, 1978

<u>Waste Weight (kg)</u>	<u>Total Burn Time (min)</u>	<u>Average Combustion Rate (kg/hr)</u>	<u>Total Ash Weight (kg)</u>	<u>Ash (wt % of Feed)</u>	<u>Total Ash Volume (liters)</u>	<u>Ash (Vol % of Feed)</u>
135.8	413	19.7	6.437	4.7	15.6	1.9
350.1	645	32.6	14.370	4.1	23.6	1.3
359.4	601	35.9	15.531	4.3	28.4	1.4
307.5	533	34.6	10.265	3.3	22.2	1.2
183.5	266	41.4	5.520	3.0	9.0	0.7
196.4	363	32.5	6.108	3.1	11.8	0.9

Solutions and sludges simulating these radioactively contaminated system by-products were formulated. These samples are being used for drying tests at the testing facilities of vendors of several selected dryer types.

The first test was run with a spray-dryer system. The spray dryer was chosen for testing not only because it was considered capable of handling the material, but also because of its potential to use flue gas heat for drying. The tests of the unit proved successful. Test data will be available at a later date.

Two problems with spray drying will have to be considered, however, in the final selection of a dryer system: 1) equipment is large relative to the drying rate; and 2) although most of the dried product could be collected by a simple cyclone, sophisticated gas cleaning equipment would be required to collect the portion of dried product with a particle size too small to be separated from the gas by the cyclone.

Dryer systems testing will continue into next quarter. The next scheduled test is with a vertical thin-film contact dryer.

Quality Control

A Quality Control program for the D.W.M. funded development project, TRU Waste Cyclone Drum Incinerator and Treatment System, was started this quarter. The objective of this program is to generate reliable, traceable data. Because the developed technology is to be used in a full-scale operating system, the data must be valid. The quality control program is built upon process flow diagrams which identify the specific control mechanisms used to validate the data generated. These diagrams provide an easy way to check our quality control program during its development and to implement a more specific quality control program. A good quality control organization is presently operational at Mound, but it has not previously scrutinized research and development projects.

The triangles on the flow diagram (Figure 1) identify the areas where quality control methods are used in the new procedures.

FIGURE 1 - Cyclone incinerator process flow diagram.

Waste Immobilization

J. W. Doty, D. H. Batchelder and E. L. Lewis

Introduction

The objectives of this task are to evaluate various TRU waste immobilization methods and compare these against existing and newly developed waste form acceptance criteria. Also, this program has as its objective the immobilization of sludges, adsorbents, incinerator ash, and salts. This section is funded by the Defense Waste program but is included here for completeness.

Pressed ash-cement pellet experiments

Additional experiments were done in order to evaluate and select the best pellet matrix for incinerator ash and Portland 1A cement. Pellets of 1/2-in. diameter were pressed with the following parameters held constant:

1. Fabrication pressure of 25,000 psi for 1-min duration
2. Three-gram pellet weight
3. Dry cure cycle - a minimum of two days (48 hr) in open atmosphere
4. Wet cure - a minimum of four days (96 hr) cure in distilled water followed by a one-day cure in open atmosphere

Four groups of waste samples were evaluated during this period. Pellets were pressed with Type I, II, III, and UK (unknown) ash. The water-to-cement ratio was varied in each sample group to determine the most acceptable composition. Normally, four

water-to-cement ratios were evaluated ranging from a too-dry condition to a too-moist condition. Table 2 contains data for the 65% ash pellets as well as 0, 60, 70, and 80% ash pellets completed last quarter. The data for the 65% ash/35% cement are given for only the best water-to-cement ratio.

Once again, the wet-cured pellets exhibited higher crush strengths over the dry-cured pellets. The 65% dry-cured ash pellets produced acceptable crush strengths for Type I, II, and III ash. The 70% and 80% ash/cement pellets, dry cured, were unacceptable because of low crush strengths. Therefore, the 65/35 matrix appears to be the best for dry-cured pellets. When considering crush strengths and percent ash for wet-cured pellets, the 80/20 matrix appears to be the best. The 65/35 pellets containing 3 wt% sodium metasilicate (Na_2SiO_3) binder had approximately the same crush strengths as those without. Additional pellets containing 10 wt% sodium metasilicate were fabricated in an attempt to produce pellets having higher crush strengths. Test results are not yet available.

Table 3 contains free moisture data for pellets of different mixture ratios and ash type. When pellets of identical composition were compared, the wet-cured pellets had more free moisture than the dry-cured pellets. This was as expected.

Table 4 lists bulk and tap density measurements of various ash types and bone char. These measurements were made so that the fill depths of the 1/2-in. diameter die sets could be determined. There was a wide variation in bulk density, from a minimum of 0.29 g/cm^3 to a maximum of 0.91 g/cm^3 .

Table 2 - PRESSED ASH-CEMENT PELLET MATRIX CONTROLLED EXPERIMENTAL PROCESS

Ash Type	Ash Content (%)	Ash Content (%)	Water/Cement	Cure		Average Weight Loss During Cure (%)	Density (g/cm ³)	Average Compressive Strength (psi)	Mechanical Shaking Weight Loss (%)
				Dry	Wet				
	0	100	0.10	X		5.9	2.29	3635	
	0	100	0.125	X		6.1	2.30	3661	
	0	100	0.15	X		6.5	2.32	3668	0.50
	0	100	0.175	X		6.7	2.33	3670	
	0	100	0.10		X	2.1	2.43	4580	
	0	100	0.125		X	2.0	2.45	4330	
	0	100	0.15		X	1.5	2.47	4192	0.84
	0	100	0.175		X	1.2	2.49	4293	
I	60	40	0.45	X		6.2	2.00	3470	4.45
I	60	40	0.45		X	4.1	2.30	3600	3.21
I	60	40	0.50	X		8.9	2.00	3470	0.62
I	60	40	0.50		X	3.5	2.29	3620	4.33
I	65	35	0.60	X		11.8	1.90	3484	
I	65	35	0.60		X	5.5	2.21	3583	
II	65	35	0.60	X		7.9	2.51	3605	
II	65	35	0.60		X	5.2	2.56	3911	
III	65	35	0.25	X		2.7	2.47	3618	
S-UK ^a	65	35	0.60	X		7.4	2.08	3619	
S-UK ^a	65	35	0.60		X	3.3	2.18	3733	
I	70	30	0.70	X		11.0	1.96	2480	1.78
I	70	30	0.70		X	4.9	2.01	3640	3.70
I	70	30	0.75	X		11.1	1.96	3470	2.27
I	70	30	0.75		X	3.2	2.11	3625	3.63
I	80	20	1.10	X		7.1	1.92	2480	3.72
I	80	20	1.10		X	3.3	2.08	3600	3.84
I	80	20	1.15	X		7.9	1.92	2480	1.85
I	80	20	1.15		X	2.9	2.08	3570	4.45
I	80	20	0.70	X		9.0	2.03	~2507	
I	80	20	0.70		X	2.7	2.15	~3640	
I	80	20	0.85	X		9.0	2.04	~2500	
I	80	20	0.85		X	5.6	2.10	~3670	

^aS-UK - denotes pellets containing 3 wt% Na₂SiO₃ and were made with "unknown" type ash.

Table 3 - FREE MOISTURE IN PELLETS

Ash Type	Mixture Ratio	Water/Cement	Free Moisture (%)	Cure	
				Dry	Wet
I	60/40	0.45	1.2		X
I	60/40	0.45	0.78	X	
I	60/40	0.50	0.76		X
I	60/40	0.50	0.50	X	
I	70/30	0.70	0.95		X
I	70/30	0.70	0.22	X	
I	70/30	0.75	0.89		X
I	70/30	0.75	0.37	X	
I	80/20	1.10	1.2		X
I	80/20	1.10	0.22	X	
I	80/20	1.15	0.80		X
I	80/20	1.15	0.28	X	

Thermal-gravimetric analysis (TGA) of crushed ash-cement pellets was completed but the results are not yet available. The reason for the analysis is to determine how much water vapor and other gases are given off at various temperatures.

An analysis is being done by the Experimental Design Group to find the optimum ash-cement matrix and to suggest further experiments necessary for the determination.

Sintering of experimental incinerator ash

Sintering experiments were performed using experimental incinerator ash containing 10-50 wt% carbon plus other incompletely burned material. The ash must therefore be sintered or burned again to remove this combustible material. Table 5 contains data from four experimental sintering tests.

Table 4 - BULK AND TAP DENSITY MEASUREMENTS

Ash Type	Bulk Density (g/cm ³)	Tap Density (g/cm ³)
I	0.53	0.80
II	0.80	1.25
III	0.61	1.02
UK-1 ^a	0.34	0.45
UK-2 ^a	0.29	0.41
UK-3 ^a	0.36	0.60
CSBC ^b	0.91	1.21

^aUK is an abbreviation for "unknown"

^bCSBC is an abbreviation for "crushed, sintered bone char"

Table 5 - SINTERING OF ASH

Run	Combustion Rate (g/cm ³)	Sintered (hr)	Temperature (°C)	Initial Weight (% Carbon)	Final Weight (% Carbon)	Ratio Carbon Wt Loss to Total Wt Loss
1	5.7	6-1/2	800-900	12.82	0.005	0.46
2	5.8	10-3/4	850	46.3	<0.10	0.95
3	1.7	8	900	48.7	<0.05	0.88
4	1.6	8	850	48.7	<0.005	0.92

The purpose of these experiments was to develop an acceptable sintering process. This process must reduce the carbon content to less than 0.10% at a fairly rapid rate. Runs #1 and #2 were the most successful of the four tests. The final carbon percentages and combustion rates were almost identical for these runs. Runs #3 and #4 produced ashes of acceptable carbon contents but the combustion rates were approximately 3/10 of those found in Runs #1 and #2. In Runs #1 and #2, the ash was sintered in a cylindrical quartz vessel containing a quartz frit (see Figure 2). The ash was placed on the frit, and air was either pulled downward through the frit or pumped upward through the frit. The air flow rate was approximately 3.5 ft³/hr. In Runs #3 and #4, the ash was sintered in a shallow quartz dish with air flowing above the surface of the dish at a rate of approximately 3.5 ft³/hr. The greater combustion rates for Runs #1 and #2 were probably attained by better contact between the combustion air and the heated dish. Some problems were, however, encountered in the use of the fritted vessel. The quartz frit partially plugged after 8 hr of use. Both the quartz side arm (air

inlet-outlet tube) and vessel wall both broke during the second run. No problems were encountered in the use of the quartz dish. The problems encountered with the quartz vessel may possibly be corrected by fabricating a platinum vessel. Figure 3 is a plot of percent carbon remaining in ash as a function of sintering time for Run #2. As can be seen, it is nearly linear between time zero and 7-3/4 hr and non-linear between 7-3/4 hr and 10-3/4 hr. All four runs were conducted using a muffle furnace and a temperature range of 800-900°C. Analytical tests are now being performed to determine the composition of the combustion gases produced at various temperatures (200 to 900°C). These test results are not yet available.

References

1. D. F. Luthy and J. W. Doty, TRU Waste Cyclone Drum Incinerator and Treatment System: October-December 1977, MLM-2510 (April 21, 1978), p. 5.

FIGURE 2 - Cylindrical quartz sintering vessel.

FIGURE 3 - Percent carbon in ash as a function of sintering time.

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