MASTER

RECOVERY OF PLUTONIUM FROM
ZPPR UNMEASURABLE WASTES

Progress Report
July 27, 1967 to January 27, 1968

NUMEC-1661-1

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Project Management

F. D. Fisher

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Previous Reports in this Series

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I. Background and Problem

Part of the ZPPR Plutonium Supply Contract No. AT(11-1)-1661, dated July 26, 1967, Section 5.7 "Disposition of Unmeasurable Wastes" defines the conditions for recovery of plutonium from "unmeasurable wastes" generated in the manufacture of ZPPR fuel and the return of this plutonium to the Commission. Primarily, this includes the option of designing and constructing a facility for processing "unmeasurable wastes".

This is the first semiannual progress report on this subject.

Dr. F. D. Fisher (NUMEC Central Engineering) has the overall responsibility for the initial phases of the project.

For the purpose of this development effort, "unmeasurable wastes" are defined as plutonium-bearing heterogeneous solid wastes which are generated during the fabrication of ZPPR ternary alloy fuel plates. Typically, these wastes are PVC bags, neoprene gloves, paper wipes, cardboard boxes, molds, crucibles, brushes and tools. These diverse materials all have two common characteristics:

(1) gross plutonium contamination and (2) non-uniform contamination distribution patterns which make measuring of plutonium contents by analysis of samples infeasible.

Recovery of plutonium from unmeasurable wastes must consist of techniques for economically concentrating unmeasurable wastes into a recoverable form. This recoverable form must be suitable for

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final processing in the NUMEC Waste Treatment Plant.

II. Methods

There are two basic approaches to the recovery of plutonium from unmeasurable waste. These approaches are total incineration and total laundering which are shown in block diagrams, Figures 1 and 2. Another approach which may have merit is the combination of incineration and laundering.

The selection of the optimum approach is not possible at this time. Data evaluation must be completed before the selection is made.

III. Data Collection

A. Incineration

During the first six months period, effort was expended primarily on a state-of-the-art survey of incinerators used for burning radioactive contaminated solid waste. Visits were made to government owned facilities where plutonium wastes are processed to review the operation of existing incinerators. The sites visited were Los Alamos Scientific Laboratory, New Mexico; Rocky Flats Plant, Colorado, and Hanford, Washington. A summary of the physical and operating characteristics for these three facilities are shown in Table I. A trip was also made to the Y-12 Plant at Oak Ridge to review the operation of the Destructive Distillation Unit used for recovery of enriched uranium from

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combustible solid wastes. Trip reports of visits to these facilities are included in the Appendix.

Leading commercial manufacturers of incinerators were consulted. Companies contacted were: Brule Incinerator Company, Blue Island, Illinois; Nash Cadmus & Voelker, Inc., Freeport, New York; Morse-Boulger, Inc., Corona, New York; and Plibrico Company, Chicago, Illinois

Each of the manufacturers listed indicated that burning of a hypothetical reference waste composed of 50 per cent PVC sheet, 30 percent neoprene gloves, 15 per cent rags, sponges, plastic bottles, brushes, and 5 per cent paper and cardboard, while difficult, is technically feasible. All but one of the manufacturers recommended gas firing. Whereas none of the manufacturers had the necessary experience to design an off-gas cleanup system adequate for a plutonium incinerator, all but one were willing to work with NUMEC to develop such a system.

With respect to other incinerator design factors such as open grate versus closed hearth, wet versus dry gas cleaning, metal versus brick lining, etc., there was marked divergence of opinion.

TOTAL INCINERATION

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FIGURE 1

TOTAL LAUNDERING

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FIGURE 2

TABLE I

Summary on Operating Plutonium Incinerators
 (For details see attached trip reports and
 references listed in the bibliography in
 the Appendix)

Organization	Hanford	Los Alamos Scientific Laboratory	Rocky Flats
Contaminant	Pu	Pu	Pu
Burning Capacity	20 cu. ft./day	12 liters of wet waste/8 hrs.	60#/hr.
Incinerator Type	Electrically heated metal tube with traveling wire mesh belt.	Electrically heated 12" diam. x 18.5" high pot.	Gas fired, 3 chambers, 4' x 3' x 5'3" overall, 6" brick lining
Charge Packaging	Material shredded prior to loading on belt.	Trash is hand packed into furnace pot.	Polyethylene bags 6" x 6" x 6", 3 lbs/bag.
Combustion Air	80 CFM air	oxygen	200 CFM Air
Off-Gas Treatment	Two cyclone separ- ators, caustic scrubber, off-gas reheater, and three absolute filters. (Wet Process)	8 gallon bubbler, 4" water cooled pipe, 30 CFM ultrafilter, pumped into a closed 70 gallon tank, insoluble gases are vented to "hot" exhaust duct system. (Wet Process)	Dilution air pre- heater, gas to air fin cooler, slag wool filters, tar trap, gas cooler, gas re- heat by injection of preheated (900°C) dilution air, and absolute filters in series. (Dry Process)
Operating Temperature	1500°F	650 - 850°F	1600 - 1700°F
Overall Decontamination Factor	Unknown	Unknown	Unknown

Equipment Details
And Operating
Characteristics

Operates 24 hours per day. Many operation difficulties. Down approximately 3 months per year. No details on stack emission levels.

Unit keeps current with scrap generated. Very little maintenance.

Unit is down 60% of time. Filter life very short. Estimate \$90,000/year for filters (basis: burning 500 lbs/day).

Comments

Unit cost in excess of 1/2 million dollars. High operating costs are justified by large quantities of Pu recovered per month.

Neither plastics nor neoprene gloves are burned in this unit.

Economically operable only because of large quantities of Pu recovered and decreased storage costs.

Plutonium
Recovered

Approximately 90 kgs. through incinerator per year.

Total Pu scrap recovery operation recovers 20-40 kgs. Pu per month. Total through incinerator is unknown.

Approximately 250 kilograms through incinerator per year.

Design And
Construction

Hanford

LASL and Morse-Boulger, Inc.

Rocky Flats Plant, Plibrico Co. and Nash, Cadmus & Voelker, Inc.

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B. Laundering

During the visits to government owned facilities that process plutonium contaminated wastes, it was noted that laundering was being conducted in conjunction with the incineration operations. Wastes that were laundered or processed in leaching pots were plastic sheeting and neoprene gloves.

Tests were performed at NUMEC to evaluate the feasibility of laundering as a recovery scheme for plutonium contaminated plastic bags and neoprene gloves. Plutonium contents of the wastes were estimated before and after laundering by a gamma scanning technique. Twenty-three packages of plutonium contaminated plastic sheeting and gloves were washed with 7.2 M HNO_3 and twenty packages were washed with clear water. The results of the laundering are shown in Table II.

Similar hand laundering of impermeable ZPPR-generated wastes, e.g. gloves, plastic sheeting, tape, small parts, is being done in an attempt to minimize the accumulation of plutonium as unmeasurable wastes. No gamma-scan estimates of before-laundering plutonium contents are available since the impermeable wastes are being laundered as they are generated without any intermediate packaging and "bagging out". However, the bagged-out packages of laundered scrap are exhibiting plutonium contents, as estimated by gamma scanning, markedly lower than those pre-

TABLE II

Laundering of Plutonium Contaminated
Plastic Sheeting and Neoprene Gloves

<u>7.2 M HNO₃</u>		<u>Clear Water</u>	
<u>Laundering Medium</u>		<u>Laundering Medium</u>	
<u>Pu (grams)</u>		<u>Pu (grams)</u>	
<u>Before</u>	<u>After</u>	<u>Before</u>	<u>After</u>
2.3	0.5	1.1	0.2
1.6	0.3	2.2	0.7
5.0	0.7	1.1	0.2
2.0	0.5	8.8	0.7
1.2	0.2	0.6	0.5
1.5	0.1	0.8	0.2
4.0	0.5		
6.5	3.5	3.6	0.9
1.5	0.1	6.3	0.7
2.0	0.2	2.1	0.3
1.7	0.1	20.0	0.1
4.2	0.2	7.8	0.9
3.5	0.1	4.9	0.8
8.9	0.6		
5.5	0.3	3.4	0.1
9.5	0.7	1.5	0.3
3.4	0.5	3.3	0.6
9.5	1.2	2.6	0.6
1.3	0.5		
0.7	0.2	2.3	0.9
4.0	0.3	1.2	0.7
2.5	0.1	2.9	0.4
<u>8.9</u>	<u>0.4</u>	<u>1.1</u>	<u>0.2</u>
Total	91.2	Total	77.6
	11.8		10.0

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viously experienced with similarly packaged non-laundered wastes. The recovered plutonium has not yet been assayed.

The laundered "lean" packages are being segregated from "rich" packages of non-laundered impermeables and other types of waste, e.g., molds, crucibles, paper. It may prove practicable to directly dispose of the "lean" portions of the wastes, thus, drastically reducing the volume of unmeasurable waste to be processed in a recovery facility. More detailed design analysis and, possibly, even operating experience will be needed before an economical "discard level" can be established with certainty.

IV. Data Evaluation

A. Incineration

The general mechanical and operating characteristics of the three government owned facilities that process plutonium contaminated wastes are outlined in Table I. The advantages and disadvantages of those facilities relative to the processing of ZPPR unmeasurable wastes were evaluated and are tabulated in Table III.

TABLE III

<u>Facility</u>	<u>Advantage</u>	<u>Disadvantage</u>
Los Alamos	<ol style="list-style-type: none"> *1. Low operating temperature (650-850°F) 2. Low maintenance 3. Low capital cost 	<ol style="list-style-type: none"> 1. Small processing capacity 2. Hand loading of furnace 3. Does not burn plastics or neoprene
Rocky Flats	<ol style="list-style-type: none"> 1. High production capacity (60 lbs waste/hr) 2. Moderate capital cost 	<ol style="list-style-type: none"> 1. High operating temperature (1600-1700°F) 2. High operating costs 3. Fires in filter chambers 4. Furnace chamber subject to explosions 5. Requires periodic replacement of brick lining 6. Requires replacement of 12 absolute filters every two days 7. Not used for burning plastic sheeting or neoprene gloves
Hanford	<ol style="list-style-type: none"> 1. Can handle some plastic sheeting and neoprene gloves 2. No refractory brick to replace 3. Capable of running continuous 24 hours per day for a week (filter change each week) 	<ol style="list-style-type: none"> 1. Replacement of mesh belt every 3-4 months 2. Back firing at feeder end requires operator attention 100% of feeding time 3. Mesh belt stretches and requires adjustment 4. No capability for recovery of plutonium from scrubber solution. 5. First absolute filter down stream from scrubber must be changed each week 6. High operating temperature, 1500°F 7. Capacity is only 20 ft³ waste per 24 hrs. 8. High capital and operating cost

*Incinerator temperatures in excess of 700°F result in increasing difficulty of processing plutonium-bearing ash.

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B. Laundering

No specific data were obtained from the government owned facilities that process plutonium except that plastic and neoprene gloves were largely laundered (leached) instead of burned.

The tests described in Section IIIB and Table II demonstrated 87 per cent recovery of plutonium using a 7.2M nitric acid wash and also 87 per cent recovery using a clear water wash. The use of detergent with water should increase recoveries above 87 per cent.

Discussion with personnel of NUMEC's laundry affiliate (Nuclear Decontamination Corporation) indicated that laundering of garmets, rubbers, gloves, etc. very successfully removed uranium from the "wastes" and, thus, should be effective for the recovery of plutonium from similar materials.

V. Future Work

The project schedule, Table IV, outlines the overall schedule of events for completion of the project.

The data collection and data evaluation are scheduled for completion during the next six months. During this period the system of processing unmeasurable wastes will be selected and the preliminary design of the system will be initiated.

1

----- COMPLETED EFFORT
- - - - - FUTURE EFFORT

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APPENDIX

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TRIP REPORT, LOS ALAMOS Pu WASTE INCINERATOR

Discussions were held with the following Los Alamos personnel:

W. J. Maraman	Group Leader
E. Christenson	Section Leader
C. Nordeen	Staff Member

Plant Tour: Building #2 DPW Area

The primary objective of the incinerator at Los Alamos is to recover the Pu from waste generated in their Pu processing. They stated that they have successfully done this for the past 15 years in a batch type incinerator as shown in the attached reprint. They have kept current with their waste during the past 15 years after working off a 3-4 year accumulated backlog of material. They incinerate only that material containing sufficient plutonium to be processed economically. This selection is based upon neutron-gamma scanning of all wastes.

At the present time the unit is operating 8 hours/day, 5 days/week. The rate of processing is dependent upon the wetness of the initial charge. If the charge is wet or damp, it must first be dried before ignition. The drying process takes approximately 2 hours and the entire cycle takes 4-5 hours. If the charge is dry then the entire cycle is only $1\frac{1}{2}$ to 2 hours. The ash from the incinerator is milled, leached in HNO_3 , put through a fusion step and followed by another leach in HNO_3 . They feel that in order to recover the Pu from the ash it is necessary to operate the incinerator at the lowest possible temperature - 350°C to 450°C . Air flow, which they try to maintain at 50 CFM through the unit, is another critical control point.

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From an operational standpoint the unit has been relatively trouble free, no uncontrolled fires, no explosions, no excessive pressurizations. The unit is built with an expansion chamber, any explosion is vented into the entire glove box line so that it would be contained. They burn mostly paper, cheesecloth, cardboard, wood, rags, and a very small amount of plastics - no rubber gloves. The rubber gloves and most of the plastic (PVC) are washed with 10 M HNO_3 . The scrubber, or bubbler, as they call it, solution is caustic and is changed after 6-7 runs. Its Pu content is normally < 1 mg/l. The caustic solution in the Nash pump normally runs < 0.1 mg/l. The absolute filter ahead of the Nash pump is changed only once a year. The unit has a fitting for steam cleaning, this has been found to be unnecessary.

Other items discussed and observed on this trip were: (1) The processing of absolute filters by putting them through a fluoridation process (being patented). (2) The plastic washing set up, which consists of a basket in a stainless steel pan through which 10 M HNO_3 is recirculated with an ECO positive displacement pump (driven by an air motor) and (3) A general tour of building number 2 in the DPW area - this building is primarily used as a scrap processing facility and has 10,000 ft^2 floor space with 800 ft^2 of glove box floor area. The processing rate was given as 20-40 kgs of Pu recovered from scrap per month, using anion exchange and oxalate precipitation. Analytical laboratory wastes are neutralized and precipitated. Raffinate and filtrate solutions normally run 1 mg. Pu/l. and are fixed in concrete and buried.

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Other publications of interest regarding this trip are:

LA-3499 Anion Exchange Processing of Plutonium

LA-3542 Plutonium Processing at Los Alamos

LA-1691 Incinerator

I&EC Reprint - Attached

Incinerator for Radioactive Residue

by W. D. McNoese and W. J. Maraman
 Los Alamos Scientific Laboratory

This batch-type incinerator was built to dry and to burn 12 liters of wet, packed rags or the equivalent in other organic matter in 8 hours. The material is ignited and burned in a stream of oxygen. Tars in the off-gas are trapped in a water bubbler, residual contaminated particles are caught by an ultrafilter, and acid vapors are reacted in a caustic scrubber. The unit was designed to process plutonium residues; other radioactive materials could be handled by the use of appropriate shielding and manipulators.

AN INCINERATOR unit was required in a recovery operation to burn organic material contaminated with plutonium to a more recoverable form without loss of plutonium. It was necessary for the equipment to be resistant to the corrosive conditions and safe to operate from both common and radioactive hazards.

The unit consists of burning chamber, off-gas system, and enclosures.

Burning Chamber

The burning chamber is a tube $\frac{1}{8}$ inch thick, 12 inches in diameter, and 18.5 inches long, with a flanged top and conical bottom. Eight 250-watt strip heaters are attached to the outside, wired in pairs to four off-on switches. Asbestos cloth insulates the unit. Top flange of burning chamber is attached to the bottom of an air lock and gasketed with neoprene, which is kept cool by a circulating-water coil.

The 0.5-inch-thick burning chamber lid is raised, lowered, and sealed

by an air cylinder nose-mounted to the top of the air lock. The sealing gasket is a silicone O-ring. Heat is reflected away from the lid by a perforated plate suspended 3 inches beneath the lid. A stirrup hanging from the reflector plate holds the basket which contains the charge. This basket, 10 inches in diameter and 10 inches long, has a No. 4 mesh screen wall and a 12-gage solid-bottom pan.

Air and oxygen are metered through a rotameter and enter the burning chamber through a $\frac{1}{4}$ -inch pipe between the lid and the reflector plate. Below the reflector plate is a $\frac{1}{2}$ -inch steam line for cleaning the unit.

Temperatures, measured from the thermocouples located at appropriate points on the outside of the burning chamber, are recorded.

The ignitor cartridge holder is inserted through a hole which is off-center in the lid. The ignitor, a

Burning chamber

This has been eliminated
 self-contained soldering-iron cartridge, is fired and pushed into the basket, and the hole sealed by a modified automatic center punch attached to an air cylinder nose-mounted to the top of the air lock.

Off-Gas System

Off-gases from the bottom of the burning chamber are pulled through a finned 2-inch pipe and into a gas sparger in an 8-gallon glass bubbler. A $\frac{3}{4}$ -inch dip tube is mounted off-center through the lid of the bubbler and connects to a water line and the withdrawal apparatus. Scrubbed off-gases pass upward through a standard Teflon expansion joint flanged to a 4-inch jacketed water-cooled pipe and downward into a 30 c.f.m. ultrafilter, located in a housing arranged for filter changing by the standard plastic bag technique. A 1-inch valved air-bleed line and a vacuum gage are located between the condenser and filter.

Filtered off-gases are pulled from the system through a back-up trap by a liquid-sealed vacuum pump, sealed by recirculating caustic. The pump discharges into a 70-gallon tank, where insoluble gases escape and are vented into the "hot" exhaust duct system.

Enclosures

The burning chamber and off-gas system are enclosed within a room which is separated from the operating area by metal wall partitions and dry boxes and kept negative to the operating area by ventilation control. There are facilities in the dry boxes for loading and unloading the charge basket, ball milling the ash, and withdrawing and handling the water-

bubbler solution. These dry boxes are connected to others in the recovery operation. Instruments and controls, as well as the working fronts of dry boxes, are located within the operating area.

Operating Procedure

Rags and other combustible material with varying degrees of moisture content are loosely packed to level full in the charge basket. The proper services are checked and the basket is lowered into position in the burning chamber. Lid and firing openings are sealed and the drying cycle begins.

The vacuum pump is started and the bleed valve adjusted to sustain 1 to 2 inches of mercury vacuum on the unit. About 1 c.f.m. of air is metered into the chamber through the oxygen system. The eight heaters are turned on. Within an hour the temperature rises to 400° C., after which all but two heaters are turned off. The rags are dried for 2 hours.

Heaters and air are turned off and about 1 c.f.m. of oxygen is metered

into the chamber. After 15 minutes of oxygen flow, a cartridge is placed in its holder and fired to ignite the charge. The temperature reaches a maximum of 350° to 450° C. in about 30 minutes and then gradually falls. Within 2 hours a sharp drop in temperature indicates that the burning is complete. Oxygen is turned off and air introduced at 1

c.f.m. until the basket is cool enough to handle. All services are then turned off.

The ash residue is inspected, the spent igniter removed, and residue placed in a storage bottle or left in the basket for mixing with subsequent lots.

The 4.5 gallons of bubbler solution and 40 gallons of 1% sodium hydrox-

ide seal tank solution are replaced after five runs. Bubbler solution is filtered through a medium glass frit and sampled for plutonium analysis. The seal tank solution is acidified and sampled. Normally, these solutions contain less than 10^{-4} gram of Pu per liter.

The burning chamber is periodically steam-cleaned and the accumulated tars on the walls of the bubbler are removed with trichloroethylene. The solvent is evaporated and the tars are added to the ash or incinerated.

Operating Experience

...The incinerator unit can dry and burn safely 12 liters of combustibles in 8 hours.

...The room-enclosure air count averages 3.5 d./m./cu. m. There has been no over-tolerance air count in the operating area attributable to this unit. Samples of the exhaust gases above the seal tank liquid indicate a count of 10^1 d./m./cu. m.

...Twelve liters of charge give about 150 ml. (or 100 to 150 grams) of residue, which contain an average of 5% plutonium by weight. The bubbler solution filtrate has an average analysis of 7×10^{-4} gram of

Pu per liter and the acidified seal solution, 5×10^{-5} gram of Pu per liter.

...After 306 runs the ultrafilter was in good condition and contained a negligible amount of plutonium.

...Cheese cloth (with varying salt content), paper, emery cloth, wood, graphite, surgical and dry box gloves, paint, Bakelite bottle caps, Tygon tubing, and poly(vinyl chloride) bags have been incinerated.

...Scaling of the burning basket necessitated replacement twice in 4 years of operation. Other parts of the burning chamber and off-gas system have not been changed.

Plastics are no longer burned, they are leached in HNO_3

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TRIP REPORT - ROCKY FLATS PLANT INCINERATOR

The Rocky Flats installation was visited by Dr. C. S. Caldwell, Mr. T. P. Bullock and Mr. C. W. Showalter to discuss their incinerator operation and experience. Among those contacted were:

<u>AEC</u>	<u>Dow</u>
L. Grow	K. Best (Mfg.)
	K. Calkins (Mfg. Tech. Staff)
	J. Byrne (R&D)
	L. Zodtner (Mfg.)

The Rocky Flats incinerator has been in operation for about 8-9 years. Although referred to as Mark 4 (current) and Mark 5 (future) designs, the facility has actually been under continuous evolution.

The capacity was variously stated, viz:

25 kilograms Pu charged/month x 10 months = 250 kilograms Pu/year.

20 drums/day, yearly average is 125 drums/month.

2 days operation/filter change, 1 filter change (12-24 x 24 inch filters)
= 48 drums.

Two months of the year the unit is shut down for rebricking. Every two days it is down for replacement of 12 absolute filters. Other times it is down for misoperation (9 fires so far in the filter chamber, one explosion -- cause undetermined) or making the many facility modifications.

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PVC plastic sheets and rubber gloves are not incinerated except for those which are inadvertently included with paper, etc. Polyethylene sheets were burned satisfactorily except for incomplete combustion due to some melting and dripping through the grate.

It was stated that 95% of the Pu reports to the ash, 2.5% is retained by the exhaust gas treatment units and 2.5% is held up in incinerator brick.

The ash from the incinerator is dissolved in 9 M HNO_3 - 2% HF solution. Five or six sequential leachings recover 95% of the Pu from the ash.

The current modifications now being installed, takes the off-gas from the incinerator through cooling heat exchangers, a new cyclone (replacing slag wool filters and tar pots), more cooling heat exchangers, and then through absolute filters. Bleed air cooling is also used. No information was available on temperatures and flows at various system points. A large amount of excess air is used (16-18% O_2 in flue gas), and the estimated burning zone residence time for gas-borne material is less than one second.

It was positively stated that the slag wool filters previously used were not worthwhile, and that the tar collection pot was of little use, although both locations collected material. In spite of these devices, the absolute filters caught fire on occasion, indicating combustibles accumulating at that point. The nature of the deposits on the filters that had caught fire was not known.

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The projected next modification of the present unit is the addition of a venturi-type caustic scrubber.

No cost data were available specifically for the incineration operation; however, costs for incineration and subsequent ash leaching were reported to be \$11 per cubic foot of solid waste.

Capital costs were indicated as follows:

Book Value (nondepreciated)	\$98,000
Items not included in book value:	
Walk-in filter bank plenum	25,000
Current refit (cyclone)	55,000
Final air exhaust (building exhaust)	----
Space	----
	<hr/>
	178,000 +

The following advice was offered relative to a NUMEC incinerator.

1. Take as much advantage of RFP's experience with new modifications as project timing permits.
2. Gas-fired incinerator design should include these features:
 - a. Explosion containment. Put incinerator in isolated room or design for blow-out into isolated room - occasional explosions are probably unavoidable.
 - b. Long residence time in hot zone. Include extended multipass (maybe 5-10 passes) hot zone, approximately one minute residence to promote

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combustion of entrained aerosol tars and solids. Since RFP's present design has an effective residence time of less than one second, carryover of unburned distillates and aerosol tars is inevitable. PVC sheet plasticizer (di-octyl phthalate) contributes to the problem.

- c. High temperature in hot zone. At 1200°C and above, combustion is rapid. Design for maximum integrated temperature-time environment consistent with furnace lining life.
- d. Preheat and continuous charging. Provide preheat chamber to reduce gas pulse (and, therefore, entrainment in the exhaust gases) at the instant of charging. A pusher ram and side chamber would be adequate. Wild gas pulses occur with the present batch charging. Non-steady-state conditions probably establish the limits of performance of the RFP system.
- e. Eliminate open door charging. A double-door vestibule lock combined with (d) and (f) is needed to prevent upsets of gas flow rate and pattern.
- f. Combustion gas and air control. To reduce entrainment, reduce overall gas flow by adjusting to optimum air-gas ratio. Flue gas temperature, flow, and composition may require monitoring.

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- g. Quick removable furnace lining. Line furnace with a throwaway lining or cleanable lining to eliminate annual two-month shutdown for rebricking and recovery of multi-kilogram amounts of plutonium from brick. Include Inconel-screw ash removal unit.

- h. Deliberately design to handle PVC and neoprene rubber or exclude these materials by administrative control. If the materials of construction and grate design problems for handling PVC and hot moist-HCl flue gas can be solved, a very useful piece of equipment would result. An incinerator for polyethylene, polypropylene, paper, wood, and minor quantities of PVC sheeting only meets 1/3 to 1/2 of the bulk handling demand; the rest must be met by washing, leaching, etc.

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TRIP REPORT, PLUTONIUM WASTE INCINERATOR AT HANFORD

Discussions were held with the following Hanford personnel:

R. E. Olson, Manager, Plutonium Reclamation

J. Teal, Planner and Scheduler, Plutonium Reclamation

V. Smith, Manager, Plutonium Metal Production

Facility Visited: Plutonium Waste Incinerator Facility, 232-Z Bldg., 200-W Area

The Hanford incinerator has two electrically heated chambers and is continuously fed by belts, as shown in the attached figures. Waste is received in corrugated paper cartons, 24" x 24" x 30". These cartons are charged, one at a time, through an air lock into a sorting "hood" (glove box). In the sorting "hood" the cartons are opened and bulk plastics, glass, graphite and gloves are segregated and directed to the leaching "hoods" (glove boxes). Glove finger tips are cut off to facilitate leaching.

Combustibles, comprised primarily of paper, wood, rags, PVC plastic sheet (ca. 20% of the combustibles), and glove finger tips are charged to a shredder for size reduction. The shredded material is stored in a hopper. A rubber belt delivers the shredded waste continuously from the storage hopper to the mesh belt which then carries the feed into and through the incinerator primary (lower) combustion chamber.

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Air flow through the primary combustion chamber is 80 CFM. The exhaust gases from the primary combustion chamber are "reburned" in the secondary (upper) combustion chamber. Exhaust gases from the secondary combustion chamber pass through two cyclones in series, a caustic scrubber, a reheater which dries the gases by heating them to about 150°C, a primary absolute filter, a blower, and then through secondary and tertiary absolute filters. The exhaust gases are then combined with incinerator facility ventilation exhaust gases and transferred to the Z-Plant stack facility where they are disposed to atmosphere in combination with ventilation exhausts from the entire Z-Plant. Plutonium aerosol concentrations after the various stages of exhaust gas treatment are not known at this time, except for the final gas mixture leaving the Z-Plant stack. Even those data are not presently available at NUMEC.

Ashes delivered out of the primary combustion chamber by the mesh belt and fly ash from the exhaust-gas cyclones are canned in No. 2 steel cans.

The canned ashes are then decanned and leached with a mixture of nitric and hydrofluoric acids in miscellaneous treatment "hoods" (glove boxes) in the Plutonium Reclamation Facility (880 plant). Although an ammonium bifluoride fusion process for ash solubilization was developed by Crocker (1) it has not been used in production operations.

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Although the incinerator tubes are geometrically favorable, the scrubber (even though fitted with neutron probes) is not considered to be ever-safe, hence, control of criticality hazards is based upon administrative control of plutonium inventories. Plutonium in incoming waste is estimated by a neutron counting technique.

The facility is operated on a continuous basis; at the present time it is running 24 hours/day, 7 days a week with 2 operators per shift. The throughput is about 20 ft³ of material every 24 hours. The facility capital cost was approximately \$500,000.

Since the startup of the unit in January, 1962, it has been shut down three times for major repairs on the burning chambers. The first shutdown involved rewelding the flues connecting the primary and secondary chambers. The second shutdown involved a complete change of the chambers to Incoloy-800 plus a redesign of the flues. On the third shutdown, it was found necessary to replace parts of the chambers. It appeared that the chamber failures were due to metal fatigue caused by thermal-induced stresses. It is felt that this problem has been solved by addition of flexible joints at the chamber-flue junctures. The materials of construction used to date include: Hastelloy-N, Incoloy-800, and, at present, 321 stainless. It is planned to go to a completely wrought Incoloy-800 system. Both wrought and cast Incoloy-800 were previously used. It is believed that the cast Incoloy-800 is more prone to failure and presently only wrought Incoloy-800 is being specified. The reason that 321 stainless is still being used is that it was not possible to get delivery of sufficient Incoloy-800 prior to the latest startup.

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Additional Incoloy-800 is on order and all 321 stainless parts will be replaced during the next shutdown.

Other problems have been: (1) Replacement of the mesh belt - every 3-4 months. The present belt is fabricated from Nichrome V. It is also necessary to remove links from the belt periodically to compensate for stretching, (2) Back firing at the feed end of the incinerator. To control this, it is necessary to have an operator at this location 100% of the feeding time, (3) the scrubber solution picks up 1 gram of Pu every hour. They do not have a method of recovering this from the solution; therefore, it is cribbed, (4) the first absolute filter downstream from the scrubber has to be changed every week, apparently due to being flooded with scrubber solution.

The project number for the incinerator facility is CGC 813. The project folder contains everything that pertains to the incinerator, building, boxes, etc. (Estimated to include 500 prints). Drawing H-2-23100 is a drawing list for the entire facility and includes drawings for everything with the latest modifications.

The Hanford incinerator works, although it does have a number of operating problems as pointed out above. It successfully recovers plutonium from contaminated solid wastes. The responsible Hanford personnel are proud of their facility and claim they would build another just like it if another were required.

(1) Crocker, H.W. "Ammonium Bifluoride Fusion of Ignited Plutonium Dioxide", Hanford Atomic Products Operation, Richland, Washington, HW-68655 (MEC-2161), Feb. 1961, Declassified.

CONTAMINATED WASTE RECOVERY FACILITY

232-Z BUILDING

CONTAMINATED WASTE RECOVERY FACILITY

INCINERATOR FOR PLUTONIUM RECOVERY

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TRIP REPORT, OAK RIDGE ENRICHED-URANIUM DESTRUCTIVE-DISTILLATION INCINERATOR

Discussions were conducted with the following Oak Ridge (Y-12) personnel:

MacMahon	AEC Representative
J. W. Ruthven	Staff Engineer
J. R. Barkman	Section Chief, Uranium Processing

The Y-12 plant at Oak Ridge "incinerates" enriched-uranium-contaminated paper, cardboard, rags and filters by a process based upon destructive distillation. Although the process facility is called a destructive distillation unit, the process actually consists of a destructive distillation step followed by a burning step.

The destructive distillation step consists of retorting a batch of contaminated waste at 800°C under a nitrogen atmosphere. The wastes are "destroyed" by being pyrolyzed into nonvolatile carbonaceous residues and various gases and vapors. The gases and vapors are distilled out of the retort into a scrubber-condensor. Tars and oils that condense in the scrubber-condensor float to the top and are skimmed off into a tar collection bottle. Those gases which are neither condensed nor dissolved in the scrubber-condensor are disposed of via the general plant process exhaust system.

After the destructive distillation step is complete, oxygen is introduced into the retort to burn the carbonaceous residues. The combustion temperature is maintained at about 1000°C by controlling the oxygen addition rate. Ashes

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from this step are then transferred to other equipment for crushing, leaching, and subsequent recovery operations. A cycle of loading, destructive distillation, combustion, and unloading takes 24 hours. The process and equipment are further described on the attached sketch.

There are four of the destructive distillation units in use at Y-12. In addition, there are four superficially similar units for ashing of graphite crucibles and two muffle furnaces for burning wet rags and for drying wet solid residues from the ash leaching operations. Wet rags are ashed at 600°C in air. All the units use similar off-gas systems.

All the units use administrative mass control as the basis for control of criticality hazards. The uranium contents of incoming wastes are estimated by gamma scanning.

Operating costs specific to the destructive distillation step were not available. However, the overall cost to process a kilogram of contaminated waste into uranium metal product was given as \$14.20.

Destructive distillation has been in use at Y-12 since 1952. Oak Ridge personnel indicated that they are completely satisfied with the process and have no plans for further development. The process is described in detail by Patton, et, al. (1).

The following drawings describe the unit but they do not necessarily include all the modifications which have been made.

OAK RIDGE DESTRUCTIVE DISTILLATION PROCESS

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E-10F-13862	Burner Retort and Details
E-10F-13828	Equipment Layout
E-10F-13886	Burner Equipment Installation
E-10F-14156	Burner Equipment Installation Plans
EP-32863	Condensor Details
DP-26041	Condensor Details

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- (1) Patton, F. S. et al, Enriched Uranium Processing, International Series
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