INCINERATION METHOD FOR VOLUME REDUCTION AND DISPOSAL OF TRANSURANIC WASTE

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ABSTRACT

The Process Experimental Pilot Plant (PREPP) at Idaho National Engineering Laboratory (INEL) is designed to process 7 TPD of transuranic (TRU) waste producing 8.5 TPD of cemented waste and 4100 ACFM of combustion gases with a volume reduction of up to 17:1.

The waste and its container are shredded then fed to a rotary kiln heated to 1700°F., then cooled and classified by a trommel screen. The fine portion is mixed with a cement grout which is placed with the coarse portion in steel drums for disposal at the Waste Isolation Pilot Plant (WIPP).

The kiln off-gas is reheated to 2000°F to destroy any remaining hydrocarbons and toxic volatiles. The gases are cooled and passed in a venturi scrubber to remove particulates and corrosive gases. The venturi off-gas is passed through a mist eliminator and is reheated to 50°F above the dew point prior to passing through a High Efficiency Particulate Air (HEPA) filter. The scrub solution is concentrated to 25% solids by an inertial filter. The sludge containing the combustion chemical contaminants is encapsulated with the residue of the incinerated waste.

INTRODUCTION

The objective of PREPP is to demonstrate the viability of a commercial plant for processing selected TRU waste at INEL into a form acceptable for disposal at WIPP. An incineration method is proposed for volume reduction of wastes followed by encapsulation of solids in cement grout.

Coplan [1] reviewed various incineration and off-gas treatment systems. Controlled air incineration systems typically use primary (1200-1700°F) and secondary (2000-2500°F) combustion chambers to achieve complete waste combustion. Rocky Flats Plant [2] employs a fluidized bed incinerator and dry off-gas system for processing TRU combustible wastes. Savannah River Laboratory [3] developed a controlled air incinerator to treat solid combustible TRU wastes. Dry and wet scrubbers were tested for treatment of off-gases. A controlled air pyrolysis incinerator [4] was reported in which the off-gases were burned in a combustion chamber under controlled excess air then treating the gases in a dry clean-up system. Tests for PREPP [5,6] were performed in a rotary kiln under controlled air combustion to assess the potential for processing the TRU waste at INEL.

EG&G Idaho Inc. is the operator of the Department of Energy facility at INEL. The Systems Division of The Ralph M. Parsons Company, Pasadena, California, U.S.A. provided the engineering design for the PREPP under Contract Number DE-AC07-79ET41703, Job Number 5943 [7,8].

DESIGN CRITERIA

Basic Function

The initial processing method will consist of low speed shredding of container, (includes principally 55-gal steel drums and 4' x 4' x 7' tall fiberglass reinforced wooden boxes) and contents, incineration, immobilization by cementing, and off-gas treatment. These selected wastes will be processed at approximately 7 TPD. Unshreddable items inadvertently sent to the plant will be removed from the shredder and will be repackaged and returned to Stored Waste Examination Pilot Plant (SWEPP). The PREPP is designed to provide processed waste meeting the SWEPP Waste Acceptance Criteria.

The PREPP is designed to operate three shifts per day, five days per week, for 40 weeks per year (4800 hrs/yr), while no more than 12 weeks per year will be reserved for facility upgrade and repair and major equipment maintenance [7,8]. The design incorporates provisions for future modifications and/or expansions in phases to increase the process capabilities should they become desirable [7,8].

The plant design allows for the hands-on maintenance of the off-gas treatment equipment, bagout of HEPA filter elements and to prevent generation of liquid waste during operation. Based on cost of repair and decontamination, contaminated components may be routed back to the shredder for processing.

SWEPP Interfaces

SWEPP provides both the front and back end support for PREPP and performs the following functions: retrieve stored waste, x-ray and assay, segregate containers, store retrieved waste, and store PREPP product [7,8]. PREPP performs the following functions: shred, incinerate, immobilize by concreting, package product, package unshreddables, and verify certification procedures [7,8].

Major Equipment

Shredder - The shredder has the capability of processing TRU waste in wooden or steel boxes and drums at a rate of 7 TPD of average waste when shredding 5 minutes per hour.

Incinerator - The nominal feed rate to the incinerator is 7 TPD of average waste (683 lb/hour). The nominal size constrains for the rotary kiln are 8' OD, 6' ID, by 25' long.

The size restraints for the rectangular secondary combustion chamber (SCC) are 7' deep by 11' wide by 21' high with a nominal 12" of refractory. Normal operating temperatures are 1300° to 1800° for the kiln and 1900° to 2100°F for the SCC. Waste retention time in the kiln is 90 minutes minimum. Off-gas residence time in the SCC is a minimum of 2 sec at 2000-2200°F with a minimum 3% by weight excess oxygen in the off-gas measured at the SCC exit.

Trommel Screen - The feed rate to the trommel is 600 lb/h maximum. The coarse material is loaded into the end-product containers and the fines are diverted to fines tanks.

Quencher - The quencher cools the off-gas from the SCC to its adiabetic saturation temperature ($\leq$ 185°F) by evaporative quenching.

Venturi Scrubber - The venturi removes particulates, hydrogen chloride, and sulfur oxides gases from the quenched off-gas by high-efficiency scrubbing ($>$ 99% particulates removal). The venturi has a constant scrubbing efficiency at varying loads and has a variable throat under differential pressure of 50 inches of water. The liquid and gases are separated by a Chevron type entrainment eliminator.

Mist Eliminator - The demister (mesh type) removes any residual particulates and scrubbing mist carryover from the entrainment eliminator. Demister shall be 100% efficient on droplets $\geq$3 micron and at least 94.0% efficient on $<$ 3 micron.

Inertial Pressure Filter - The filter (4-6 gpm of filtrate) removes entrained particulates from the scrubbing solution by high-efficiency filtration.

Waste Composition

The PREPP is designed to process selected types of TRU waste with composition shown in Table I. Four types of waste, namely, average waste (40% inorganic sludge and 60% non-sludge), shreddable metals, combustibles, and inorganic sludge are considered for PREPP design. Each waste, containers and their contents, will be shredded and incinerated separately from any other type of waste.

The waste consists of wood, paper, cloth, plastics, stainless steel, other metals, rubber, glass, sludge, concrete, etc.

Average waste drums are 55 gallons with an average weight of 327 lb and filled with metals, noncombustibles, combustibles, and inorganic sludge.

Metal-filled boxes generally are 4' x 4' x 7' fiberglass-coated plywood with an average weight of 2,366 lbs.

Combustible waste-filled boxes are 4' x 4' x 7' fiberglass-coated plywood with an average weight of 1,921 lbs.

The inorganic sludge drums are 55 gallons with an average weight of 483 lbs. This waste is mainly metal oxides with no free water whose composition provides an extreme low case for the mass balances.

The PREPP design is based on a 7 TPD of average mix. Other mix compositions are given to provide information on the wide range of material which may be processed at rates lower than 7 TPD to maintain plant parameters within the design values, specifically 4100 ACFM of combustion gases.

Process Flow Diagram

The PREPP flow diagram, figure 1, shows the major process flows. Containers of verified waste to be processed are routed to a shredder for simultaneous opening and sizing. All shredded wastes plus container material are routed to the incinerator. Unshreddable material are repackaged and shipped back to SWEPP.

The fines are removed from incinerator residue. The coarse material is containerized; the wetted fines and a cement grout are then combined with the containerized coarse material to form a concreted end product. Combustion gases are treated in a wet scrubber then reheated prior to passing through a HEPA system.

TABLE I

Waste Characterization

	COMPOSITION (%)													ULTIMATE ANALYSIS (%)								
	STAINLESS AND CARBON STEELS	LEAD	OTHER METALS	PAPER	CLOTH	PLASTICS	RUBBER	INORGANIC SLUDGE (A)	NON-COMBUSTIBLES (B)	FIBER GLASS	PLYWOOD	CARDBOARD	MISC. ITEMS (C)	CARBON	HYDROGEN	OXYGEN (D)	NITROGEN	SULFUR	CHLORIDE	LEAD	MOISTURE	INERTS
AVERAGE WASTE DRUMS (E)	28.9	0.4	0.7	11.2	2.7	1	0.2	46.9	8	-	-	-	-	7.32	1.05	9.59	0.72	0.01	0.29	0.40	28.14	52.80
SHREDDABLE METAL-BOXES	64.6	5.5	3.2	0.6	0.8	1.6	0.2	-	-	7	14.7	0.8	-	10.06	1.27	7.41	0.05	0.03	0.36	5.5	-	75.32
COMBUSTIBLE WASTE-BOXES	-	-	1.1	47.1	11.4	3.8	0.8	-	1.2	10.6	22.4	1.6	-	41.81	5.41	34.55	0.61	0.15	1	-	-	16.47
INORGANIC SLUDGE DRUMS	12.4	-	-	-	-	5.2	-	81.4	-	-	-	-	1	3.24	0.59	6.65	1.02	0.11	0.06	-	48.84	39.49

(A) 60% WATER
(B) BRICK, SAND, GLASS CERAMICS, ETC.
(C) CLOTH, TOOLS, FIBER GLASS, ETC.
(D) EXCLUDES OXYGEN IN OXIDE FORM OR MOISTURE

(E) AVERAGE WASTE MIX 600-1300 BTU/LB (AV. 1200 BTU/LB)
INORGANIC SLUDGES 0- 500 BTU/LB (AV. 100 BTU/LB)
SHREDDED METAL 900-2000 BTU/LB (AV. 1700 BTU/LB)
COMBUSTIBLE WASTE 5400-8100 BTU/LB (AV. 6700 BTU/LB)

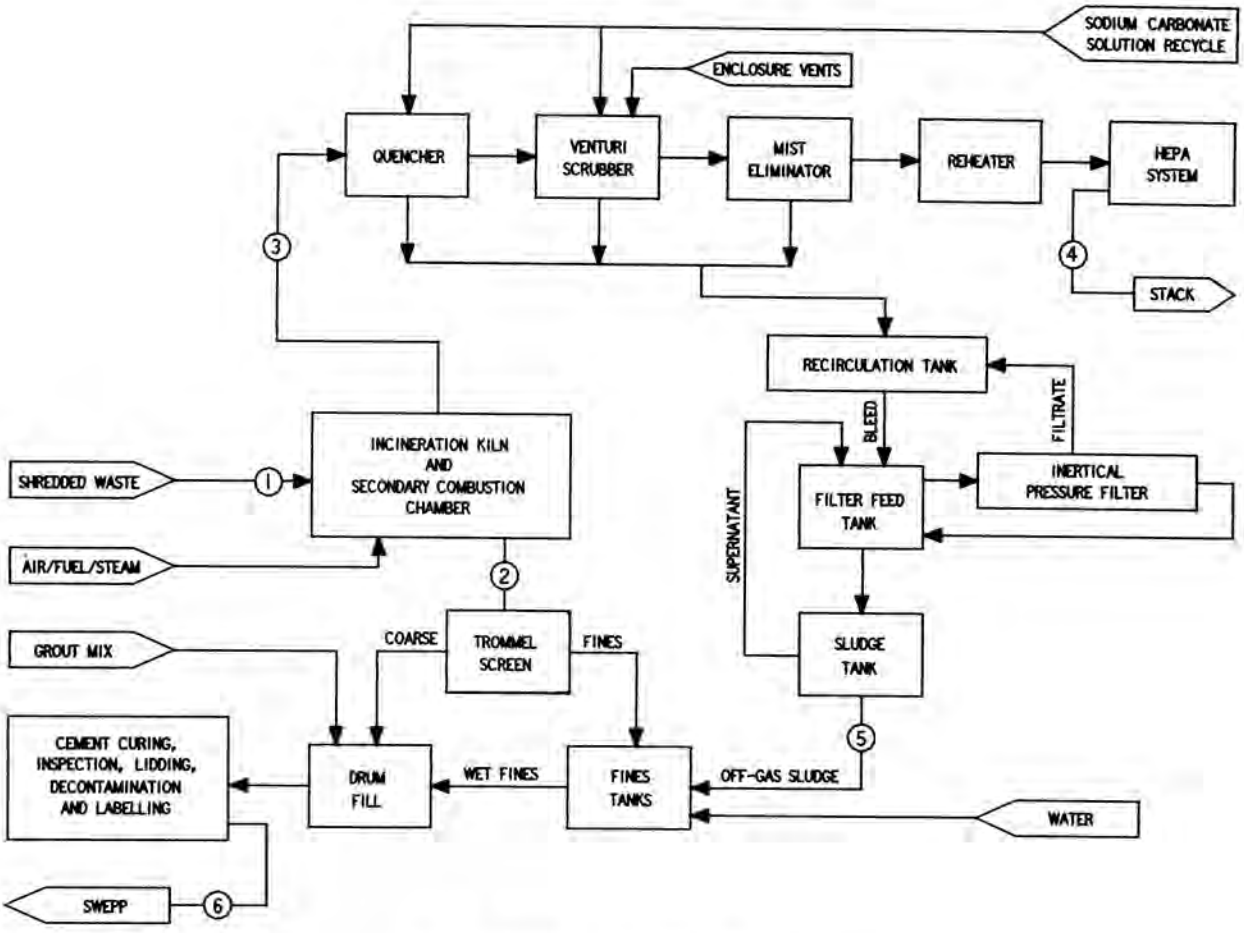

Fig.1. PREPP Process Flow Diagram.

The end product waste container (and contents) are inspected, and then shipped to SWEPP for final certification and labeling for shipment to WIPP.

MATERIAL BALANCE

The material balance for the four wastes considered for PREPP design, namely average waste, shreddable metals, combustibles and inorganic sludge are shown in Table II and is based on 7 TPD of an average waste or waste producing 4100 ACFM of combustion gases.

DISCUSSION

Waste containers are presorted and inspected at SWEPP. The waste and its container are shredded then fed to a rotary kiln incinerator heated to 1700°F. The non-shreddable materials are packaged and returned to SWEPP.

The incinerator waste is cooled and classified by a trommel screen. The fine portion is mixed with a sand and cement grout which are placed with the coarse portion in 55 gallon steel drums. The drum is vibrated during filling to ensure complete matrixing of the coarse material. After curing, inspection, siphoning of any free standing water, lidding, decontamination, and labelling, the drums are shipped to WIPP.

The kiln off-gas is reheated to 2000°F for at least two seconds with 3% excess oxygen in the SCC to completely burn any remaining hydrocarbons and toxic volatiles. The gases are cooled adiabatically to about 180°F with aqueous sodium carbonate spray in a quencher. Enclosure vent is mixed with the quencher off gas prior to entering the venturi scrubber (160°F). Removal of particulates (99.9%), hydrogen chloride (95%), sulfur oxides (90%) and some nitrogen oxides (35%) from the combustion gases using sodium carbonate solution is accomplished in a venturi scrubber operating at a differential pressure of 50 inches of water. The off-gas is passed through a mist eliminator to remove excess moisture and reheated to about 50°F above the dew point prior to the HEPA filter.

The liquid effluent from the quencher and venturi scrubber is concentrated to 25% solids by an inertial pressure filter before discharging the slurry into a sludge tank where it is settled to about 40% solids. The thickened sludge containing the combustion chemical contaminants in the form of liquid waste is encapsulated with the residue of the incinerated waste.

Combustibles produce the highest volume reduction ratio of 17:1 while shreddable metals produce the least volume reduction ratio of 2:1. The average waste feed rate (maximum) is 7 TPD and combustibles

TABLE II

Material Balance

WASTE TYPE	STREAM NUMBER AND NAME	COMPONENTS												
		MASS FLOW lb/H	WATER/MIST/VAPOR lb/H	OXYGEN lb/H	NITROGEN lb/H	CARBON DIOXIDE lb/H	SULFUR OXIDES lb/H	HYDROGEN CHLORIDE lb/h	NITORGEN OXIDES lb/H	PARTICULATES/SOLIDS lb/H	SODIUM SALTS lb/H *	VOLUME FLOW GPM, ACFM, FT^3/H	TEMPERATURE °F	DENSITY lb/FT^3
AVERAGE WASTE DRUMS	1. SHREDDED WASTE TO INCINERATOR	583										13.3	77	44
	2. INCINERATED WASTE TO COOLER	291										2.2	1700	136
	3. SECONDARY COMBUSTION CHAMBER OFF-GAS	3141	424	112	2082	494	1.1	1.7	9	17		4074	200	0.013
	4. SLURRY TO SLUDGE TANK	68	41							17	10.1	<0.1	85	89
	5. GAS LEAVING HEPA	8911	1973	1093	5334	498	<0.1	<0.1	13.8	<0.1		3395	210	0.044
	6. FILLED DRUMS	592	42							545	5.0	3.8	77	156
SHREDDABLE METAL-FILLED BOXES	1. SHREDDED WASTE TO INCINERATOR	570										8.6	77	66
	2. INCINERATE WASTE TO COOLER	445										4	1700	111
	3. SECONDARY COMBUSTION CHAMBER OFF-GAS	3206	366	171	2175	473	0.3	2.1	0.6	18		4116	2000	0.013
	4. SLURRY TO SLUDGE TANK	72	44							18	10.1	0.1	85	88
	5. GAS LEAVING HEPA	703	1948	1157	5427	476	<0.1	<0.1	0.9	<0.1		3426	210	0.044
	6. FILLED DRUMS	9009	34							665	4.1	4.3	77	164
COMBUSTIBLE WASTE-FILLED BOXES	1. SHREDDED WASTE TO INCINERATOR	130										7.6	77	17
	2. INCINERATED WASTE TO COOLER	13										0.1	1700	136
	3. SECONDARY COMBUSTION CHAMBER OFF-GAS	3096	433	157	2042	453	0.4	1.4	1.7	8		4048	2000	0.013
	4. SLURRY TO SLUDGE TANK	32	18							8	5.8	<0.1	85	93
	5. GAS LEAVING HEPA	8914	2020	1141	5294	456	<0.1	<0.1	2.6	<0.1		3410	210	0.044
	6. FILLED DRUMS	77	13								3.1	0.5	77	166
INORGANIC SLUDGE DRUMS	1. SHREDDED WASTE TO INCINERATOR	560										26.7	77	21
	2. INCINERATED WASTE TO COOLER	204										1.2	1700	171.7
	3. SECONDARY COMBUSTION CHAMBER OFF-GAS	2972	542	43	1889	470	1.2	0.4	12.2	15		3967	2000	0.013
	4. SLURRY TO SLUDGE TANK	60	39							15	6.0	0.1	85	83
	5. GAS LEAVING HEPA	8808	2154	1022	5141	473	<0.1	<0.1	18.7	<0.1		3398	210	0.043
	6. FILLED DRUMS	603	60							540	3.0	3.7	77	163

* SODIUM CARBONATE, CHLORIDE AND SULFITE

feed rate (minimum) is 1.6 TPD. The rotary kiln incineration system was chosen as it yields the maximum desirable volume reduction with optimum off-gas system because of reduced ash carryover; i.e., at minimum capital and operating cost especially energy consumption. PREPP is designed to verify the various equipment for scale up to commercial plant.

CONCLUSIONS

PREPP has a simple design incorporating proven unit operations to achieve volume reduction up to 17:1 with the solid and liquid wastes being disposed of in a cement grout and the gaseous effluent is cleaned in a wet scrubber to meet EPA, DOE, and State of Idaho environmental regulations on effluent standards.

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