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**FLUIDIZED BED INCINERATION SYSTEM
FOR U.S. DEPARTMENT OF ENERGY
DEFENSE WASTE
JANUARY - JUNE 1978**

David L. Anderson

Burke A. Bell

Pen K. Feng

Frank G. Meyer

Chemistry Research and Development
PILOT PLANT DEVELOPMENT

CB

Rockwell International

Energy Systems Group
Rocky Flats Plant
P.O. Box 464
Golden, Colorado 80401

U. S. DEPARTMENT OF ENERGY
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SUBJECT DESCRIPTORS

Fluidized Bed
Incinerators
Waste Management

**ROCKWELL INTERNATIONAL
ENERGY SYSTEMS GROUP
ROCKY FLATS PLANT
P.O. BOX 464
GOLDEN, COLORADO 80401**

**Prepared under Contract DE-AC04-76DPO3533
for the
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 Boston, Mass. 02115

- 1 – Dr. Peter J. Dyne
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Whiteshell Nuclear Research Establishment
Pinawa, Manitoba
Canada, R0E1L0
- 1 – A. K. Williams
Allied-General Nuclear Services
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Barnwell, South Carolina 29812
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Ontario Hydro
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700 University Ave.
Toronto, Canada M5G1X6
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Westinghouse Electric Corporation
Nuclear Fuel Division
Box 355
Pittsburgh, Pennsylvania 15230
- 3 – D. H. MacNary
ORM, 801000
P. O. Box X
Oak Ridge, TN 37820
- 1 – Dr. D. N. Van De Voorde
Centre d'Etude de l'Energie Nucleaire
Belgium Nucleaire SA, Mol, Belgium
25 rue de Champ-de-Mars, 1050
Brussels 1, Belgium
- 1 – Zentralstelle für
Atomkernenergie-Dokumentation
(ZAED)
Kernforschungszentrum Karlsruhe
D7501 Leopoldshafen
Federal Republic of Germany
Attn: Dr. Mrs. Bell
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Commonwealth
Scientific & Industrial
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Advanced Technology Division
Kaiser Engineers
300 Lakeside Drive
Oakland, CA 94666
- 1 – P. Dudley Josselyn
FMC Corp.
Box 760
San Jose, CA 95106
- 1 – Gary Simmons
Whiteshell Nuclear Research Establishment
Pinawa, Manitoba
Canada, R0E1L0
- 1 – Dr. M. Laser
Institut für Chemische Technologie
Der Kernforschungsanlage
517 Jülich 1, Den
Postfach 365
Federal Republic of Germany
- 1 – Process Systems & Component Development
Nuclear Fuel Division
Box 355
Pittsburg, PA 15230
- 1 – D. E. McKenzie
Atomics International Division
Rockwell International
8900 DeSota Ave.
Canoga Park, CA 91304
- 3 – J. D. Dempsey, R. W. Ramsey, R. A. Wolfe
DOE Division of Waste Management

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FLUIDIZED BED INCINERATION SYSTEM FOR U.S. DEPARTMENT OF ENERGY DEFENSE WASTE

David L. Anderson, Burke A. Bell, Pen K. Feng, and Frank G. Meyer

Abstract. A fluidized bed incineration facility has been designed for installation at the Rocky Flats Plant to develop and demonstrate the process for the combustion of transuranic waste. The unit capacity will be about 82 kg/hour of combustible waste. The combustion process will utilize *in situ* neutralization of acid gases generated in the process. The equipment design is based on data generated on a pilot scale unit and represents a scale-up factor of nine. Equipment installation was completed on April 30, 1978. Equipment checkout and startup is in progress.

INTRODUCTION

Fluidized bed incineration is being evaluated at the Rocky Flats Plant (RFP) as an alternative to conventional incineration for processing transuranic (TRU) combustible waste. The fluidized bed concept was developed successfully from a 9 kg/hour (20 lb/hour) pilot plant system which has been testing low level plutonium contaminated solid and liquid wastes. This concept is now being pursued with an 82 kg/hour (180 lb/hour) development plant. Process equipment installation for the plant was completed on April 30, 1978. Incineration of solid waste will begin in July 1978. This substantial amount of research is being expended in an effort to overcome inherent problems in conventional incineration of TRU wastes, and to develop an improved incineration system for processing existing and/or future waste from the nuclear industry in general.

Through the years, operation of the plutonium recovery facilities of the Rocky Flats Plant has identified a need for an improved incineration system. The conventional methods employed at RFP, though effective, have resulted in substantial maintenance problems because of equipment

corrosion, short refractory life, and mechanical problems. In addition to frequent maintenance requirements, the process utilizes an aqueous flue gas scrubbing system which produces a secondary waste stream that requires additional treatment, and increases the total plant waste volume. Also, the conventional open flame incinerator produces a high temperature (850 to 1000 °C) refractory type of plutonium dioxide that does not readily lend itself to the plant's aqueous recovery technique. The fluidized bed incinerator was conceived as an alternative to the present conventional system. Promising data from subsequent work has led to the present intensive development program to produce a production scale development plant.

The fluidized bed process incorporates three concepts that set it apart from conventional incineration. One unique concept is the *in situ* neutralization of acid gases that are produced when materials such as polyvinyl chloride plastic are burned. Another is the use of a catalytic afterburner, and the third is non-flaming low-temperature combustion throughout the system. These three features are responsible for several advantages of this process over conventional methods. The most significant benefits derived are the elimination of refractory lined equipment, the elimination of aqueous flue gas scrubbing, and minimization of equipment corrosion. These factors are expected to extend equipment life, decrease maintenance requirements, and improve overall waste volume reduction.

SUMMARY

A fluidized bed incineration (FBI) system has been designed for combustion of transuranic waste. The facility is designed for a capacity of about 82

kg/hour (180 lbs/hour) which will correspond to a heat release rate of about 1,600,000 kJ/hour (1,500,000 BTU/hour). The process equipment design is based on data generated in the pilot plant and represents a scale up factor of nine based on solid waste feed rates. Approximately 45% of the heat of combustion will be extracted through the walls of the afterburner by a water spray cooling system. A water cooled heat exchanger in the flue gas stream will be used to remove approximately 55% of the heat of combustion from the process. High speed blowers will be used to provide motive force for gas flow through the process.

The four stage high efficiency particulate air (HEPA) filter exhaust plenum was made fully operational in February, 1978. A beneficial occupancy inspection was performed on April 28, 1978, and Phase II work, process equipment installation, was completed on April 30, 1978. System operational (SO) testing began on May 1, 1978, and will be concluded by the end of June 1978.

About 90% of the installation of the computer hardware equipment has been completed. The remote weighing station and control panel have been built and installed. Hardware requirements for the graphics display of the fluidized bed incineration process are being specified and will be purchased during FY 1978. The data acquisition system for 62 process variables is about 60% finished.

An Operational Safety Analysis (OSA) report for the FBI was reviewed in an OSA meeting on April 18, 1978. Changes to the report have been made and the report is going through final review.

PLANT DESIGN

Process Description

The actual fluidized bed incineration process for radioactive waste differs considerably from conventional incineration techniques. The entire operation (see Figure 1, Fluidized Bed Incineration System) is carried out within a canyon and glovebox system for containment of radioactive contamination. Waste is first passed through an air lock into a feed

preparation glovebox where it is hand sorted for removal of large size tramp metal. Sorted combustibles are then fed into a low-speed, cutter-type shredder for coarse shredding. Small pieces of tramp metal that were undetected by hand sorting are shredded along with the combustibles. Coarse shredded material passes through an air classifier for removal of most of the remaining tramp metal. Metal separated by the classifier falls into a glovebox where it can be bagged out for disposal. The waste, containing trace amounts of metal, is pneumatically transferred into a second shredder for final sizing prior to incineration. A constant-pitch tapered screw feeds the shredded waste into a primary reactor of heated sodium carbonate (Na_2CO_3) granules that are fluidized by a flow of compressed air and nitrogen gas. Within the hot fluidized bed, the waste is decomposed by partial combustion and pyrolysis which produces sufficient heat to maintain a bed temperature of 550 °C. The air-nitrogen ratio of the fluidization gas is adjusted to promote the desired amount of combustion without open flame burning. Within the fluidized bed of Na_2CO_3 , *in situ* neutralization of acid gases is accomplished. Neutralization is achieved rapidly when nascent hydrogen chloride gas (HCl), formed during the decomposition of PVC plastic, reacts with Na_2CO_3 bed materials to produce sodium chloride (NaCl), carbon dioxide gas (CO_2), and water vapor. Offgas from the primary reactor passes into a cyclone separator where most of the entrained Na_2CO_3 , NaCl, and fly ash is removed before the gas is introduced into the catalytic afterburner. In the afterburner chamber, combustion air is added to the gas stream as it passes through a fluidized bed of oxidation catalyst. Here, complete combustion is achieved without open flame burning. Convective heat from the afterburner will be removed by a water jacket heat transfer system.

Flue gas leaving the catalytic afterburner contains fly ash, catalyst dust, and small amounts of Na_2CO_3 and NaCl fines that were not removed from the primary reactor offgas by cyclone separation. About 75 to 85% of this dust is removed by passing the gas stream through a second cyclone separator. The remainder is removed as the gas passes through a bank of sintered metal filters prior to cooling to 50 °C in a water-cooled heat exchanger. The cooled

FIGURE 1. Fluidized Bed Incineration System

flue gas is then pulled into four high-speed blowers that provide motive force for the process flow and maintain a slightly negative pressure throughout the system. Offgas from the process passes through a bank of high efficiency particulate air roughing filters prior to exiting through the building plenum system of four-stage HEPA filtration. Dust removed by cyclone separation and sintered metal filtration is cooled in a screw conveyor that transfers the residue into a drum for disposal.

The development plant will feature automatic control systems to regulate bed temperatures within the primary reactor and catalytic afterburner. The primary bed temperature will be controlled by the air to nitrogen ratio of the fluidization gas. A drop in bed temperature will activate automatic controls to increase the percent of air until the bed temperature climbs to the desired set point. Conversely,

the percent of nitrogen will automatically be increased if a heat spike drives the bed temperature above a predetermined point. Catalytic afterburner temperature will be regulated by the quantity of waste being fed into the system. If the water jacket heat transfer system for the afterburner does not maintain the desired bed temperature, automatic controls will increase or decrease the speed at which the screw feeder transfers waste into the primary reactor. In this manner, the amount of fuel entering the afterburner will be controlled to maintain a preset catalyst bed temperature.

Status of Engineering Work

Roughing filters for the four-stage HEPA system were installed in February, 1978. The four-stage HEPA system was also tied into the pilot plant. This system is now fully operational.

Equipment Installation

Phase II, process equipment installation, was completed on April 30, 1978. The beneficial occupancy inspection for the process equipment was conducted on April 27, 1978. An Operational Safety Analysis (OSA) report was written and reviewed on April 18, 1978. Changes are being made to the report before final approval. System Operational (SO) testing of process equipment started on May 1, 1978. All SO testing should be completed by the end of June, 1978.

Process Monitoring and Control Systems

The fluidized bed incineration process will utilize a programmable data processor - 11/10 (PDP-11/10) minicomputer in conjunction with the Foxboro Interspec System for process monitoring and control purposes (refer to previous Progress Report RFP-2654). Field measurements consisting of 25 temperatures, 16 pressures, three flows, one contact closure, one weight, six analyzers, and ten control loops will be brought into the Foxboro Interspec System where analog-to-digital conversion takes place. These signals are sent to the PDP minicomputer to form a process data base from which pertinent information concerning the process can be extracted. A timer will continuously transfer and update the data base at some preset interval (e.g. one minute).

The incorporation of computer process control will take place in two steps. During Phase I, the computer will perform strictly process monitoring and data acquisition operations. As more experience is gained from the operation of the fluidized bed incinerator, Phase II will be implemented. Phase II will consist of programming into the computer the control logic necessary for direct digital control with supervisory set-point control. The advantage of such a computerized control system with the correct analog-digital interface is the great flexibility it offers the user. Once the hardware (computer, instrumentation peripheral and interphase equipment, etc.) is in place, any field measurement can control any one or more actuating device by changing the system software (computer programs) environment. Little or no hardware change is necessary.

Work Performed During This Period

Work accomplished during this period is divided into two areas:

1. Hardware

- a. The remote Weighing Station has been installed.
- b. The control panel was wired and installed in the control room.
- c. The Foxboro Interspec System has been wired to the process sensors and the computer.
- d. Installation of process sensors was completed with the exception of the HCl analyzer.

2. Software

- a. Hardware diagnostic routines and operating system routines have been completed and are undergoing debugging tests.

Future Work

1. Hardware

- a. Final calibration of process sensors.
- b. Procure and build Graphics Display Panel.
- c. Order and take delivery of spare parts.

2. Software

- a. Prepare a process control instruction manual.
- b. Indoctinate and train operating personnel.
- c. Continue to upgrade a package of off-line scientific programs that will analyze data collected during an incineration run.
- d. Formulate control equations necessary to incorporate computer control of the steady state incineration process.

Experimental Equipment

A lab-scale fluidized bed incinerator has been designed as part of the fluidized bed laboratory development program. This unit will be used to investigate changes in fluidized bed incineration temperatures, catalysts, bed composition and dimension, fluidizing techniques, and other operating parameters which are not easily obtainable or are impractical to investigate on the larger pilot and/or demonstration scale equipment.

The lab-scale unit is being designed to burn 1.7 kg per hour of pre-shredded simulated waste. This represents a scale-down factor of approximately five from the pilot unit and forty-eight from the demonstration plant.

The process flow diagram of the lab scale unit is virtually identical to the pilot plant. An air ejector will be used as in the pilot unit to provide motive force. Notable exceptions in similarity are listed below:

1. The lack of a waste shredder and air classifying system. The lab-scale unit will burn only pre-shredded, simulated waste material.
2. The lab-scale unit will not be used to process any contaminated material. Therefore, it will not require gloveboxes and can be installed in a contamination free area (Building 701).

The fluidized bed diameters for the incinerator vessel and afterburner have been sized at 15.2 cm and 30.5 cm, respectively. Both of these reactors will be approximately 92 cm in height. Anticipated bed depths for both vessels are 30.5 cm. The design of both of these vessels will be such that longer extensions may be easily bolted on to the vessel's upper flange to extend the bed depth and volume if desired. In addition, the design of the flue gas combustion air distributor on the afterburner can easily be changed.

The process flow diagram and heat and material balance have been completed for this unit. After completing detailed equipment design and drafting, equipment fabrication can proceed. Purchase requisitions have been initiated for temperature and flow instrumentation.

EXPERIMENTAL CONCLUSION

About 30 percent of the scheduled SO testing has been completed, and it appears that the present data acquisition system can handle initial process startup needs. This system will also be invaluable in maintaining the accuracy of process control and non-control loops.