TITLE: COMMERCIAL INCINERATION DEMONSTRATION

AUTHOR(S): J. S. Vavruska and L. C. Borduin

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COMMERCIAL INCINERATION DEMONSTRATION

John S. Vavruska and Leon C. Borduin
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

ABSTRACT

Low-level radioactive wastes (LLW) generated by nuclear utilities presently are shipped to commercial burial grounds for disposal. Increasing transportation and disposal costs have caused industry to consider incineration as a cost-effective means of volume reduction of combustible LLW. Repeated inquiries from the nuclear industry regarding the applicability of the Los Alamos controlled air incineration (CAI) design led the DOE to initiate a commercial demonstration program in FY-1980. Development studies and results in support of this program involving ion exchange resin incineration and fission/activation product distributions within the Los Alamos CAI are described.

INTRODUCTION

Since 1975, low-level waste transportation costs have increased by 50 percent and disposal fees have risen five-fold. (1) This adverse expenditure trend has caused many within the commercial nuclear industry to view advanced volume reduction techniques with renewed interest. Among the alternative technologies being considered, incineration of combustibles is recognized as one of the most effective methods for reducing both the mass and volume of waste shipments.

At present, several universities and hospitals are operating, installing, or have committed to install combustion processes to treat institutional wastes. (2) Nuclear utility commitment in this area, however, has been substantially less. Factors in this hiatus include cost, technical, and licensing uncertainties associated with reactor waste combustion systems. To fill this technical need and in response to continued, substantial utility interest in the Los Alamos controlled air incineration (CAI) system (developed for transuranic (TRU) waste treatment), DOE initiated this program in FY-1980 to support demonstration at a nuclear utility site. An architect-engineering firm has been selected by the DOE to prepare a licensing submittal for a LLW incinerator based on the Los Alamos CAI design at an operating commercial power reactor. The license application is scheduled to be submitted
for Nuclear Regulatory Commission review by the end of the second quarter of CY-1983.

An important objective of the program is to determine the key design and operating conditions necessary to convert the CAI from a TRU waste incineration system into one which can accept nuclear utility low-level wastes.

An important difference between the two waste types is the radio-nuclide makeup of each. Transuranic wastes generated by the defense program are contaminated with non-volatile heavy metal radioisotopes, primarily Pu-239. Power reactor wastes, on the other hand, contain a wide variety of fission and activation products of varying volatility. In addition, power reactors generate significant quantities of spent ion exchange resins. These resins have been identified as a challenging combustion problem in earlier tests in other systems. Data and results obtained from the incineration tests described in this paper will provide a basis for design and licensing of the CAI for incineration of LLW at the selected nuclear utility site.

COMMERCIAL INCINERATION DEMONSTRATION PROGRAM

The goal of this program is demonstration of CAI/LLW technology at a nuclear utility site. Program objectives contributing to this goal include resolution of technical uncertainties through development studies at Los Alamos, preparation of a design specifically adapted to nuclear utility LLW handling and treatment requirements, NRC licensing of the process, and installation/operation at a utility site. The selected project approach is a DOE-sponsored joint effort involving participation of Los Alamos, the nuclear utility which will serve as demonstration site, and a subcontractor to serve as interface in design, licensing, fabrication, and installation activities.

PROCESS DESCRIPTION

The CAI/LLW demonstration program has expanded the capabilities of the transuranic waste incineration process shown in Figure 1. The CAI/TRU system which has been described in earlier reports (3,4) is based primarily on commercially available equipment components.

Much of the equipment is enclosed to provide containment of plutonium to meet health and safety standards for transuranic materials. As demonstrated with Pu-239 contaminated solid wastes, the CAI/TRU process consisted of four major subsystems: solid feed preparation, incineration, offgas cleanup, and scrub solution recycle. A liquid/slurry feed system and high intensity liquid burner have since been incorporated into the process to support LLW and hazardous waste incineration studies. The heart of the system is a dual-chamber controlled air
The major objectives of the Los Alamos program in support of the CAI/LLW demonstration are to: 1) develop and transfer design and operating data based on experimental tests to the liaison subcontractor, and 2) provide technical assistance to both the subcontractor and utility through licensing and completion of the demonstration. Los Alamos, therefore, assumes the lead technical role in establishing design and operating parameters for the CAI/LLW demonstration process.

**Development Studies**

Experimental development studies in support of the CAI/LLW demonstration program have focused on two areas: 1) evaluation of fission/activation product distributions within the process, and 2) feasibility of incineration of ion exchange resins.

**Fission and Activation Product Studies**

Two tests were conducted to determine the behavior of fission and activation products within the CAI system. Each test used as feed material, a solid combustible composition (Table 1) typical of nuclear power plant dry active waste. The simulated waste was packed in 0.057 m³ cardboard boxes at a package density of 79.7 kg/m³ (4.54 kg per box). Fission and activation products used in both tests were selected as being representative of the physical and chemical properties of a broader selection of isotopes which would be expected to occur in actual reactor LLW. The radionuclides used in these studies included I-131, Cs-137, Ru-106, Fe-59, and Co-60. Feed conditions for both tests are given in Table 2. The order in which the isotopes appear in Table 2 for each test is the order in which they were fed to the incinerator. In Run FAP-1, isotope feed periods were sequential, whereas Run FAP-2 provided a four hour period between each isotope feed period in which non-spiked boxes were fed at the same rate as spiked boxes. Run FAP-1, conducted in July 1981, involved the use of hybrid germanium detectors installed at various locations in the offgas cleanup system (Fig. 2). The purpose of the detectors was to measure the gamma activity and thereby quantity of each isotope in the gas phase at each location, indicated by the numbers in Fig. 2. Some difficulties were
encountered in obtaining representative gamma detection at locations 1 and 2. At location 1, a gas side stream was withdrawn from the hot duct and passed through the detector with some uncertainties arising in quantifying the fraction withdrawn. Due to the configuration at location 2, the base of the quench column, the detector counted not only activity in the gas phase but also in the liquid draining down through the column. Despite these problems, some interesting results were obtained from the test burn. For example, count rates for all isotopes at each detector location reached a maximum approximately six hours after completion of feeding each isotope. Data from run FAP-1 is being used to supplement data generated by run FAP-2.

**TABLE 1**

**COMBUSTIBLE COMPOSITION FOR FISSION/ACTIVATION PRODUCT INCINERATION TESTS**

<table>
<thead>
<tr>
<th>Component</th>
<th>Percent by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellulosics</td>
<td>35</td>
</tr>
<tr>
<td>PVC</td>
<td>12</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>23</td>
</tr>
<tr>
<td>Rubber</td>
<td>30</td>
</tr>
</tbody>
</table>

Run FAP-2, conducted in August 1982, involved the use of modified EPA Method 5 sample trains as a means of sampling the gas phase for radionuclides. Gas sampling was carried out at locations 1, 4, and 5 of Figure 2, and in addition, just downstream of the absorber column. Sampling was not done at the base of the quench column. The technique involved the steady withdrawal of a measured volume of gas at each location over the feed duration of each isotope. The sample trains consisted of two liquid-filled impingers, an activated carbon impinger, and a silica gel impinger in series to condense and adsorb all volatile isotopes in the gas sample. Preliminary results of sample counting indicate that for I-131 and Cs-137, the two most volatile isotopes used in the test, absolutely none of either isotope was detected in the carbon bed outlet (location 5, Fig. 2). Trace quantities of I-131 and no Cs-137 were detected in the gas phase downstream of the HEPA filters. Volume and mass reduction factors based on feed and ash were approximately 400:1 and 40:1, respectively for Run FAP-2. A comprehensive report will be issued summarizing the results of both tests with emphasis on radionuclide decontamination factors and material balances throughout the system.
<table>
<thead>
<tr>
<th>TEST NUMBER</th>
<th>ISOTOPE</th>
<th>ISOTOPE CONCENTRATION (mCi/box)</th>
<th>FEED RATES WASTE (kg/h)</th>
<th>FEED ISOTOPE (mCi/h)</th>
<th>FEED DURATION (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAP-1 1</td>
<td>I-131</td>
<td>0.125</td>
<td>36.4</td>
<td>1.0</td>
<td>8</td>
</tr>
<tr>
<td>FAP-1 1</td>
<td>Cs-137</td>
<td>0.125</td>
<td>36.4</td>
<td>1.0</td>
<td>4</td>
</tr>
<tr>
<td>FAP-1 1</td>
<td>Ru-106</td>
<td>0.125</td>
<td>36.4</td>
<td>1.0</td>
<td>4</td>
</tr>
<tr>
<td>FAP-1 1</td>
<td>Fe-59</td>
<td>0.125</td>
<td>36.4</td>
<td>1.0</td>
<td>4</td>
</tr>
<tr>
<td>FAP-1 1</td>
<td>Co-60</td>
<td>0.125</td>
<td>36.4</td>
<td>1.0</td>
<td>4</td>
</tr>
<tr>
<td>FAP-2 2</td>
<td>I-131</td>
<td>0.313</td>
<td>36.4</td>
<td>2.5</td>
<td>4</td>
</tr>
<tr>
<td>FAP-2 2</td>
<td>Cs-137</td>
<td>0.156</td>
<td>36.4</td>
<td>1.25</td>
<td>4</td>
</tr>
<tr>
<td>FAP-2 2</td>
<td>Ru-106</td>
<td>0.156</td>
<td>36.4</td>
<td>1.25</td>
<td>4</td>
</tr>
<tr>
<td>FAP-2 2</td>
<td>Fe-59</td>
<td>0.156</td>
<td>36.4</td>
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</tr>
<tr>
<td>FAP-2 2</td>
<td>Co-60</td>
<td>0.156</td>
<td>36.4</td>
<td>1.25</td>
<td>4</td>
</tr>
</tbody>
</table>

(1) Continuous monitoring using hyperpure germanium gamma detectors
(2) Offgas sampling using modified EPA method 5 sample trains.
Ion Exchange Resin Incineration Tests

Test burns were conducted to examine the feasibility of combustion of ion exchange resins in two feed modes: 1) batch solid feed, and 2) continuous slurry feed. For the batch feed mode, cation and anion powdered and beaded resins were fed separately into the incinerator in 0.057 m³ cardboard boxes (9.08 kg/box). Although the resins were clean and nonradioactive, observation of burning characteristics showed the absence of problems reported with other incineration systems such as violent spalling reactions and melting.

As an alternative to batchwise feeding of resins to the incinerator, a test was conducted in April 1982, to establish the feasibility of continuous resin slurry feed. A liquid/slurry feed/burner system consisting of an agitated feed tank, positive displacement progressing cavity pump, and a commercial high intensity vortex liquid burner was installed as a new addition to the CAI process. The burner (Fig. 3) is mounted on the lower chamber of the CAI firing at a 45° angle downward into the chamber. The burner nozzle can accept high concentration slurries via external atomization with air or steam. Combustion air is supplied tangentially into the burner wind box creating high turbulence for thorough mixing of the atomized feed stream and air. Natural gas can be supplied at the burner should supplemental heat be required. A test was conducted using this arrangement to burn clean non-radioactive beaded cation exchange resins.

After a number of laboratory feed preparation studies, a slurry composition was established which would provide both suspension of the resin beads in the liquid during transport to the burner, and sufficient heating value to maintain a stable flame. The slurry was prepared by adding the wet resin to a 50/50 w/w emulsion of No. 2 fuel oil and water. The emulsion was formed by adding a small quantity of commercial surfactant. Resin concentrations tested were as high as 50 weight percent of the slurry on a wet resin basis. Optimum flame stability was achieved at slurry feed rates of 60 to 82 kg/h (15 to 20.5 kg/h dry resin). Based on the overall excellent performance of the CAI during these tests, both batch and continuous slurry feed appear to be viable methods of introducing ion exchange resins into the incinerator. A detailed report summarizing the results of the resin incineration tests will be issued in early FY-1983.

Program Plans for FY-1983.

Involvement of the utility GPU-Oyster Creek, NJ will require, as a minimum, site-specific waste and site boundary release limit information, participation in the licensing proceedings with the selected subcontractor Gilbert-Commonwealth, and CAI/LLW operation. At the outset, tasks, objectives, and responsibilities will be redefined to reflect the capabilities and circumstances of all participants.
Anticipated Los Alamos activities will include incineration tests using site-specific or non-radioactive loaded resins. These experiments will serve to verify design and operating parameters and provide offgas emissions information for the CAI demonstration unit. Further assistance will be provided to the subcontractor and host utility during start-up, non-radioactive shakedown tests, and demonstration operation of the CAI/LLW system.
REFERENCES


FIGURE TITLES

Fig. 1  Controlled air transuranic waste incineration process.

Fig. 2  CAI offgas cleanup system showing locations of hybrid germanium detectors.

Fig. 3  Liquid/slurry burner system mounted on lower chamber of CAI.
CONTROLLED-AIR TRANSURANIC WASTE INCINERATION PROCESS