WSRC-TR-93-681

CONSOLIDATED INCINERATION FACILITY TECHNICAL SUPPORT (U)

Conf-940225--28

by

DAN BURNS

Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

MARSHALL G. LOOPER

A document prepared for:
WASTE MANAGEMENT '94
at TUCSON, AZ
from 2/27/94 thru 3/4/94

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DOE Contract No. **DE-AC09-89SR18035**

This paper was prepared in connection with work done under the above contract number with the U. S. Department of Energy. By acceptance of this paper, the publisher and/or recipient acknowledges the U. S. Government's right to retain a nonexclusive, royalty-free license in and to any copyright covering this paper, along with the right to reproduce and to authorize others to reproduce all or part of the copyrighted paper.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

This report has been reproduced directly from the best available copy.

Available to DOE and DOE contractors from the Office of Scientific and Technical Information, P. O. Box 62, Oak Ridge, TN 37831; prices available from (615) 576-8401.

Available to the public from the National Technical Information Service, U. S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161

WSRC-TR-93-681

CONSOLIDATED INCINERATION FACILITY TECHNICAL SUPPORT

Dan B. Burns and Marshall G. Looper
Westinghouse Savannah River Company
Savannah River Technology Center

ABSTRACT

In 1996, the Savannah River Site plans to begin operation of the Consolidated Incineration Facility (CIF) to treat solid and liquid RCRA hazardous and mixed wastes. The Savannah River Technology Center (SRTC) leads an extensive technical support program designed to obtain incinerator and air pollution control equipment performance data to support facility start-up and operation. Key components of this technical support program include recently completed waste burn tests at both EPA's Incineration Research Facility and at Energy and Environmental Research Corporation's Solid Waste Incineration Test Facility. The main objectives for these tests were determining the fate of heavy metals, measuring organics destruction and removal efficiencies, and quantifying incinerator offgas particulate loading and size distribution as a function of waste feed characteristics and incineration conditions. In addition to these waste burning tests, the SRTC has recently completed installation of the Offgas Components Test Facility (OCTF), a 1/10 scale CIF offgas system pilot plant. This pilot facility will be used to demonstrate system operability and maintainability, evaluate and optimize equipment and instrument performance, and provide direct CIF start-up support. Technical support programs of this type are needed to resolve technical issues related with treatment and disposal of combustible hazardous, mixed, and low-level radioactive waste. Implementation of this program will minimize facility start-up problems and help insure compliance with all facility performance requirements.

INTRODUCTION

The Consolidated Incineration Facility (CIF) is a rotary kiln incinerator currently under construction at the Savannah River Site to treat solid and liquid RCRA hazardous, and mixed wastes generated by site operations and clean-up activities. A WM PEIS will determine if low-level radioactive waste is also treated in the CIF. Thermal treatment will be performed in a 13 million Btu rotary kiln incinerator and 5 million Btu secondary combustion chamber. The facility air pollution control system (APCS) consists of a recirculating liquid quench and steam-atomized scrubber for offgas cooling and cleaning, a cyclone separator and mist eliminator for liquid/gas separation, and final HEPA filtration prior to atmospheric discharge through the facility stack. A process flow diagram for the CIF is shown in Figure I.

The technologies selected for use in the CIF were based on discussions and reviews of existing commercial and DOE incinerators, on-site air pollution control experience, and recommendations from contracted consultants. This approach resulted in a unique facility design utilizing experience gained from other operating hazardous/radioactive incinerators. The Savannah River Technology Center (SRTC) has developed an integrated technical support program to resolve open technical issues concerning facility start-up, operation, and process optimization. Technical issues are currently identified and managed by a CIF technical issues committee. This committee is comprised of managers representing all program elements, design, operation, maintenance, engineering, and technical. Issues are scheduled, tracked, and documented by a technical issues program. SRTC is the primary resource for resolution of CIF technical issues.

TECHNICAL SUPPORT PROGRAM OVERVIEW

The CIF technical support program has three primary areas of focus: performance evaluation and optimization of the APCS and rotary kiln seals (minimizing facility emissions), treatment and disposal of generated secondary wastes (kiln ash and offgas scrubber blowdown), and modeling system behavior under normal and facility upset (e.g. loss of power) scenarios. The first two areas require accurate characterization of expected CIF emissions and secondary wastes, and offsite tests burning simulated CIF waste have been performed to provide this data. In addition to these offsite test programs, pilot-scale equipment testing, and process computer modeling comprise the CIF technical support program. A brief description of each program component follows.

Offsite Experimental Programs

During the CIF early design period, several tests were conducted at vendor facilities to evaluate equipment performance. These tests included burner tests that evaluated organic destruction efficiency and turndown. Offgas scrubber tests evaluated particulate removal efficiency, and crossflow filter tests were conducted to concentrate scrubber blowdown waste prior to treatment and disposal. These tests aided in the selection of specific technologies and equipment for the CIF. After the CIF design was completed, the objective of offsite testing change from technology evaluation to characterizing equipment performance/emissions as a function of various operating parameters. Characterization of kiln emissions and secondary waste streams is required for waste treatment determination and equipment optimization tests. These tests, which have been completed, are summarized below.

Scrubber Vendor Testing[1] - Tests were conducted at the CIF scrubber vendor facility to characterize salt emissions from the process quench and steam-atomized scrubber. Previous testing and DOE experience at another mixed waste incinerator indicated excessive salt emissions could significantly affect downstream air pollution control equipment, in particular high efficiency particulate air (HEPA) filters. A series of runs determined the effect of the following operating parameters on salt emissions.

- salt concentration in the quench and scrubber solutions
- total gas flow through the scrubber/cyclone
- quench liquid flow rate and droplet size
- scrubber steam/offgas flow ratio

These tests revealed that carry-over of salt form the APCS depends primarily on salt concentration in the scrubber liquid. To keep salt concentrations below 0.02 gr/dscf, salt in the scrubber water had to be below 3 wt%. Increasing salt concentrations in the quench liquid caused salt deposits to form in the process piping leading to the scrubber, yet higher inlet salt loadings did not increase salt carry-over through the scrubber. Operation of the scrubber at 60% of the design throughput did not significantly increase salt carry-over. Yet, dropping the offgas flow to 40% of the design throughput significantly reduced scrubbing efficiency and doubled salt emissions. Test data also revealed that the flow rate of liquid to the quench, the droplet size of quench water sprayed into the hot gas stream, and the scrubber steam/offgas flow ratio did not significantly effect scrubber salt emissions.

<u>Metals Partitioning Test</u> - Test burns were conducted at Energy and Environmental Research Corporation's (EERC) rotary kiln simulator, the Solid Waste Incineration Test Facility, using surrogate CIF wastes spiked with hazardous metals and organics. The primary objective of this test was to determine the partition of heavy metals in waste feed between the kiln bottom ash, scrubber blowdown, and stack gas as a function of the following test variables:

- incineration temperature
- waste chloride concentration
- waste form (solid or liquid)
- chloride concentration in scrubber water

Also, these secondary waste streams were characterized to determine waste treatment requirements prior to final disposal.

Three CIF waste simulants (Table 1) were incinerated, two mixtures of solid waste (paper, plastic, latex, and polyvinyl chloride), and a liquid waste mixture (benzene and chlorobenzene). Toxic organic and metal compounds were spiked (Table 2) into simulated wastes to evaluate their fate at three different kiln operating temperatures. Kiln offgas (uncontrolled emissions) was sampled for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), metals, particulate loading and size distribution, and hydrochloric acid. Stack gas sampling (controlled emissions) was performed to determine scrubber capture efficiency for both metals and particulates. Kiln bottom ash and offgas scrubber blowdown was characterized to determine additional treatment requirements prior to final disposal.

Insert Table 1

Insert Table 2

The metals partition results showed each of the ten spiked metals could be categorized into one of three groups: volatile, semi-volatile, and nonvolatile metals. The volatile metals completely partition to the kiln offgas and enter the APCS, where a fraction of the metal is removed and a fraction is discharged with the stack gas. The semi-volatile metals distribute between the kiln bottom ash, scrubber liquid, and stack gas, as a function of incineration conditions. The nonvolatile metals remain in the kiln bottom ash.

Mercury was the only tested metal exhibiting volatile behavior. At all test conditions, no mercury remained in the kiln bottom ash, and the split between scrubber blowdown and stack gas was dependent upon incineration conditions. The semi-volatile metals included lead, cadmium, thallium, and silver. While chromium, nickel, barium, antimony, and arsenic all exhibited nonvolatile behavior.

Of the test variables listed above, incineration temperature, waste chloride concentration, and the physical form of the waste (solid or liquid) had a significant effect on partitioning of some of the tested metals. Higher incineration temperatures increased the partition of both volatile and semi-volatile metals out of the kiln, while having no effect on the partition of nonvolatile metals. For only three of the metals tested, lead, cadmium, and mercury, increasing the concentration of chlorides in the waste increased the partition of metal out of the kiln and stack. And for all tested metals, the partition of metal to the stack gas was significantly increased when liquid waste was burned.

Low levels of VOCs and SVOCs were detected in the kiln offgas. The high chloride solid waste produced the highest concentrations and numbers of both VOCs and SVOCs. Detected VOCs included chloromethane, chloroform, carbon tetrachloride, benzene, toluene, and xylene. The maximum measured VOC concentration in the uncontrolled kiln offgas was 64 ppbv. Detected SVOCs included benzyl alcohol and polyaromatic hydrocarbons (PAH) such as naphthalene, fluorene, and pyrene. The maximum measured SVOC concentration in the uncontrolled kiln offgas was 0.13 ppbv. The destruction and removal efficiency (DRE) was measured for four principal organic hazardous constituents (POHC), hexachloroethane, hexachlorobenzene, benzene, and chlorobenzene. DREs of the spiked POHCs were greater than 99.99998, independent of waste type or incineration temperature. The liquid waste (95% benzene) was burned without detectable levels of benzene in the kiln offgas.

<u>CIF Waste Burn Test</u> - A series of pilot-scale incineration tests were performed at the EPA Incineration Research Facility Rotary Kiln Incineration System. Three simulated waste types (Table 3) were incinerated in a twenty-two test program in which waste type, waste density, waste feedrate, solid residence time, and incineration temperature were varied. The primary test objective was characterization of the incinerator flue gas particulate loading and size distribution upstream of the APCS as a function of the test variables. Also, sufficient kiln bottom ash and blowdown was collected for future secondary waste treatment tests. In a limited set of three tests, simulated waste spiked

with hazardous organics and selected trace metals of interest was burned to measure organics DRE and determine the partition of metals in this facility. This test facility is significantly larger than the EER rotary kiln simulator, and more closely represents the CIF kiln. The concentration of metals and organics spiked for these tests is shown in Table 4.

Insert Table 3

Insert Table 4

Particulate concentrations in the afterburner flue gas ranged from 175 to 743 mg/dscm corrected to 7 % oxygen. In general, higher waste feedrates and incineration temperatures resulted in higher offgas particulate concentrations. Detailed analysis of the particulate test data is currently in progress. Statistical modeling of the particulate loading and size distribution has not been completed.

Greater than 99.9984 percent DRE of the spiked organics were achieved in the afterburner exit flue gas at the three tested operating conditions (Kiln temperatures of 760, 870, and 1,000 °C). Neither organic was found above method detection limits.

Three of the metals spiked in the waste feed, lead, mercury, and thallium, exhibited volatile behavior. Essentially all of the discharged amount of each metal was found in the afterburner exit flue gas, and essentially none in the kiln discharge. One of the tested metals, antimony, exhibited semi-volatile behavior, being relatively evenly distributed between the kiln bottom ash and afterburner exit flue gas. The remaining tested metals, barium and chromium, exhibited relatively nonvolatile behavior, with approximately 80 % of the metal remaining in the kiln bottom ash. The metal detected in the afterburner exit flue gas is most likely is due to ash entrainment in the offgas.

Pilot-Scale Equipment Testing

Two pilot-scale test facilities have been installed at SRTC to provide test data supporting operation of the CIF. These facilities are required to conduct long-term testing of critical CIF components, the rotary kiln seal and the air pollution control equipment. Both of these test facilities are scheduled to begin operation the first quarter of 1994. A discussion of the facilities test objectives and program is given below.

Seal Test Unit - Rotary kiln seals are an area of concern since these seals are the primary containment devices preventing uncontrolled process gases (containing radionuclides and combustion products) from entering the environment. To insure the current seal meets the established design requirements (including seal life expectancy), a 1/4 scale CIF seal will be tested in the SRTC seal test unit. Test objectives include quantifying air flux through the seal as a function of various operating parameters, determine seal wear rates under differing conditions, and test seal containment during positive pressure excursions. The seal test unit will also allow future evaluation of seal design modifications or other advanced seal designs.

Offgas Components Test Facility (OCTF) - The OCTF is a 1/10 scale CIF air pollution control system. Individual equipment components and instruments were designed and fabricated by the same vendors selected for the CIF. Hot offgas is produced in a three million Btu burner chamber. Particulate and HCl gas are metered into the gas stream to simulate kiln particulate carry-over and acid gas produced during incineration of chloride containing waste. Kiln offgas characterization data from the CIF Waste Burn Test will be used to determine particulate concentrations and size distributions during OCTF operation. The gas is cooled in down flow recirculating quench before entering a high efficiency steam-atomized scrubber. The scrubber removes particulates and neutralizes acid gases. The scrubbed offgas enters a cyclone separator where liquid and solid particulates are removed from the gas stream. After exiting the cyclone, the offgas enters a mist eliminator to remove any residual liquid droplets. A reheater upstream of the HEPA filters prevents condensation in the filter housing. The filtered offgas is discharged to atmosphere through the facility stack.

The OCTF test program is designed to evaluate operational parameters of the CIF offgas system design. Equipment performance will be studied to optimize operation to reduce emissions and minimize secondary waste generation. Operation of this facility will prove invaluable during operating training and facility startup and trouble shooting. The primary technical issues to be investigated on the OCTF are discussed below.

- Particulate and acid gas removal efficiency will be measured in the quench and scrubber as a function of equipment operating parameters, including solids and salt concentrations in the recirculating liquids, steam/offgas ratio, and offgas flowrate.

- The offgas system must be operated to provide acceptable HEPA filter life. Parameters affecting filter life that will be studied include salt concentrations in the quench and scrubber solutions, flue gas particulate loading and flow rate, and water condensation.

- Prototypic pH, conductivity, density, and flow instrumentation are included in the OCTF design. The instrumentation and proposed control schemes (particularly pressure control) will be evaluated for reliability and stability.

- The materials of construction selected for the CIF will be evaluated in the OCTF. Operation of a pilot-scale facility at actual CIF process conditions will allow accurate determination of actual material corrosion rates.

Process Computer Modeling

A FORTRAN computer model was developed to simulate the transient responses of the CIF to fluctuations in solid waste feed. Of particular interest was the performance of two independent pressure control loops in maintaining system pressure. The model is capable of predicting the dynamic behavior of all system components (rotary kiln, secondary combustion chamber, quench, scrubber, cyclone separator, mist eliminator, HEPA filters, and induced draft fans).[2] Kiln offgas flow profiles generated by this model will be used as input data for operation of the OCTF. Gas flows from the OCTF burner chamber can be controlled to simulate batch waste burning, as predicted by this dynamic simulation computer model.

In addition to modeling system behavior at normal operating conditions, this model has been used to predict system flows and temperatures during system upsets. The model has been used to analyze a burner flameout scenario, ram feed failure, combustion air fan failure, and total power loss.[3,4] These studies were used primarily in explosion risk assessments of the CIF.[5]

SUMMARY

The CIF technical support program is designed to resolve open technical issues concerning facility design, construction, operation, and process optimization. Off-site tests have been conducted to verify technology performance and characterize incinerator emissions and secondary wastes. Detailed process modeling has been used to predict facility performance both during normal operating conditions and system upsets. Operation of the on-site pilot facilities will provide long-term performance data of integrated systems and critical facility components. All of these efforts will combine to minimize facility start-up problems and help insure compliance with all facility performance requirements. In today's environment of increased public participation and awareness, technical support programs of this type assist in assuring all stakeholders the CIF can properly treat combustible hazardous, mixed, and low-level radioactive wastes.

REFERENCES

1. H. HOLMES and D. B. BURNS, "Testing to Reduce Salt Loading via Wet Scrubbing", 1990 Incineration Conference.

2. T. HANG, "Dynamic Simulation Study of the CIF Incinerator", 1992 Incineration Conference.

3. T. HANG, "CIF Dynamic Simulation Study (U)", DOE internal report WSRC-TR-91-577 (1991).

4. T. HANG, "CIF Rotary Kiln Air Inleakage Study (U)", DOE internal report WSRC-TR-92-489 (1992).

5. "Explosion Risk Assessment of the Consolidated Incineration Facility Rotary Kiln and Secondary Combustion Chamber", prepared by Science Applications International Corporation (SAIC) and Professional Loss Control (PLC), WSRC-TR-92-384 (1992).

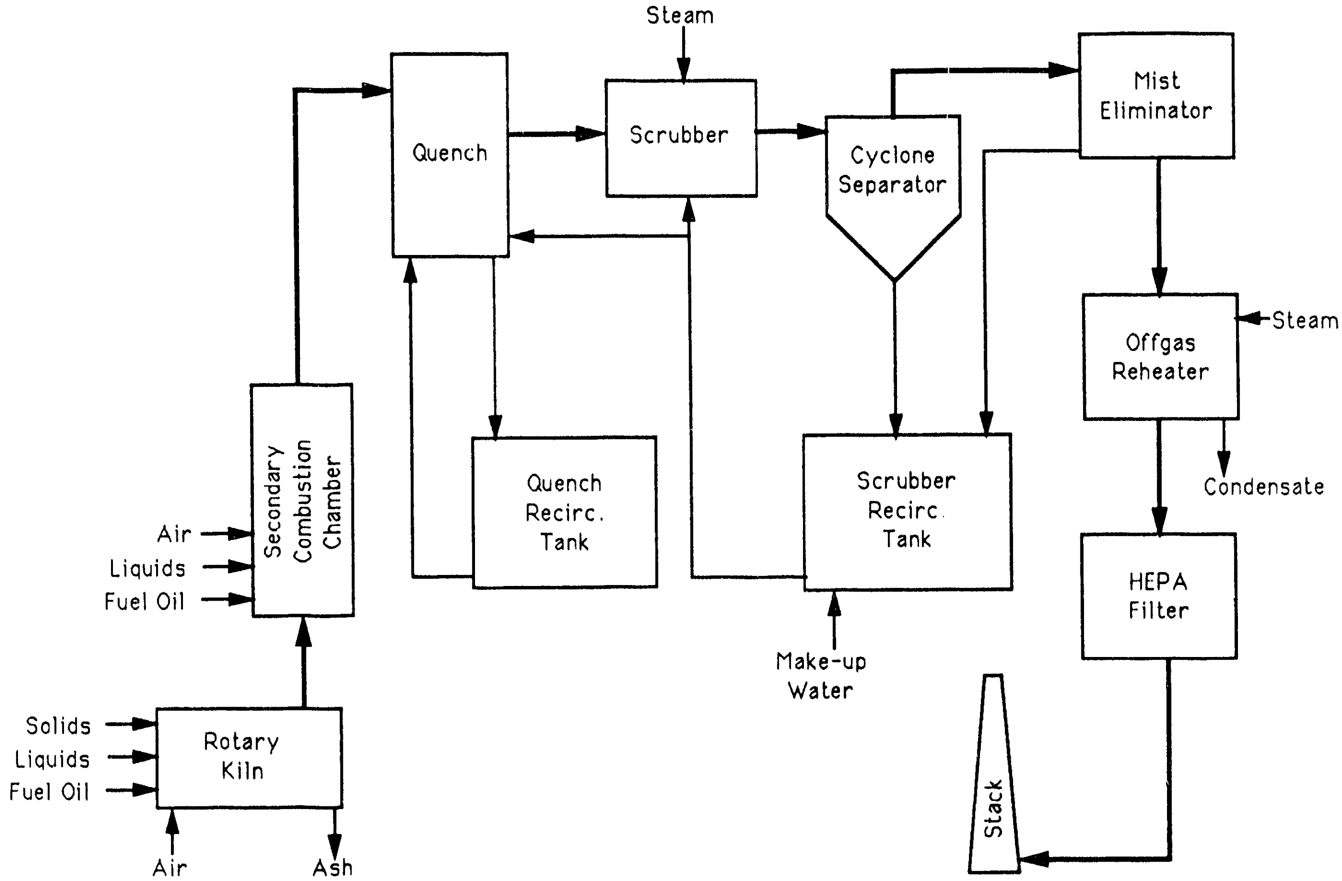

Figure 1
CIF Process Flow Diagram

TABLE 1
Simulated Waste Compositions (Wt %)

Component	Waste Type E	Waste Type F	Waste Type G
Paper [$C_6H_{10}O_2$]	45	55	0
Polyethylene [C_2H_2]	25	25	0
Latex [$(C_5H_8)_{23}S$]	20	20	0
PVC [C_2H_3Cl]	10	0	0
Benzene [C_6H_6]	0	0	95
Chlorobenzene [C_6H_5Cl]	0	0	5

TABLE 2
Average Spiked Metals and Organics Concentrations in Waste Feed
(mg /kg waste feed)

Metal Compound	Solid Waste (Type E & F)	Liquid Waste (Type G)
Antimony, $C_4H_4KO_7Sb$	538	0
Arsenic, $Na_2HAsO_4 \cdot 7H_2O$	38	0
Barium, $Ba(C_2H_3O_2)_2 \cdot H_2O$	85,741	0
Cadmium, $Cd(NO_3)_2 \cdot 4H_2O$	9	10
Chromium, $Cr(NO_3) \cdot 9H_2O$	1,860	2,267
Lead, $Pb(NO_3)_2$	7,426	9,114
Mercury, $Hg(NO_3)_2 \cdot H_2O$	446	542
Nickel, $Ni(NO_3) \cdot 6H_2O$	7,297	8,963
Silver, $AgNO_3$	5,435	6,663
Thallium, $TlC_2H_3O_2$	545	663
Hexachloroethane	6,000	0
Hexachlorobenzene	6,000	0

TABLE 3
Simulated Waste Compositions (Wt %)

Component	Waste Type A	Waste Type B	Waste Type E
Paper [$C_6H_{10}O_2$]	45	100	45
Polyethylene [C_2H_2]	25	0	25
Latex [$(C_5H_8)_{23}S$]	20	0	20
PVC [C_2H_3Cl]	10	0	10
Organic spike	No	No	Yes
Metal spike	No	No	Yes

TABLE 4
Spiked Metals and Organics Target Concentrations in Waste Feed
(mg /kg waste feed)

Metal Compound	Type E Waste
Antimony, $C_4H_4KO_7Sb$	730
Barium, $Ba(C_2H_3O_2)_2 \cdot H_2O$	10,000
Chromium, $Cr(NO_3) \cdot 9H_2O$	550
Lead, $Pb(NO_3)_2$	9,000
Mercury, $Hg(NO_3)_2 \cdot H_2O$	590
Thallium, $TlC_2H_3O_2$	730
Hexachloroethane	6,000
Hexachlorobenzene	6,000

END

DATE FILMED

3/28/94