United States
Environmental Protection
Agency

Industrial Environmental Research
Laboratory
Cincinnati OH 45268

Research and Development

EPA-600/S7-80-170 Dec. 1980

EPA

Project Summary

Environmental Assessment of a Waste-to-Energy Process: GSA/Pentagon Co-Fired Boiler Tests

Mark A. Golembiewski, K. P. Ananth, T. Sutikno, and Harry M. Freeman

A series of emission tests at the Virginia Heating and Refrigeration Plant (VHRP) in Arlington, Virginia, were conducted by Midwest Research Institute. This plant provides steam heat or refrigerated air to the Pentagon building. The study was designed to obtain emission data while one of the steam boilers was co-fired with different blends of coal and densified refuse-derived fuel (d-RDF).

The No. 4 boiler at VHRP was utilized for this test program. The steam output of this underfeed-retort stoker boiler is rated at 70,000 lb/hr, although usual maximum load is about 50,000 lb/hr. Coal is normally the sole fuel. For this d-RDF burn program, sampling was conducted during three fuel firing modes: coal only, 20% d-RDF + 80% coal, and 60% d-RDF + 40% coal. The tests were intended to be run at a single boiler load for comparative purposes, but steam output could not be held constant during much of the sampling period.

Samples of the coal, d-RDF, and coal/d-RDF fuel mixtures were collected hourly and analyzed by the National Center for Resource Recovery (NCRR) for moisture, ash, heating value and chemical composition. Several daily samples of bottom ash were also collected by NCRR. These were analyzed for loss-on-ignition and chemical composition.

Midwest Research Institute was responsible for sampling and analysis of the stack effluent. Tests were conducted for particulate concentration, gaseous criteria pollutants (SO_2, NO_x, CO, and total hydrocarbons), and chlorides. Particulate samples were also analyzed for lead content.

This publication is a summary of the complete project report, which can be purchased from the National Technical Information Service.

Introduction

Under the sponsorship of the U.S. Environmental Protection Agency's Fuel Technology Branch in Cincinnati, Midwest Research Institute (MRI) is presently conducting multi-media environmental assessment of various waste-to-energy conversion systems. This paper will discuss the results of a series of emission tests at the Virginia Heating and Refrigeration Plant (VHRP) in Arlington, Virginia.

VHRP is operated by the General Services Administration (GSA) for the purpose of satisfying the steam heat and chilled water needs of the Pentagon and the Henderson Hall office building. The heating plant consists of five coalfired boilers, one of which (No. 4) was utilized for the testing described in this report.

The National Center for Resource Recovery (NCRR) in Washington, D.C., is concerned with developing the use of refuse-derived fuel (RDF) as an alternative energy source. Discussions were held with representatives of GSA concerning possible use of densified RDF as a supplemental fuel for their coal-fired boilers. The outcome of these discussions was an agreement to test fire a coal-RDF fuel mixture at VHRP and evaluate the subsequent effects on boiler operation and air emissions. The U.S. Environmental Protection Agency (EPA), with MRI as contractor, provided air sampling and analysis capabilities.

The test burn and air sampling activities were conducted during the week of March 19-23, 1979, and results of those emission tests are described herein. Subsequent sections of this report present a description of the boiler test facility, an overview of the sampling and analytical methodologies employed, and a discussion of the test results.

Test Facility

The No. 4 boiler at VHRP was ma factured by the Riler Stoker Comp and installed in 1941. It is an underfe retort stoker boiler with a rated ste capacity of 70,000 lb/hr. Normal m mum operating load for the boi however, is about 50,000 lb/hr. schematic of the boiler with its auxili equipment is shown in Figure 1.

Coal is supplied to the plant from outdoor storage pile or directly from cars via an underground belt conve The coal is transferred from t conveyor to a bucket conveyor wh feeds a coal bunker located above

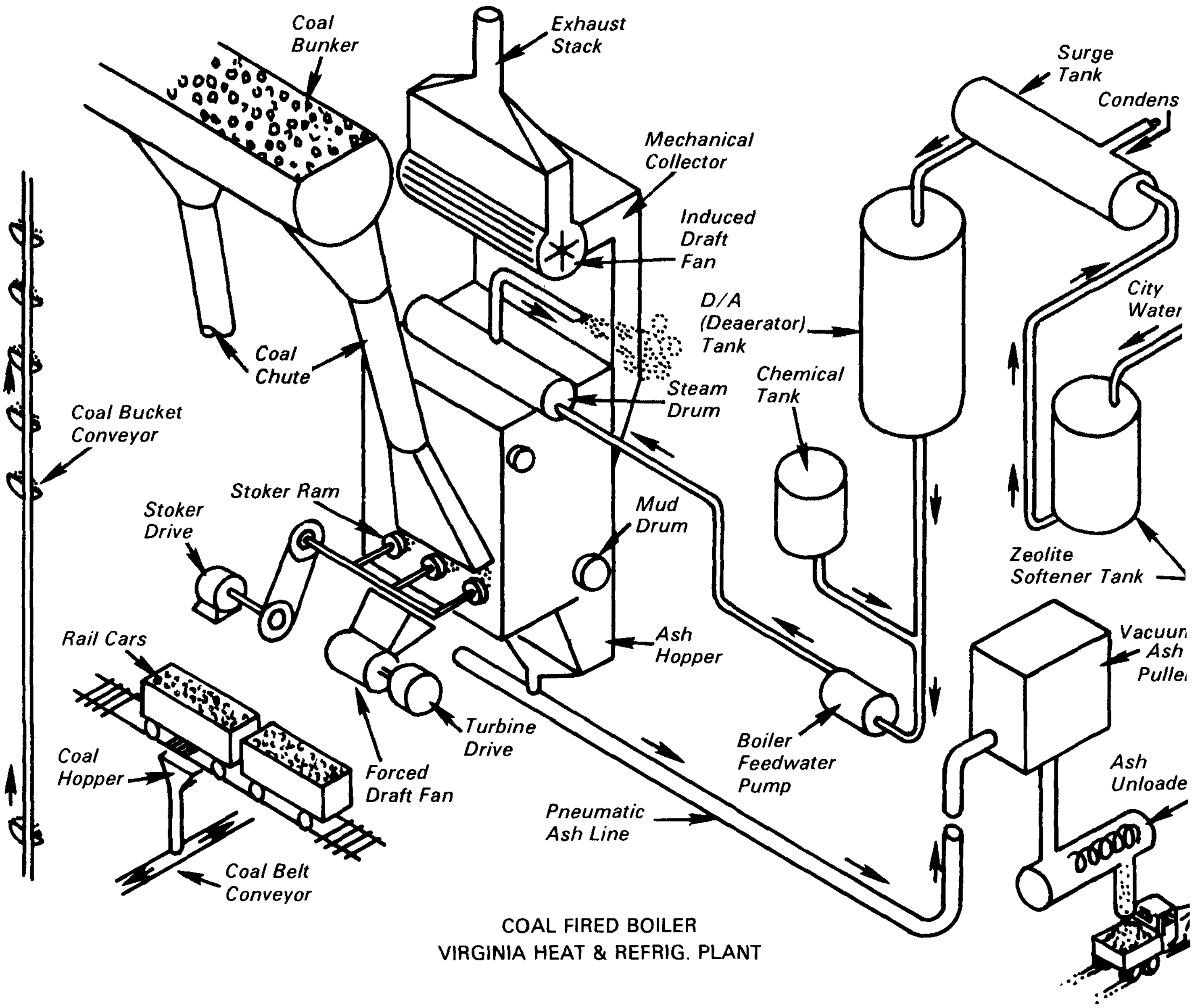

Figure 1. *Schematic diagram of the test boiler.*

ɔiler. During the test burn program, the RDF pellets were fed to the same cket conveyor, using a second belt onveyor. The specified volume ratio of ıellets to coal was maintained in each ıucket through the use of throttling ılates at the conveyor transfer points. 'he coal/d-RDF mixtures were also ransferred to the same overhead ɔunker that is normally used for coal eeding.

Further information on the process ;onditions and equipment specifica- ions is given in the complete project 'eport.

;ampling and Analytical /lethodology

The emissions sampling program for he GSA/NCRR d-RDF test burn was esigned to characterize boiler exhaust as emissions when firing coal and vhen firing two blends of coal and d- ʔDF. The sampling matrix is illustrated n Figure 2. In addition to the stack esting conducted by MRI, samples of he input fuels as well as bottom ash vere collected by NCRR during the test ɔrogram. The analytical matrices for hese samples are also shown in Figure ʔ. A summary of the test chronology is esented in the table below.

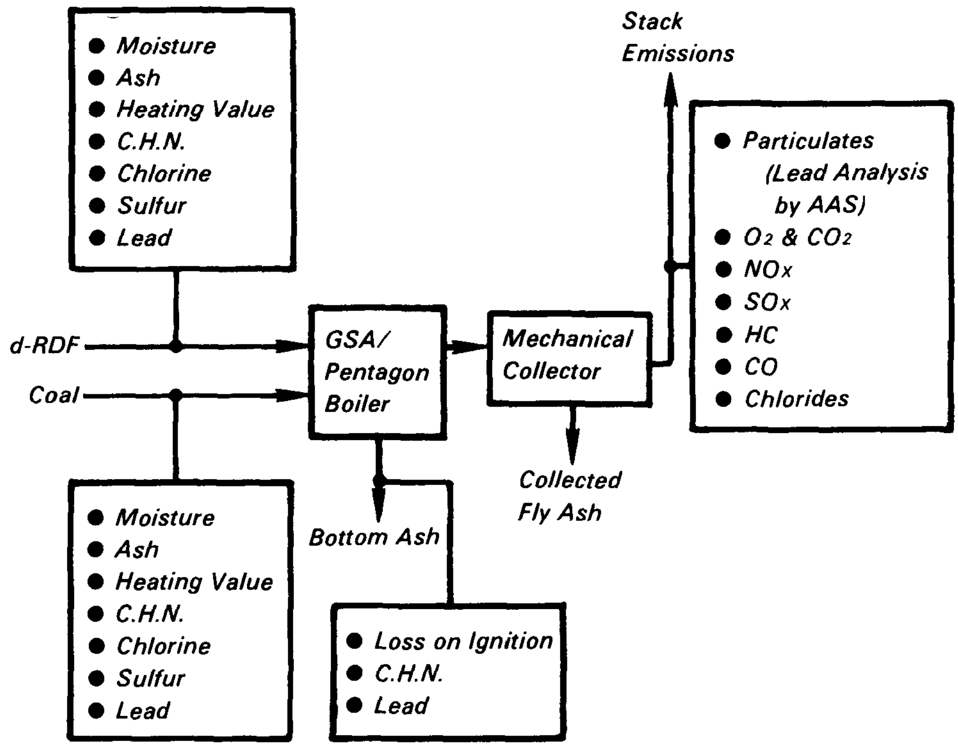

Figure 2. *Samplng and analysis matrix.*

Table 1. *Pentagon Boiler Test Schedule*

Run No.	*Date*	*Fuel Fired*	*Test Period*
1, 2, 3	*3/20*	*100% coal*	*10:15-18:57*
4, 5, 6	*3/21*	*20% d-RDF/80% coal*	*08:10-17:05*
7, 8, 9	*3/22*	*60% d-RDF/40% coal*	*08:10-17:02*
10, 11	*3/23*	*100% coal*	*08:07-12:49*

Brief discussions of the sampling and analytical procedures are presented next. Full descriptions of the methods used are contained in the complete report.

Coal and d-RDF Fuels-Hourly grab samples of the fuels (of about one cubic ft) were taken from the weigh station area above the ram feed chutes. Each sample was then progressively subdivided to about a 5 kg size using a riffler apparatus and stored in a plastic bag. The fuel analysis basically followed standard procedures of American Society for Testing and Materials (ASTM).

Bottom Ash—Grab samples of the boiler bottom ash were collected twice daily and composited. Analysis was done in accordance with the standard procedures of ASTM and U.S. Bureau of Mines, and consisted of loss-on-ignition, carbon/hydrogen/nitrogen, and lead determinations.

Stack Emissions—Samples of the boiler exhaust gases were collected over a 4-day period and later analyzed in the MRI laboratories. The sampling analysis methods used for each of the gas parameters measured are discussed next.

Particulate Concentration—Three EPA Method 5 runs were conducted during each of the three fuel firing modes. In addition, two extra runs were taken during a second baseline coal mode, for a total of five runs when the boiler was supplied with 100% coal. The probe wash, filter catch, and impinger contents of each sample were analyzed for net particulate weight. Filter samples were also analyzed for lead content using atomic absorption spectrometry (AAS).

Oxygen and Carbon Dioxide—O_2 and CO_2 contents of the stack gas were measured using Fyrite detectors. Replicate readings were taken during each Method 5 run to determine the molecular weight of the air stream and the percentage of excess air used by the boiler.

Criteria Gaseous Pollutants—Continuous gas analyzers were used to measure the concentrations of O_2, CO, NO_x, SO_2, and total hydrocarbons in the stack effluent on a realtime basis. The sample was drawn through a heated Teflon sample line to a field trailer which housed the monitoring equipment. There, the sample stream was dried and filtered before it was proportioned to each of the analyzers. Instrument responses were registered on strip chart recorders and transcribed to data log sheets at 15-minute intervals.

Chlorides—A midget impinger train containing a dilute sodium hydroxide solution was used to collect stack gas samples for chloride analysis. One chloride sample was taken for each Method 5 particulate run (i.e., three per fuel firing mode). Each sample was collected over a half-hour period.

Presentation and Discussion of Results

Results of the sampling and analysis efforts are discussed as follows:

Boiler Operation

Although the full load rating of the No. 4 boiler is 70,000 lb of steam per hour, unseasonably mild weather conditions (and thus reduced steam demand) precluded running the unit near full load conditions. As a result, GSA plant personnel established an operating level of 30,000 lb/hr as one that could be reasonably maintained for the test program.

Fuel usage and heat input data from the test program are summarized in the complete project report. These data, which have been selected to correspond with the particulate sampling runs, show a wide variation in boiler operation, even among the three runs at each fuel firing conditions. Heat input rates during the 11 sampling runs ranged from 23.5 to 82.1 x 10^6 kJ/hr (22.3 to 77.8 x 10^6 Btu/hr). The variation in boiler operation was primarily due to fluctuating steam demand, the influence of the adjoining on-line boilers when loads changed, and improper functioning of some control instruments.

Coal and RDF Fuels

The chemical composition of each fuel was analyzed. Analysis results are reported in detail in the complete project report. Basically, the results are

report. Basically, the results showed that the blend with the higher proportion of d-RDF had a greater moisture content, a lower ash content, and a lower heating value. The higher heating value of d-RDF was about 7800 Btu/lb dry.

Bottom Ash

The bottom ash sample of both coal only and the 20% d-RDF blend showed a very high proportion of combustible material (over 30%), which would indicate incomplete combustion of the fuels during these two firing modes. The average percentages of hydrogen and nitrogen in the bottom ashes of the fuels were about 0.10% and 0.08%, respectively. The lead content in each bottom ash sample was below the detectablility of the instruments (0.6 ppm).

Stack Emissions

Particulate emissions were reduced from 22 to 38% when d-RDF was blended with the original coal fuel. Filterable particulate emissions were lowest when using the 20% d-RDF blend and rose again when the proportion of d-RDF was raised to 60%. This finding may not be conclusive, however, since the boiler load was held steady during the 20% d-RDF firing but not during the 60% mode. Further tests, conducted over longer periods of time, and at consistent boiler conditions, are needed to substantiate the observed trend.

The amount of particulate lead emitted when burning the d-RDF with coal is substantially higher than that from combustion of coal alone and may be a cause for environmental concern. Approximately 200% more lead was emitted during firing of the 20% d-RD blend (an average of 1,000 $\mu g/n$ versus 330 $\mu g/m^3$ during co combustion), and 580% more (2,26 $\mu g/m^3$) when the 60% d-RDF fuel wa used.

Concentrations of sulfur dioxid nitrogen oxides, and carbon monoxid all decreased slightly when the RDF wa used with coal. Because of the very lo sulfur content of d-RDF, SO_2 emission were reduced progressively as th proportion of d-RDF with coal wa increased. NO_x and CO levels, howeve are highly dependent on boiler combus tion conditions which may or may nc have been the direct result of burning c RDF.

Chloride emissions showed n definite trend which could be used t correlate chloride emissions with RD modes, though slightly highe concentrations of HCl were observed i two of the samples collected durin combustion of the 60% d-RDF blend.

In summary, co-firing of d-RDF wit coal at the Virginia Heating and Refrig eration Plant appears to be a viabl option from an environmental stand point. However, the role of lead emis sions must be considered when makin a final evaluation of the overall potentia of d-RDF substitution.

Mark A. Golembiewski, K. P. Ananth, and T. Sutikno are with Midwest Research Institute, Kansas City, MO 64110.
***Harry M. Freeman** is the EPA Project Officer (see below).*
The complete report, entitled "Environmental Assessment of a Waste-to-Energy Process: GSA/Pentagon Co-Fired Boiler Tests," (Order No. PB 81-109100; Cost: $6.50, subject to change) will be available from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Industrial Environmental Research Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268

☆ U.S. GOVERNMENT PRINTING OFFICE: 1981-757-064/0250

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