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EMISSION ASSESSMENT FROM FULL-SCALE CO-COMBUSTION TESTS
OF BINDER-ENHANCED DRDF PELLETS AND HIGH SULFUR COAL
AT ARGONNE NATIONAL LABORATORY

by

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EMISSION ASSESSMENT FROM FULL-SCALE CO-COMBUSTION
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SULFUR COAL AT ARGONNE NATIONAL LABORATORY

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ABSTRACT

Argonne National Laboratory (ANL) and University of North Texas (UNT) research teams collected over 800 emissions and ash samples during the combustion of over 650 tons of binder enhanced densified refuse-derived fuel (b-dRDF) pellets with high sulfur coal in a spreader-stoker boiler at ANL. This full-scale test burn was conducted to validate predictions from laboratory and pilot scale test results that indicated substantial reductions of SO_2 , NO_x and CO_2 in the flue gas, and the reduction of heavy metals and organics in the ash residue, when combusting the b-dRDF pellets with coal. Effects of varying fuel composition on performance of the boiler's spray-dryer/fabric filter emissions control system was also evaluated.

This paper describes the b-dRDF pellet/coal cofiring tests, the emission and ash samples that were taken, the analyses that were conducted on these samples, and the final test results.

INTRODUCTION

As part of Argonne's Energy from Municipal Waste Program, ANL and the University of North Texas conducted a multi-phase research study on the use of low-cost binder additives for improving b-dRDF pellets. The laboratory test phase of this study, which was completed in 1985, examined over 150 potential binders and binder combinations [1]. Each binder was ranked on the basis of a series of

criteria, including cost, environmental acceptability, and effectiveness. Many binder candidates were quickly eliminated by this ranking procedure [2]. Approximately 60 were subjected to a more detailed analysis, including laboratory testing.

The 13 most promising candidates from this laboratory testing and analysis were selected for field testing. The field work, witnessed by industry, was conducted during 1986 at the Naval Civil Engineering Laboratory's test facility at Jacksonville Naval Air Station, Florida. The pellets that were produced from fifty-three individual test runs were subjected to a battery of chemical and physical tests, which indicated that calcium hydroxide was the top-ranked binding agent.

As the third and final phase of the multi-phase study, ANL/UNT conducted full-scale combustion tests of binder enhanced dRDF pellets and high-sulfur coal. These tests were conducted during June and July of 1987 in ANL's Boiler #5 with industry, state, and municipality participation in critiquing the test plan and witnessing the actual test runs.

STUDY APPROACH

Binder-enhanced dRDF pellets were blended with Argonne's normal high-sulfur (about 2.7% S) coal at 10, 20, 30, and 50% on the basis of Btu content. When steady-state operation was attained for each blend, data samples were taken for mass and energy

balances, emissions characterizations, and ash analyses. Baseline evaluations were conducted with 100% coal at the beginning and at the conclusion of the test program. One hundred percent coal burning was also conducted between the firing of each of the blend ratios to minimize possible carryover effects from the previous test. Dust blowing of the boiler was conducted and completed either just prior to or at the completion of each test run. The condition of the facility during testing can be considered normal because the facility did not require either special maintenance or any physical modifications before the test program. However, other, concurrent tests at the facility made available computerized data logging equipment and an unusually high amount of process monitoring information.

Two possible sources for obtaining the required quantity of b-dRDF pellets were identified: a small (60-80 ton/day) dRDF processing facility at Thief River Falls, Minnesota, and a 400 ton/day facility at Eden Prairie, Minnesota.

The b-dRDF pellets that were fabricated at the Thief River Falls facility were produced during November and December of 1986 and were stored inside the facility. The pellets were produced in three lots with binder contents of 0, 4 and 8% by weight. A total of 225 tons of b-dRDF were produced. The Thief River Falls facility, which uses Lundell processing equipment, had been in operation for approximately one year at the time the pellets were made. The equipment for adding the binder additive to the RDF substrate was designed, built and installed by the Lundell company as part of their contribution to the project.

An additional 352 tons of pellets were supplied by the Reuter facility located in Eden Prairie, Minnesota. The pellets were produced in five lots, with three lots containing binder contents of 0, 4, and 8% by weight, identical to the three lots of b-dRDF pellets fabricated at the Thief River Falls, Minnesota facility. Two additional lots were prepared, each with approximately 95% of the PET and HDPE plastics removed and with binder contents of 0 and 4% by weight. This processing facility uses equipment manufactured by Buhler-Miag, Inc.

TEST FACILITY DESCRIPTION

The boiler plant at ANL consists of five boilers that provide steam for the entire laboratory. Although the steam is used primarily for space heating, the steam is also used for refrigeration and possibly for driving emergency electrical turbo generators. Boiler No. 5, the boiler used for this research program, is a spreader-stoker unit with a capacity of 170,000 lb/h of 200 psig saturated steam, the equivalent of about 20 MW_e. At 170,000 lb/h, the coal use (based on 11,600 Btu/lb) is 9.0 ton/h; at one-half rated capacity (85,000 lb/h), the coal use is 4.49 ton/h. The maximum operational firing rate, equivalent to producing 130,000 lb/h steam, is about 144.4×10^6 Btu/h. This boiler was installed in 1965 by the Wickes Boiler Company (now Combustion Engineering Company) and was converted to gas/oil firing in 1973. In 1979, the boiler was reconverted to coal firing with the expectation of burning high-sulfur (nominally 3.5%), Illinois-basin coal. Because the original emissions control equipment consisted of only a multiclone particulate-matter collector, additional SO₂ control was required. A number of possible flue-gas cleanup (FGC) systems were evaluated and spray-dryer technology was selected on the basis of several factors, including system simplicity and dry-waste production. A schematic of the steam-generating equipment and air pollution control devices is shown in Figure 1.

SAMPLING METHODS AND ANALYSES

Over 800 samples (as shown in Table 1) of the flue-gas emissions, flyash, bottom ash, and feedstock were collected during the 12 test runs. These samples were taken at the sampling station locations shown in Figure 1. Analysis of the data from these tests was performed by ANL in cooperation with the University of North Texas [3].

Coal and b-dRDF Pellet Sampling and Analysis Methods

A total of 61 feedstock samples were collected. These samples included 26 coal and b-dRDF pellet samples and 35 composite coal/

b-dRDF samples. Individual random coal samples were taken daily as the coal was being transferred to the coal bunker. These random samples were composited daily into a five-gallon pail. Random b-dRDF pellet samples were collected from each truck load of pellets and composited daily into five-gallon pails. Coal/b-dRDF samples were taken once every two hours at the two coal scales (one shovel-load from each scale) and composited daily in five-gallon pails. These samples were collected in accordance with standard ASTM procedures. Each of the coal, b-dRDF pellets, and coal/dRDF samples were subjected to proximate and ultimate analysis, and were also analyzed for heating value, ash fusion temperature, bulk density, and trace metals.

Ash Sampling and Analysis Methods

A total of 190 bottom ash samples were collected from the traveling grate at two points: from under the grate and through the grate. Random samples were taken every eight hours at sampling station 2. A total of 184 of the 190 samples collected were analyzed by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES). Fourteen metals were investigated. These metals included As, Cd, Hg, Pb, Sb, Se, Ti, Ba, Be, Cr, Cu, Ni, V, and Zn.

A total of 176 flyash samples were collected from the multiclone and from the economizer. Random samples were collected every eight hours at sampling stations 3a and 3b. A total of 172 of the 176 samples collected were analyzed by ICP-AES techniques. As in the case of the bottom ash, 14 metals were investigated.

Results of these analyses suggest that concentrations of Ba, Be, Cr, Cu, Ni, and V in both the flyash and bottom ash decreased as the binder content increased. One exception to this general trend was the concentration of Zn. The reason for increased Zn concentration with higher binder content is thought to be the result of Zn being an impurity in the calcium hydroxide binder agent.

The ICP-AES analyses indicated that Ba, Be and Zn levels are more predominant in

flyash than in the bottom ash, whereas Cu, Cr, Ni and V are more predominant in the bottom ash than in the flyash.

A total of 216 flyash and bottom ash samples were subjected to the EP Toxicity test. All test samples successfully passed these tests. It is important to note that Pb and Cd, which have been found to fail the EP tests in many cases involving the mass burning of municipal solid waste [4], were not found to exceed the limits of 5 and 1 mg/L, respectively, in the leachate solution.

Flue Gas Sampling and Analysis Methods

A total of 229 flue-gas samples were collected. These samples included 94 organic samples, 54 trace metal samples, and 81 inorganic samples.

Organic Samples. The organic emissions were collected at sampling station 8 (combustion chamber of the boiler), station 9 (prior to the SDA and fabric-filter baghouse), and at station 10 (the stack), for the determinations of polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs), dioxins, and furans.

PAH and PCB average emissions were typically reduced by over 70% at sampling station 10 (stack) as compared to sampling station 9 (prior to pollution control devices).

A definite decrease in PAH emissions with increasing binder content was observed. The magnitude of the decrease remained fairly constant as the binder content increased from 0 to 8%. A similar decrease in PCB emissions with increasing binder content was also noted [5].

Trace Metals in Flue Gases. A total of 54 trace-metal samples were collected at sampling stations 9 and 10. These samples were collected using a Method 5 sampling train and were analyzed by an Inductively Coupled Plasma (ICP) instrument. The samples were analyzed for a total of 13 metals. As with most analyses of trace element emissions, the range

of results from sample to sample varies. However, the emissions of these trace metals were much less than the emissions of these same metals emitted by mass burn plants or facilities firing fluff RDF.

Inorganic Flue Gas Emissions. A total of 81 inorganic gases samples were taken at sampling stations 9 and 10. These samples were collected using a Method 5 sampling train with midjet impingers. The samples were analyzed by Ion Chromatography.

Substantial reductions of uncontrolled SO_2 , NO_x and CO_2 emissions were observed both as blend ratios and binder percentages were increased.

Uncontrolled HCl flue-gas emissions were noted to increase as dRDF/coal blends increased. However, the uncontrolled HCl emissions were reduced as the amount of binder was increased from 0 to 8%. With the removal efficiency of 95% (achieved in all tests), the HCl emitted to the atmosphere is well below the proposed EPA control level of 25 ppmv.

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Figure 1 Cofiring Test Sampling Station Locations

Table 1 Flue Gas and Ash Samples Collected

● Flue Gas	
- Metals	54
- Inorganic	81
- Organics	94
	<hr/>
● Ash	229
- Bottom Ash	190
- Fly Ash	176
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● Feedstock	336
- dRDF Pellets & Coal	26
- Composite Coal/dRDF	35
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● Miscellaneous	61
- Clinkers, etc.	12
- SDA Feed Slurry	29
- SDA & Baghouse Powders	112
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	153
 TOTAL	 809

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