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ENVIRONMENTAL EFFECTS OF SOLID
WASTE AS A SUPPLEMENTAL FUEL

J.L. Hall, A.W. Joensen and H.R. Shanks

AMES LABORATORY, USERDA
IOWA STATE UNIVERSITY
AMES, IOWA

MASTER

Date Transmitted: March 1976

PREPARED FOR THE U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
UNDER CONTRACT W-7405-eng-82

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AS A SUPPLEMENTAL FUEL

J. L. Hall, A. W. Joensen and H. R. Shanks

Ames Laboratory, ERDA
Iowa State University
Ames, Iowa 50011

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ABSTRACT

This report documents progress and summarizes effort between June 1975 and February 1976 on a project entitled "Environmental Effects of Solid Waste as a Supplemental Fuel." Procurement and calibration of equipment as well as training of personnel has been accomplished, and sampling is in progress to satisfy the objectives of the environmental study. All input and output stream associated with operation of the steam generating units at the Ames Municipal Power Plant are being sampled. Sampling and characterization of fuel (both coal and processed refuse), ash and particulate effluent have been accomplished. In addition, the oxides of nitrogen (NO_x), oxides of sulfur (SO_x), and heavy organics have been sampled. Results of all analysis accomplished to date of the various samples are reported herein.

INTRODUCTION

This report documents progress accomplished on the research project entitled "Environmental Effects of Solid Waste as a Supplemental Fuel" and summarizes effort and results between June 1975 and February 1976. Because of the time span required in receiving analytical results from the samples obtained during this period, it is not possible to summarize all of the analytical results that will be eventually available. However, results currently available are included herein.

The study is now proceeding to include the testing of all steam generating units (designated units #5, #6, and #7) at the Ames Municipal Power Plant. Table 1 summarizes design data for the generating units.

A review of the research program objectives are outlined below for the reader's reference.

OBJECTIVES OF THIS STUDY

- I. Sample and characterize the fuel used in the steam generators
 - A. Coal (Iowa and Wyoming coal are mixed in order to satisfy emission standards. Mixing is done at the coal storage yard by bulldozer.)
 - B. Processed solid waste
- II. Sample and characterize the effluents from the steam generating units.

Table 1. Characteristics of Ames Municipal Power Plant Steam Generators

Unit	5	6	7
Manufacturer	Riley	Union Iron Works	Combustion Engineering
Installation Date	1951	1958	1968
Pressure/Temperature, PSI/F	710/825	725/825	900/900
Nominal Steam Output Capacity, pph	95,000	125,000	360,000
Coal Firing Equipment	Spreader Stoker Travelling Grate	Spreader Stoker Travelling Grate	2-Pulverizers 8-Non-Tilting Tangential Burners
Furnace Pressure	Balanced Draft	Balanced Draft	Balanced Draft
Dust Collection Equipment	Western multiple cyclone	American multiple cyclone	American electrostatic precipitator
Stack Height, ft.	200	200	200
Heat Input at Nominal Capacity, BTU x 10 ⁶ /per hour	146	191	436

A. Solids

1. Study of the particulates in the flue gas for quantity, size distribution and composition. This testing would be conducted both before and after the cyclone dust collector.
2. Analysis of bottom ash.
3. Analysis for possible carcinogens in particulates.

B. Gases

1. Analysis for SO_2 , SO_3 , NO_x and HC. It should be noted that no data appear to be available on NO_x emissions from stoker fired boilers.
2. Identification and analysis of heavy organics in the stack gases.

Sampling of solid and gaseous effluents and fuel input to the steam generating units has been accomplished several times to date. Part of this sampling has been for purposes of training our sampling crew as well as for initiating and checking analytical techniques. Most of the effort from June 1975 through October 1975 was expended for such purposes as well as for design and construction of probes, fixtures and other equipment needed to support the sampling tasks. In addition, the operation and calibration of all instrumentation was accomplished as it was delivered from the appropriate vendors.

From November 1975 to date, the sampling has proceeded on a systematic basis designed to satisfy the objectives of the proposed research project. The refuse process plant has been operating on a continuous basis since December 1975. However, initial startup and "shake down" problems have caused some difficulty in operation of the refuse plant as well as the operation of steam generating unit #7. Many of the startup

problems have been solved while some remain to be solved. Thus, results obtained from this study will be most valid after January 1976.

A summary of the major problem is that the processed or combustible refuse received from the process facility appears to be oversized from a combustion viewpoint and is not burning completely in Unit No. 7. However, the size specifications on the processed refuse are close to being met. Visual observation indicates a high amount of large wood chips, brown carton paper and plastics falling into the bottom hopper and then being sluiced out to the ash pond. The process plant personnel are now attempting to adjust the air classification and shredder systems for a more favorably sized material.

Following are sections which describe the sampling and results attained to date along with future anticipated efforts.

ENVIRONMENTAL SAMPLING

Training

From June 1975 to October 1975, a group of six graduate students were organized and trained to perform sampling tasks required for this project. Included in this training were: (1) construction and operation of steam generating units; (2) Environmental Protection Agency (EPA) methods #1 through #9 (Federal Register - Vol. 36, No. 247, Dec. 23, 1971) for sampling effluents from stationary sources; and (3) operation, calibration and field use of source sampling apparatus and instrumentation as it was delivered from vendors or otherwise became available for use.

During this time span the above mentioned group became familiar with the general layout and the specific steam generating units in the

Ames Municipal Power Plant. After this familiarization several fixtures and sampling probes were designed and built to help accomplish the various sampling tasks.

Instrumentation

Instrumentation procured to sample for particulate and sulfur oxides includes one new (Misco Corp.) sampling train and two used (Scientific Glass Blowing Corp.) sampling trains with associated glassware, probes and sampling nozzles. Additional probes of various lengths and nozzles have been built in the Ames Laboratory to allow for greater versatility in sampling at the Ames Municipal Power Plant. Two sampling trains must be used simultaneously before and after the particulate collectors to determine their collection efficiency. The third unit is currently used as a backup system for either of the other two.

Two Fisher Scientific Orsat units have been obtained for use in determination of CO₂, O₂, CO and atmospheric nitrogen levels in the flue gas of the steam generating units.

An Anderson sampler (cascade impactor) has been received to provide particulate sizing. Composition as a function of size can be obtained, provided a suitable high purity filter can be found.

Flasks, glassware, tubing, flow meters, dry gas meters and miscellaneous equipment have been obtained and used to construct sampling apparatus for oxides of nitrogen, coal, refuse, and heavy organics in the flue gas. Except for the heavy organics the sampling devices are illustrated in the Federal Register, Vol. 36, No. 247, Dec. 1971. The details of the organic sampling train are shown in Figure 1. The hot

SAMPLING TRAIN FOR HEAVY ORGANICS

Figure 1. Sampling train for collecting heavy organics in the stack gases.

gases from the stack are drawn through the heated probe and across a column of macroreticular resin (TENAK-GC) where the organics are collected.

Calibration

Each of the above mentioned sampling trains have been calibrated according to EPA prescribed procedures. This has yielded necessary values of the sampling train orifice flow coefficient and the dry gas (volume) meter correction factor.

Each nozzle and probe combination connected to the sampling trains has also been calibrated. In this regard the EPA-suggested calibration technique has been found to be inadequate. Indeed, the EPA-suggested technique can lead to serious errors in determination of the pitot tube coefficient of the sampling probe. To avoid these errors, it has been found that corrections for blockage and turbulence level in the flow facility used for calibration must be accomplished. In addition, the closeness of the sampling nozzle to the pitot tube must be accounted for as it has a significant effect on pitot tube coefficient. Thus, each sampling probe and nozzle combination must be separately calibrated in an air flow facility where the range of flow Reynolds numbers and the proper control versatility are available to cover the range of Reynolds numbers encountered in the exhaust stack of the steam generator. The calibration must be made for the exact physical configuration of the probes used during the sampling process. The resulting pitot tube coefficients can be quite different from a value of 0.85 ± 0.02 as suggested by EPA. For example, some pitot tube coefficients have been measured to be as low as 0.74 over a wide range of Reynolds numbers. Use of an incorrect pitot tube coefficient could lead to serious errors

in concluding whether or not a particular steam generator is in compliance with EPA standards. Such possible errors make one wonder about the validity of previous stack tests where a known pitot tube coefficient would be essential in the correct determination of effluent concentrations.

Current discussions with representatives from EPA and the Iowa Department of Environmental Quality have indicated the validity and need for careful calibration and for such corrections as have been mentioned above. Current work by EPA (1) and Pratt and Whitney Aircraft (2) indicate further need for a revised technique for determination of pitot tube coefficients. Results of our efforts in this regard are currently being prepared for publication.

Sampling Locations

The sampling locations of this study are indicated in Figure 2. As shown schematically in this figure, sampling ports have been installed before the mechanical particulate collectors on units 5 and 6, and before the electrostatic precipitator on unit 7. Sampling ports and a platform on the stack already exist for units 5 and 6. Brackets were installed to support a monorail track for the sampling train and to make these ports operational for this study. Figures 3 and 4 show the sampling ports and platform on the stack for Units 5 and 6 and the particulate sampling train in place during testing. However, sampling ports, platform and brackets have not been installed on the stack for unit 7 because of lack of funds. The lowest bid to date for these items has been \$17,000 and funds have not been available for their installation. This is the only sampling point location shown in Figure 2 that is not yet operational. Sampling is underway at all other points shown in Figure 2.

Figure 2. The black circles represent the points where samples are collected. Coal samples are also collected for each unit but are not designated here.

Figure 3. The sampling platform on the stack for units 5 and 6. Note the rectangular bracket and rings installed above each port for holding the sampling train monorail.

Figure 4. Control unit for particulate sampling located at base of stack.

TABLE 2 - SUMMARY OF ENVIRONMENTAL SAMPLING

<u>Date</u>	<u>Unit</u>	<u>Fuel</u>	<u>Fuel</u>	<u>Ash</u>	<u>Sampling Matrix</u>					<u>Organics</u>	<u>Duct Velocity Profile</u>	<u>Comments</u>
					<u>Moisture</u>	<u>Particulate</u>	<u>NO_x</u>	<u>SO_x</u>	<u>ORSAT</u>			
7-23-75	#5-S*	Coal	✓						✓		✓	
7-28-75	#5-S	Coal										
	#5-S	Nat. Gas	✓		✓	✓			✓		✓	First particulate sampling
7-30-75	#5-S	Coal	✓		✓	✓					✓	
9-19-75	#5-S	Coal & Refuse	✓						✓ ✓			First day of refuse firing
9-24-75	#5-S	Coal	✓		✓	✓			✓		✓	
10-1-75	#7-Bpc**	Coal & Refuse	✓	✓			✓		✓			First NO _x sampling
10-1-75	#5-S	Coal	✓	✓							✓	
10-15-75	#5-S	Coal	✓	✓			✓	✓	✓		✓	First SO _x sampling
10-17-75	#5-S	Coal & Refuse	✓	✓			✓	✓	✓		✓	
10-29-75	#7-Bpc	Coal & Refuse	✓	✓	✓	✓	✓	✓	✓		✓	
11-5-75	#7-Bpc	Coal & Refuse	✓	✓	✓	✓	✓	✓	✓		✓	
11-12-75	#7-Bpc	Coal & Refuse	✓	✓	✓	✓	✓	✓	✓		✓	
12-5-75	#5-S	Coal & Refuse								✓		First organic sampling

Table 2 - Summary of Environmental Sampling (cont.)

<u>Date</u>	<u>Unit</u>	<u>Fuel</u>	<u>Sampling Matrix</u>									<u>Comments</u>
			<u>Fuel</u>	<u>Ash</u>	<u>Moisture</u>	<u>Particu- late</u>	<u>NO_x</u>	<u>SO_x</u>	<u>ORSAT</u>	<u>Organics</u>	<u>Duct Velocity Profile</u>	
1-8-76	#7-Bpc	Coal & Refuse	✓				✓		✓	✓	✓	
1-8-76	#5-Bpc	Coal & Refuse	✓	✓			✓		✓			
1-22-76	#7-Bpc	Coal & Refuse	✓	✓			✓		✓	✓		
1-29-76	#5-Bpc	Coal & Refuse	✓	✓	✓	✓	✓	✓	✓		✓	
2-5-76	#5-Bpc	Coal only	✓	✓	✓	✓	✓	✓	✓	✓	✓	
2-12-76	#5-Bpc	Coal & Refuse	✓	✓	✓	✓	✓	✓	✓		✓	
2-19-76	#6-Bpc	Coal & Refuse	✓	✓			✓		✓			

*S Samples taken in stack.

**Bpc Samples taken in duct before particulate collector.

Sampling Matrix

A summary of the environmental sampling accomplished to date is shown in the sampling matrix of Table 2. Additional sampling will be accomplished as the weather improves and as the appropriate apparatus is assembled and calibrated.

RESULTS

Characterization of Fuel

Both the refuse and coal have been analyzed to determine both their ultimate and proximate analysis. Coal used in the steam generators is typically a mixture of 40% to 50% Wyoming coal with Iowa coal such that EPA sulfur dioxide standards are met as required. Table 3 summarizes the refuse analysis at the time the refuse facility was in its initial stages of operation, and Table 4 below summarizes the typical coal analysis. Seasonal variation of refuse analysis is currently being determined. Table 5 summarizes the change in heating value and density for the month of October 1975.

TABLE 3 - Typical Refuse Analysis

Proximate (Sept. 1975) Analysis	Ultimate (Oct. 1975) Analysis	Heating Values* (Averages)		
		Oct. 1975	Nov. 1975	Dec. 1975
Moisture 18.62%	Moisture 24.93%	6788 $\frac{\text{Btu}^{**}}{\text{lb}}$ (19)***	6154 $\frac{\text{Btu}}{\text{lb}}$ (15)	5922 $\frac{\text{Btu}}{\text{lb}}$ (20)
Ash 14.76	Ash 9.83	*Moisture between 25% and 26% in all cases. **Contained more industrial waste than refuse in follow- ing months.		
Volatile 59.38	Carbon 35.92			
Fixed Carbon 7.24	Hydrogen 5.59	***Items in parentheses are the numbers of samples used to determine averages.		
Heating** 7046 $\frac{\text{Btu}}{\text{lb}}$ Value	Sulfur 0.27			
	Oxygen and Misc. 23.46			

TABLE 4 - Typical Coal Analysis

Fuel Ultimate Analysis	Iowa Coal	Wyoming Coal	Typical Mixtures (Averages)		
			Sept. 1975	Oct. 1975	Nov. 1975
Moisture	7.41%	14.24%	11.11%	18.76%	16.17%
Ash	17.81	5.80	8.31	8.37	12.94
Carbon	55.92	53.56	55.43	54.96	54.85
Hydrogen	5.01	6.00	5.31	5.47	4.96
Sulfur	4.26	0.68	1.38	2.17	4.28
Oxygen and Misc.	9.59	19.72	18.46	10.27	6.80
Proximate Analysis	Iowa Coal	Wyoming Coal	Typical Mixtures		
Moisture	7.41%	14.24%	11.11%	18.76%	16.17%
Ash	17.81	5.80	8.31	8.37	12.94
Volatile	37.84	48.66	41.56	34.99	35.01
Fixed Carbon	36.94	31.30	39.02	37.88	35.88
Heating Value	10,401 $\frac{\text{Btu}}{\text{lb}}$	9,265 $\frac{\text{Btu}}{\text{lb}}$	9,674 $\frac{\text{Btu}}{\text{lb}}$	9,670 $\frac{\text{Btu}}{\text{lb}}$	9,648 $\frac{\text{Btu}}{\text{lb}}$

The fuel has also been analyzed by an x-ray fluorescence technique to determine the relative amounts of the various elements in each fuel sample. For refuse only qualitative results have been obtained from the refuse ash, and Table 6 summarizes the elements found to date. Table 7 summarizes quantitative results obtained to date for coal samples.

TABLE 5 - Variation of Refuse Density and Heating Value
for October 1975

Date	Density	Heating Value		Averages	
	lbs/ft ³	Btu/lb	lb/ft ³	Btu/lb	
10-1-75	8	5982			
10-2-75	6	7317			
10-4-75	5	6589			
10-5-75	6	6591			
10-7-75	7	6883			
10-8-75	6½	6615			
10-9-75	6½	5548	6.42	6503	
10-16-75	6	6531			
10-17-75	7½	5945			
10-20-75	6	7421			
10-21-75	8	6535			
10-23-75	6	6843			
10-24-75	8	6141	6.66	6536	
10-24-75	5½	6798			
10-28-75	6	7967			
10-31-75	6	6572	6.38	6728	

TABLE 6 - Elements Found in Solid Waste Ash by X-ray Fluorescence

K	Fe	Pb
Ca	Cu	Rb
Ti	Zn	Sr
Mn	Ga	

TABLE 7

X-ray Fluorescence Analysis of Coal Samples

(Data are in ppm by weight unless otherwise indicated.)

	Typical Mixture 8-25-75	Wyoming 8-25-75	Iowa 8-25-75	10-10-75 Mixture	10-15-75 Mixture	10-17-75 Mixture	10-22-75 Mixture	10-29-75 Mixture	11-5-75 Mixture	11-12-75 Mixture
K	0.35%	0.15%	0.60%	0.16%	0.15%	0.27%	0.25%	0.32%	0.30%	0.53%
Ca	1.4%	1.2%	1.2%	0.96%	1.3%	1.1%	1.3%	1.25%	1.75%	2.5%
Ti	0.16%	0.17%	<0.2%	0.13%	0.15%	0.13%	<0.15%	<0.18%	<0.17%	<0.18%
V	<375	<450	<350	<360	<500	<340	<275	<360	<270	<200
Cr	120	50	290	60	65	60	160	160	170	200
Mn	500	440	440	140	240	240	700	410	550	710
Fe	6.0%	3.7%	8.9%	3.1%	2.9%	3.7%	10.0%	9.3%	9.5%	12.5%
Ni	120	65	200	90	60	60	100	130	90	100
Cu	250	300	350	420	400	270	280	260	320	210
Zn	210	250	0.72%	80	85	90	280	310	350	270
Ga	10	2	<60	15	10	10	4	10	10	15
Ge	45		<120	25	15	10	40	70	45	60
As	65	75	45	60	50	60	50	85	40	35
Rb	15		100	7		10	3	20	40	45
Sr	0.25%	0.30%	380	0.20	0.50%	0.18%	0.10%	0.30%	0.14%	370
Pb	<15	15	600	450	<15	<15	210	150	375	505

Particulates

The particulate matter collected via the EPA Method 5 sampling train has not only allowed grain loadings to be determined but has also provided samples for elemental analysis. Table 8 summarizes elements found from analysis by x-ray fluorescence of the filters on which particulates have been collected. Neutron activation analysis of these samples are also being accomplished for comparison of techniques of analysis. The results from neutron activation analysis of sample are not complete and thus are not presented herein.

The blank particulate filters have been analyzed by both x-ray fluorescence and neutron activation analysis to determine the amounts of various trace impurities. Because of the large amounts of impurities found on the fiberglass filters, quartz-fiber filters, with lower impurity levels, are now being used. The results listed in Table 8 are, however, for early samples collected with the fiberglass filters.

Organics

Preliminary sampling has been carried out on the heavy organic compounds in the stack gases. The efficiency of the column to collect organics has been checked by adding a second column in tandem and checking the second column for traces of organics. It appears, that at the current sampling rates, one column will be satisfactory for most sampling. Samples collected so far indicate a large number of organic compounds present, many of which have not yet been identified. A typical gas chromatograph scan for the organics is shown in Figure 5. From this figure the large number of organic compounds (peaks) is apparent. To date most of these compounds have not been identified. Further, there is little comparative data available to aid in either the qualification or the quantification of these organic compounds.

TABLE 8

Analysis by X-ray Fluorescence of Particulates
Collected on Sample Train Filters (EPA Method 5)
(all values in $\mu\text{g}/\text{cm}^2$)

	Natural gas 10-1-75	coal only 10-29-75	coal + Natural gas 11-5-75	coal + refuse 11-12-75
Al	22	315	370	280
Si				
S				
K	2.8	8	10	16
Ca	13	110	185	55
Ti				
Mn	0.05	2	4	1.8
Fe	<5	260	580	250
Cu	<0.5	<0.5	<0.5	<0.5
Zn	<0.5	17	22	5
As				
Ga	--	d**	d	d
Se	--	--		--
Br	--	1.2	--	--
Rb	--	d	d	d
Sr	--			
Pb	<0.5	1.0	5.4	1.6

* Samples obtained from unit 7 before the electrostatic precipitator. Coal used is a mixture of 60% Iowa and 40% Wyoming.

** d = trace detected

Figure 5. A typical G.C. scan for the heavy organics found in the stack gases.
Approximately 150 different compounds are indicated.

Ash

Ash Pond - Ash from Unit 7 is hydraulically sluiced to a settling pond several hundred meters east of the power plant. Samples from the settling pond were obtained for its characterization before refuse was used as a supplemental fuel in Unit 7. Tables 9 and 10 summarize typical x-ray fluorescence and neutron activation analysis of ash pond samples. An overall matrix of over 100 samples was collected from the ash pond to perform this characterization. Most of these samples remain to be analyzed as time and instrumentation work loads permit. Later in 1976 the ash pond will be sampled again at the same locations in the sampling matrix. This will provide a new characterization of the ash pond due to the addition of refuse residue.

Boiler Ash - Samples of ash have been collected at a number of points as shown in Figure 2. Neutron activation analysis x-ray fluorescence and spark source spectroscopy are being used to characterize the samples. Table 11 gives the results for one series of ash samples collected from Unit 6 as determined by spark source mass spectroscopy. These results are still semiquantitative.

Water from the ash pond has also been sampled and elements identified on a qualitative basis include lead (Pb), Iron (Fe), Arsenic (Ar), Selenium (Se) and Aluminum (Al).

NO_x

Oxides of nitrogen from stack gas samples have been analyzed by both the recommended EPA technique (0.6% hydrogen peroxide absorbing solution) and the ASTM technique (3% hydrogen peroxide absorbing solution). Values obtained using the 0.6% solution are suspect because they always appear low relative to samples obtained simultaneously

TABLE 9

Analysis by X-ray Fluorescence of Ash Samples
from the Unit #7 Settling Pond

Numbers are in weight percent and are semiquantitative.

Element	Sample 1	Sample 2	Sample 3	Sample 4
Al	1.9	2.7	3.2	3.4
Si	4.7	6.6	8.1	7.8
S	0.8	0.6	0.3	0.2
K	1.2	2.5	3.3	2.8
Ca	10.7	8.9	7.6	7.6
Ti	0.5	0.6	0.8	0.7
Fe	40	29	29	26
Zn	0.4	0.5	0.9	1.0
Ge	nd*	nd	nd	nd
As	nd	**	**	0.02
Se	nd	nd	nd	nd
Rb	0.02	0.04	0.05	0.04
Sr	0.1	0.2	0.2	0.2
Y	0.03	0.06	0.05	0.04
Zr	0.1	0.1	0.1	0.1
Pb	0.2	0.2	0.1	0.2

* not detected

** data uncertain

TABLE 10

Analysis by Neutron Activation Analysis of an Ash Sample
from the Unit #7 Settling Pond

Numbers are in parts per million by weight and are semiquantitative.

Element	Conc ppm	Element	Conc ppm
As	150	La	50
Ca	117,000	Mn	1,200
Ce	2.5	Na	1,600
Cl	1,611	U	2,500
Co	110	Sb	25
Cr	100	Sc	30
Eu	5	Sm	8
Fe	300,000	W	15
Ga	50	V	193
K	30,000	Zn	9,840

TABLE 11 - Results of Semiquantitative Survey of Ash
from Unit 6 Burning Coal*

Element	Sample Number					Probable Detection Limit**
	1 Grates	2 Bottom Ash	3 Hopper Ash	4 Heavy Ash Before Collector	5 Light Ash in Collector	
U	8	5	3	7	6	.2
Th	10	10	5	5	4	.2
Bi	<.9	<.9	<2	<.9	<.9	.9
Pb	50	30	1000	200	400	.8
Tl	<.9	<.9	40	7	10	.6
Hg	<.9	<.9	<.9	<.9	30	.8
Pt	<.9	<.9	<.9	<.9	<.9	.9
Au	<1	<.9	<.9	<.9	<.9	.9
Ir	<1	<.6	<.6	<.6	<.6	.6
Re	1	<.6	<.6	<.6	<.6	.5
Os	<2	<.6	<1	<.6	<.6	.6
W	6	2	8	4	4	.3
Ta	<.7	<.6	<.6	<.6	<.6	.6
Hf	<.6	<.6	<.6	2	2	.5
Lu	<1	<1	<.6	<.8	<1	.6
Yb	<3	<2	<3	<2	3	.5
Tm	<.3	<.3	<.3	<.4	<.3	.3
Er	2	2	<1	3	2	.2
Ho	.9	.4	.5	.8	.8	.1
Dy	5	3	3	5	6	.3

Table 11 (cont.)						Prob. Det.
Element	1	2	3	4	5	Limit
Tb	2	1	.6	1	1	.1
Gd	<20	<6	<20	<6	<6	.3
Eu	3	2	1	2	3	.2
Sm	6	5	2	4	7	.6
Nd	30	20	10	20	30	.5
Ce	70	90	20	60	30	.2
Pr	9	8	2	7	7	.09
La	30	20	7	20	10	.1
Ba	300	300	200	1000	2000	.4
Cs	40	30	10	10	10	.2
Te	1	1	2	<3	2	.1
I	.6	.3	3	4	2	.1
Sn	9	3	50	6	6	.2
Sb	2	1	40	5	6	.1
Cd	2	<2	40	20	20	.3
In	.6	<.3	2	.3	.6	.09
Pd	7	2	6	3	3	.3
Ag	1	.6	7	4	10	.1
Rh	<.3	<.3	<.3	<.3	<.3	.3
Ru	3	.6	3	1	6	.2
Mo	20	8	20	20	20	.4
Zr	100	70	50	100	200	.1
Y	20	20	30	30	40	.3
Nb	<2	<2	<2	<2	<3	2
Sr	300	300	200	600	700	.2
Rb	800	600	200	200	100	.2

Table 11 (cont.)						Prob. Det.
Element	1	2	3	4	5	Limit
Se	20	8	100	200	80	.2
Br	5	2	10	40	30	.2
Ge	20	10	1000	200	100	.2
As	20	7	10,000	600	600	.2
Ga	10	10	20	20	20	.3
Zn	300	100	9000	5000	4000	.2
Cu	200	70	200	200	100	.1
Ni	600	200	300	400	300	.1
CO	4	8	6	9	5	.5
Fe	6000	10,000	20,000	20,000	10,000	.7
Mn	40	100	100	200	90	2
Cr	60	60	50	40	40	3
V	60	60	40	30	60	.9
Ti	5000	6000	2000	4000	8000	.3
Ca	6000	10,000	10,000	30,000	20,000	.3
Sc	9	15	12	10	9	.2
K	40,000	40,000	20,000	20,000	20,000	.1
Cl	100	60	100	700	200	.1
S	6000	4000	60,000	60,000	10,000	1
P	300	300	3000	2000	1000	1
Si	100,000	900,000	20,000	200,000	80,000	8
Al	6000	15,000	10,000	10,000	5000	.3
Mg	900	2000	1000	2000	2000	2
Na	2000	20,000	8000	20,000	20,000	.7
F	10	20	60	300	500	.09

Table 11 (concluded)

Element	1	2	3	4	5	Prob. Det. Limit
O	3000	10,000	400	10,000	3000	.2
N	6000	40,000	800	8000	10,000	100
B	400	500	800	700	400	.3
Be	Line not resolved sufficiently for analysis					

* Values are in parts-per-million atomic. Totals do not equal one million due to uncertainties and unknown quantity of carbon present in the samples.

**Probable detection limit equals three times background reading at line of choice.

TABLE 12 - NO_x Determinations and Comparisons for Steam Generating Units Number 5 and 7 While Using Refuse as a Supplemental Fuel.

All Entries are in Parts per Million (ppm) by Weight.

UNIT 7 - Tangential Burner Unit						
Date	10-1-75	10-29-75	11-5-75	11-12-75	1-8-76	1-22-76
Mean	576	516	286	880	354	280
Standard Deviation	88	198	25	580	27	14
UNIT 5 - Traveling Grate Unit						
Date	10-15-75	10-17-75	10-22-75	1-8-76	1-29-76	2-5-76
Mean	1457*	105	184	180	162	148
Standard Deviation	516*	10	26	113	14	28

*Coal only on this day. The reason for the large values and large variation is believed to be due to the additional air into the system during the process of pulling ash in the steam generating unit.

using higher percentages of solution. The difficulty appears to be caused by the sulfur content of the stack gas and its reaction with the absorbing solution. Experiments were performed to determine if the percentage of hydrogen peroxide solution was statistically significant. At the 95% confidence level it was ascertained that a significant difference did exist. Further sampling and analysis have yielded no significant differences at a 95% confidence level for absorbing solution from 1% to 9% hydrogen peroxide. Consequently the ASTM 3% hydrogen peroxide absorbing solution was selected as the appropriate value for NO_x measurements of this study. Table 12 summarizes several NO_x determinations for both Unit 5 and Unit 7 while using refuse as a supplemental fuel.

From this table it can be observed that the different combustion characteristics of the two units appear to generally yield higher NO_x values on the tangential burner unit. Large variability on various sampling days is believed to be due to either soot blowing or ash pulling operations that had to be accomplished during times when the sampling was in process.

SO_x

Oxides of sulfur and sulfuric acid mist have been measured from October 1975 through January 1976 via EPA Method 8 (3). However, this method has led to considerable difficulty in analysis because interference of some constituent collected with the analysis technique. Because of this difficulty, all sampling from February 1, 1976 for oxides of sulfur has been accomplished by using the simpler EPA Method 6. No analyses are yet available for reporting from Method 6 testing.

Results of the Method 8 analysis are not reported because of the difficulty previously mentioned.

FUTURE WORK

Partial baseline data has been obtained for Units 5 and 7 burning only coal. In addition to the completion of the baseline sampling for 5 and 7, a complete study remains to be done on Unit 6. The baseline measurements on Unit 7 cannot be finished until sampling ports and platform are installed on the stack. Extensive sampling for organics in the stack gases still needs to be carried out on all three units using only coal as fuel.

As the data are completed for the three units when coal only is used, similar measurements will be carried out for various fractions of solid waste added to the coal. Once major pollutants associated with the solid waste are identified, these will be monitored for seasonal variations. Continuous monitoring of NO_x and SO_x will be carried out on one or more of the units.

As instrumentation, equipment and manpower become available, further sampling and analysis will be accomplished to attain the overall objectives as outlined in the introduction.

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