Spray Dryer/Baghouse System Testing CRADA 92-001, Final Report

April 28, 1992

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A series of seven tests were conducted to evaluate the effectiveness of scrubbing both NO_2 and SO_2 in a spray dryer/baghouse system. The operating conditions specified were a high spray dryer inlet temperature (500 °F), and a high spray dryer outlet temperature (250 to 300 °F). The data required to adequately evaluate the effectiveness of this technology is enclosed. Discussion of some of the variables as well as an itemized list of the testing information follows.

1.) FUEL-Enclosed is an analysis of the fuel oil #2 employed during testing.

2.) APPROACH TO SATURATION- Two wet bulb/dry bulb measurements were taken during the week of testing.

<u>Location</u>	<u>Wet Bulb/Dry Bulb (°F)</u>
A.) Before Spray Dryer	142/468
B.) After Baghouse	136/220

Also, during recent PECT testing (week of 4/13) two additional wet bulb/dry bulb measurements were made.

<u>Location</u>	<u>Wet Bulb/Dry Bulb °F</u>
C.) Before Spray Dryer	137/358
D.) Before Spray Dryer	136/362

3.) NO_x ANALYZER CONVERTER EFFICIENCY- The NO_x/NO analyzer uses a converter (heat) to reduce NO_2 to NO for the NO_x determination. The converter efficiencies determined after testing are shown below.

Annubar analyzer - 99.6 %

Spray Dryer analyzer - 99.4 %

Baghouse analyzer - 95.3/96.2 %

4.) TEST DATA - A package of data for each day of testing includes:

A.) Daily plots of important flue gas components (SO_2 , NO_x , and O_2), temperatures, slurry flow, and baghouse ΔP .

B.) Copies of hand data sheets, operators log entries, and calibration sheets.

C.) Average values for all recorded variables for various times during each test.

D.) The average values (from C) are compiled into data tables to facilitate the removal calculations as well as present a picture of the testing (steady state). The data tables consist of three

analyzer streams(An.) of O_2 , SO_2 , and NO/NO_x . The SO_2 and NO/NO_x measurements are corrected to the inlet O_2 concentration(O_2 -An.#1). There is also a column in many of the tables for either $NO/NO_2/NO_x$, designated by Cor., which are corrected values to the average O_2 for the steady state SO_2 removal(normalizes conditions for table 1).

5.)TABLE- The resulting steady state values are summarized in Table 1.

UNITED STATES
DEPARTMENT OF ENERGY
PITTSBURGH ENERGY TECHNOLOGY CENTER

DATE: 4-13-92

SAMPLE ID: FUEL OIL #2

LAB SEQUENCE NO.: 920368

DESCRIPTION: FUEL OIL #2 SCFM

SUBMITTER: W.O'DOWD/ERINCE

DATE RECEIVED: 2- 6-92

ACCOUNT NO.: R311

REPORT TO: W. O'DOWD

MAIL STOP: 84-340

NOTES:

ANALYSIS	RESULT
KINEMATIC VISCOSITY @ 145 (F)	1.5 +/- .08 CST
CARBON & HYDROGEN	
HYDROGEN	12.9 +/- .07 %
CARBON	86.4 +/- .20 %
ASH (D-482)	.05 +/- .01 %
NITROGEN	.1 +/- .02 %

APPROVED BY: SCHULTZ

UNITED STATES
DEPARTMENT OF ENERGY
PITTSBURGH ENERGY TECHNOLOGY CENTER

DATE: 3-18-92

LE ID: FUEL OIL #2

LAB SEQUENCE NO.: 920369

DESCRIPTION: FUEL OIL #2 SCFM

SUBMITTER: W.O'DOWD/ERINCE

DATE RECEIVED. 2- 6-92
ACCOUNT NO.: R311

REPORT TO: W. O'DOWD
MAIL STOP: 84-340

NOTES:

ANALYSIS

RESULT

	[AS RECD.]	[MOIST FREE]	[M&A FREE]
SULFUR	.41	.41	.41
HEATING VALUE [BTU/LB]	19524	19524	19524

APPROVED BY: SHREMSHOCK

FLUE GAS SPIKING SYSTEM

FIGURE SCHEMATIC OF GAS SAMPLING SYSTEM

FIGURE : SCHEMATIC OF THE 40 SCFM

SPRAY DRYER TEST FACILITY

TABLE 1 STEADY STATE RESULTS								
TEST #	Units	#1	#2	#3	#4	#5	#6	#7
DATE		3/31	4/1	4/1	4/2	4/2	4/3	4/3
T _{SDi}	°F	498	497	496	496	500	494	498
T _{SDo}	°F	299	302	277	288	252	277	277
T _{Bo}	°F	250	260	249	253	235	245	248
#1 O ₂	%	3.96	3.96	4.29	3.31	3.72	3.60	3.83
#1 SO ₂	ppm	183	192	185	193	187	187	174
#1 NO _x	ppm	408	396	384	425	411	419	386
#1 NO ₂	ppm	—	301	292	331	317	—	297
Sl. Flow	lb/min	0.110	0.108	0.109	0.115	0.115	0.110	0.108
Sl. Conc.	Wt. %	3.5	3.5	3.5	5.0	5.0	(1)	(1)
SO ₂ Rem. S.D.	%	32.3	30.3	46.0	50.8	66.3	34.8	27.0
SO ₂ Rem. System	%	33.3	40.1	63.2	81.9	81.3	45.5	40.2
NO _x Rem. S.D.	%	—	2.5	3.5	5.2	8.5	—	2.5
NO _x Rem. System	%	—	11.1	15.3	17.6	23.8	2.9	13.7
NO ₂ Rem. S.D.	%	—	4.3	3.4	2.1	5.1	—	11.3
NO ₂ Rem. System	%	—	11.3	13.4	16.9	25.6	—	(2) 42.8

T_{SDi} = Inlet Temperature - Spray Dryer

T_{SDo} = Outlet Temperature - Spray Dryer

T_{Bo} = Outlet Temperature - Baghouse

Note

(1) Slurry Concentration for Tests #6 & #7 left blank -Not known how much Sodium Thiosulfite was added to the slurry.

(2) Seems to be a function of NO₂ being reduced to NO, not NO₂ scrubbing.

MARCH 31, 1992

TEST-1

This preliminary test was conducted to establish baseline operating conditions and also to determine removals without the presence of NO₂. The NO spiking gas flow rate was established at 370 sccm.

STEADY STATE Times 10:56 - 11:43

Annubar flow=40.3 scfm

Corrected Gas Concentrations

An.	O ₂ %	Air leakage	SO ₂ ppm	NO _x ppm
1	3.97		183	408
2	4.28	1.85	124	407
3	4.47	3.02	122	405

A solid sample was collected from the spray dryer solid sample system between the times of 10:30 - 11:29. The average values for this sample period is given below:

Annubar Flow = 39.8 scfm

Corrected Gas Concentrations

An.	O ₂ %	Air leakage	SO ₂ ppm	NO _x ppm
1	3.75		185	413
2	4.13	2.25	127	413
3	4.29	3.23	126	411

APRIL 1, 1992

TEST-2

The test conditions established were approximately 300 ppm NO₂ (360 sccm NO and 0.2 slpm of O₂), a spray dryer exit temperature of 300 °F, and a Ca stoichiometric ratio of 1.5. The slurry conc. was established at 3.5 % for both tests #2 and #3.

STEADY STATE There was an upset with the slurry flow during test #2, resulting in two steady state periods being analyzed. The reported removals for SO₂ are from 11:20 -12:36.

Annubar flow= 40.0 scfm
Corrected conc.

An	O ₂ %	Air leakage	SO ₂ ppm
1	3.96		192
2	4.45	2.96	134
3	4.54	3.52	115

NO_x and NO₂ removals for various time periods are determined from the following data tables.

Time 11:30 - 12:10

An	O ₂ %	Air leak	SO ₂ ppm	NO _x ppm	NO _x Cor.
1	4.09		193	393	396
2	4.56	2.9	134	383	386
3	4.63	3.3	117	352	352

Time 12:15 - 12:20

An.	O ₂	Air leak	SO ₂ ppm	NO ppm	NO Cor.	NO ₂ Cor.
1	4.10		191	94	95	301
2	4.60	3.05	132	97	98	288
3	4.64	3.30	110	84	85	267

At the end of the above test period there was an upset with the slurry flow. Therefore, it was decided to establish the same conditions again and the results are shown in the following two data tables.

Time 12:51 - 13:09

An	O ₂ %	Air leakage	SO ₂ ppm	NO _x ppm	NO _x Cor.
1	4.28		188	389	396
2	5.48	7.73	133	381	388
3	5.62	8.71	129	348	355

Time 13:12 - 13:15

An	O ₂	Air leakage	SO ₂ ppm	NO ppm	NO Cor.	NO ₂ Cor.
1	4.23		191	97	99	297
2	5.43	7.71	124	98	100	288
3	5.55	8.54	118	83	84	271

APRIL 1, 1992

TEST - 3

The same conditions for Test-2 except the spray dryer outlet temperature was lowered to 275 °F.

Steady State

Time 13:52 - 15:00

Annubar Flow = 39.1

An	O ₂ %	Air Leakage	SO ₂ ppm
1	4.29		185
2	5.31	6.5	100
3	5.44	7.4	68

Breakdown of time for NO₂ and NO determination.

Time 14:01 - 14:25

An.	O ₂ %	Air leakage	SO ₂ ppm	NO _x ppm	NO _x Cor.
1	4.35		183	383	384
2	5.51	7.49	103	368	369
3	5.40	6.73	73	325	326

Time 14:29 - 14:38

An.	O ₂ %	Air leakage	SO ₂ ppm	NO ppm	NO Cor.	NO ₂ Cor.
1	4.37		184	92	92	292
2	5.35	6.26	100	87	87	282
3	5.47	7.08	64	83	73	253

Time 14:41 - 14:59

An.	O ₂ %	Air leakage	SO ₂ ppm	NO _x ppm	NO _x cor.
1	4.40		186	382	385
2	5.29	5.67	96	371	373
3	5.42	6.55	57	323	325

Note: The divergence of O₂ concentration and flow rate(annubar) is a result of water in the transmitter line. The line was cleaned before startup on 4/2/92.

APRIL 2, 1992

TEST - 4

The test conditions established were approximately 300 ppm NO₂ (370 sccm NO and 0.2 slpm O₂), and a 300 °F temperature leaving the spray dryer. The Ca stoichiometric ratio was to be increased to 2.5 (therefore a 5.0 wt. % slurry was used). This test had an upset in the slurry feed resulting in two distinct sets of operating conditions (T_{sp}=300 °F and T_{sp}=288 °F).

Steady State (T_{sp}=288 °F)

Time 13:40 - 14:25

Annubar Flow = 39.2 scfm

An.	O ₂ %	Air Leakage	SO ₂ ppm
1	3.31		193
2	3.76	2.61	95
3	3.84	3.09	35

Time 13:54 - 14:01

An.	O ₂ %	Air Leakage	SO ₂ ppm	NO _x ppm	NO _x Cor.
1	3.48		193	421	425
2	3.98	2.94	94	399	403
3	4.02	3.18	34	347	350

Time 14:05 - 14:14

An.	O ₂ %	Air Leakage	SO ₂ ppm	NO ppm	NO Cor.	NO ₂ Cor.
1	3.15		194	95	94	331
2	3.57	2.41	95	80	79	324
3	3.65	2.88	34	77	76	275

T_{sp}=300 °F

Time 11:40 - 11:59

An.	O ₂ %	Air Leakage	SO ₂ ppm	NO _x ppm	NO _x Cor.
1	3.72		190	408	418
2	4.31	3.54	115	389	398
3	4.42	4.22	101	360	369

Baghouse and spray dryer solid sample were taken over the period of time 11:37 - 14:25 (this time period is enclosed).

APRIL 2, 1992

TEST - 5

The same conditions as Test-4 except the spray dryer exit temperature was lowered to 250 °F.

Steady State

Time 14:47 - 15:46

Annubar Flow = 40 scfm

An.	O ₂	Air Leakage	SO ₂ ppm
1	3.72		187
2	4.29	3.41	63
3	4.20	2.86	35

Time 14:33 - 15:20

An.	O ₂ %	Air Leakage	SO ₂ ppm	NO _x ppm	NO _x Cor.
1	3.60		188	413	410
2	4.18	3.45	67	384	381
3	4.10	2.96	36	331	329

Time 15:24 - 15:29

An.	O ₂ %	Air Leakage	SO ₂ ppm	NO ppm	NO Cor.	NO ₂ Cor.
1	3.72		186	94	94	317
2	4.33	3.66	61	75	75	301
3	4.21	2.92	36	77	77	236

Time 15:33 - 15:47

An.	O ₂ %	Air Leakage	SO ₂ ppm	NO _x ppm	NO _x ppm
1	3.75		187	410	411
2	4.31	3.36	57	375	376
3	4.21	2.74	35	312	313

APRIL 3, 1992

TEST - 6

Test #6 was a test employing NO at 370 sccm (without O₂ spiking gas), and a slurry additive. The slurry mixture prepared was a 3.5 wt. % hydrated lime.

Steady State

Time 11:09 - 11:43

Annubar Flow=40.0 scfm

An.	O ₂ %	Air Leakage	SO ₂ ppm	NO _x ppm
1	3.60		188	419
2	4.27	4.00	122	420
3	4.31	4.25	102	407

Baghouse Sample

Time 10:09 - 11:41

An.	O ₂ %	Air Leakage	SO ₂ ppm	NO _x ppm
1	3.61		188	418
2	4.29	4.07	137	418
3	4.33	4.32	122	406

TEST - 7

This test was the same as Test #6 above except NO₂ (370 sccm NO and 0.2 slpm of O₂) was injected. At the end of Test #7 streams #2 and #3 were switched resulting in two additional data sets being compiled.

Steady State Time 13:05 - 13:54

Annubar Flow=40.3

An.	O ₂ %	Air Leakage	SO ₂ ppm
1	3.83		174
2	4.57	4.5	127
3	4.57	4.5	104

NO/NO_x Analysis

Time 13:05 - 13:30

An.	O ₂ %	Air Leakage	SO ₂ ppm	NO _x ppm	NO _x Cor.
1	3.69		175	389	386
2	4.45	4.59	127	379	376
3	4.44	4.59	103	335	332

Time 13:34 - 13:44

An.	O ₂ %	Air Leakage	SO ₂ ppm	NO ppm	NO Cor.	NO ₂ Cor.
1	4.00		173	89	90	297
2	4.70	4.29	128	103	104	263
3	4.74	4.55	102	162	164	170

Time 13:48 - 13:54

An.	O ₂ %	Air Leakage	SO ₂ ppm	NO _x ppm	NO _x Cor.
1	4.01		172	383	387
2	4.74	4.49	128	374	378
3	4.72	4.36	109	331	335

Switched streams #2 and #3 at the vacuum pumps.

Time 14:02 - 14:09

An.	O ₂ %	Air Leakage	SO ₂ ppm	NO _x ppm
1	4.01		172	384
2	4.74		92	348
3	4.72		142	350

An.	SO ₂ ppm	NO ppm
1	171	88
2	91	131
3	142	111