COMPLIANCE EVALUATION

OF

PARTICULATE EMISSIONS

FROM THE

COKE WORKS BOILER
BAGHOUSE OUTLET STACK

AT

WHEELING PITTSBURGH STEEL CORPORATION
STEUBENVILLE EAST COKE PLANT
FOLLANSBEE, WEST VIRGINIA

BCM PROJECT NO. 00-5167-02

JANUARY 1981

PREPARED BY:

Douglas E. Seely

Douglas E. Seely
Project Scientist

APPROVED BY:

Bernard M. Lalli

Bernard M. Lalli
Regional Manager

BETZ•CONVERSE•MURDOCH•INC.
1200 CENTRE CITY TOWER
650 SMITHFIELD STREET
PITTSBURGH, PENNSYLVANIA 15222

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1.0 INTRODUCTORY SUMMARY

Wheeling Pittsburgh Steel Corporation (WPSC) retained Betz•Converse•Murdoch•Inc. (BCM) to perform a compliance evaluation of the particulate emissions from the Coke Works Boiler Baghouse Outlet Stack at their Steubenville East Coke Plant in Follansbee, West Virginia. The program was conducted on December 22 and 23, 1980 and consisted of three (3) EPA Method Five particulate emission tests. The following Table 1 summarizes the results:

Table 1

Particulate Emissions

	Date	Time	gr/DSCF	lbs/hr	Gas Volume (DSCF)
Run 1	12/22/80	1313	.0325	23.29	83477
Run 2	12/23/80	0909	.0417	27.51	77033
Run 3	12/23/80	1316	.0367	24.50	77374

2.0 SCOPE AND OBJECTIVES

The scope of this project was defined in a letter dated December 8, 1980, BCM Proposal No. 18-8239-06, a copy of which appears as Appendix A of this report. In summary, sampling was conducted to determine:

1. Gas Flow - ACFM and SCFM
2. Volume Gas Sampled - DSCF
3. Gas Temperature - ^{o}F
4. Moisture Content - % by Volume
5. Gas Stream Molecular Weight - Orsat Analysis - Volume % CO_2, Volume % O_2, Volume % CO and Volume % N_2 (by difference)
6. Particulate Concentration - gr/DSCF
7. Particulate Emissions - lbs/hr

The project involved three (3) EPA Method Five particulate samples.

3.0 PROCEDURES

A description of the procedures used to conduct the sampling program is given below:

3.1 Field Work

All field work was performed on December ~~16~~ 22 and ~~17~~ 23, 1980 by a BCM field crew consisting of the following personnel:

Douglas E. Seely - Project Scientist
Daniel R. Petrovay - Technician
Jeffrey P. Bishop - Technician

Coordination between BCM and WPSC was provided by:

T. S. Landon - Corporate Project Engineer

The following methods, using procedures established and approved by the U.S. EPA, were employed during the program:

1. Sampling and traverse locations were determined as per Method One of the Federal Register, Volume 44, April 19, 1979, as amended, which is outlined in Appendix B, page B-1.

2. Gas flow, gas temperature and static pressure measurements were made as per Method Two of the Federal Register , Volume 44, April 19, 1979, as amended, which is outlined in Appendix B, page B-1.

3. Excess air and molecular weight determinations were performed as per Method Three of the Federal Register, Volume 44, April 19, 1979, as amended, which is outlined in Appendix B, page B-1.

4. Particulate matter and associated gas stream moisture were collected according to procedures of EPA Method Five as presented in the Federal Register, Volume 44, April 19, 1979, as amended, which is outlined in Appendix B, pages B-2 through B-4.

3.2 Equipment Calibration

In accordance with accepted procedures published by the United States Environmental Protection Agency (EPA), all gas velocity measuring equipment, volume metering equipment, temperature measuring equipment and flow rate metering equipment had been calibrated within 60 days of the actual test date. Calibration data is listed in Appendix B, pages B-23 and B-24.

3.3 Analytical Methods

Samples collected during the test program were analyzed by the BCM Laboratory in Plymouth Meeting, Pennsylvania. Refer to Appendix C, page C-1 for a detailed description of the methodologies used in the analysis of the samples. Table C-1, page C-8 of Appendix C lists the breakdown of the laboratory results.

3.4 Calculations

All calculations were performed through the use of a Hewlett-Packard 3000 Series II computer. Raw data generated from the sampling program were combined with the laboratory results and developed through the use of the equations presented in Methods Two through Five of the Federal Register for all particulate samples. Computer input and all other reduced data appear in Appendix C, pages C-8 through C-10. Pages C-3 through C-8 list the equations employed in the calculation of test results.

4.0 SUMMARY OF RESULTS

4.1 Particulate Results

A detailed listing of all evaluated parameters of the particulate tests is found in Appendix C, page C-10. The following Tables II and III summarize the results:

Table II

Particulate Results

	Run 1	Run 2	Run 3
Date	12/22/80	12/23/80	12/23/80
Time	1313	0909	1316
Sample Volume (DSCF)	60.18	58.21	57.69
Moisture (%)	2.1	5.3	5.3
Gas Temperature (^{o}F)	333	369	358
Gas Velocity (FPM)	1993	1986	1983
Gas Volume (DSCFM)	83477	77033	77874
Isokinetics (%)	96.18	100.82	98.83
Particulate Concentration (GR/DSCF)	.0325	.0417	.0367
Particulate Emissions (LBS/HR)	23.29	27.51	24.50

Table III

Opacity Results

Run No.	Time	Emissions ≥ 20% (min.)	Emissions ≥ 60% (min.)	Average Opacity (%)	Maximum Opacity (%)
1	1313-1343 1357-1427 1447-1517 1529-1559	0	0	0.1	5
2	0909-0939 0953-1023 1052-1122 1131-1201	0	0	3.1	5
3	1316-1346 1353-1423 1431-1501 1509-1539	0	0	3.8	5

5.0 DISCUSSION OF RESULTS

5.1 Particulate Sampling Results

All sampling and analysis was performed in accordance with the procedures and specifications established or approved by the United States Environmental Protection Agency (EPA). All isokinetic percentages fell within the permissible limits of 90% to 110% as prescribed. The following discussion describes relevant aspects of isokinetic sampling theory.

The isokinetic percentage is indicative of the precision with which the sample gas flow rate was adjusted to be identical to the actual stack gas flow rate. It is the best criterion in determining the validity of an individual test, presupposing all other test specifications were closely adhered to.

The dynamics of particulate motion is of interest in source sampling because particle motion does not always coincide with gas stream motion. Particles smaller than three to five microns in diameter will follow gas flow streamlines irrespective of changes in direction. However, larger particles can be expected to deviate from flow streamlines.

When the velocity of the gas stream into the sampling probe is different from that in the main stream, the size distribution and the total weight concentration of the particulate matter collected will be different from those in the main stream. The explanation lies in the behavior of particles having sufficient mass and velocity to possess appreciable momentum. At velocities less than main stream velocity, all large particles in the path of the nozzle will be projected into the sample opening, while a portion of the air or gas in this stream will be deflected around the nozzle. This results in a sample stream entering the nozzle that has more large particles than are in the main stream aerosol. When sampling velocity is greater

than main stream velocity, an excess of main stream air will enter the nozzle. Smaller particles will follow the stream lines into the nozzle, but larger particles, because of the inertia, will not be drawn in. Various investigators differ as to the magnitude of error produced by sampling at other than isokinetic velocity but agree that it is significant for particles greater than 5 μm. Deviations from isokinetic sampling rates probably do not significantly affect results for particles below 1 μm in size.

The average particulate emission for the three tests performed was .0370 gr/DSCF, with the highest concentration being .0417 gr/DSCF.

The average emission rate is 25.10 lbs/hr with the highest rate at 27.51 lbs/hr. Two of the three tests were below the compliance limit of 24.98 lbs/hr with one test, Run 2, over the compliance limit.

All three tests were well within the compliance limits for opacities, with all three tests showing 0 minutes ≥ 20% opacity, and no opacities greater than 5%.

BCM PROPOSAL

APPENDIX A

Betz • Converse • Murdoch • Inc. BCM

Consulting Engineers, Planners and Architects

December 9, 1980

Wheeling-Pittsburgh Steel Corporation
P. O. Box 118
Pittsburgh, PA 15230

Attention Mr. Doug Mangus, Purchasing Department

Subject: Compliance Evaluation of
Coke Works Boiler at
Steubenville East Coke Works of
Wheeling-Pittsburgh Steel Co.
WP P.O. No. 265-931
BCM Proposal No. 18-~~8240~~-06
18-7241-06

Gentlemen:

This letter will serve as the proposal for the above mentioned project. Betz•Converse•Murdoch•Inc. (BCM) will supply two (2) men for two (2) days with the necessary equipment to sample, evaluate and report test parameters. The testing program is to be performed on the coke works boiler at Wheeling-Pittsburgh Steel Corporation's (WPSC) Steubenville East Coke Works in Follansbee, West Virginia. The lump sum cost of this project, if performed on weekdays, tentatively December 22 and 23, 1980, is If it is performed on one weekday and one weekend day, tentatively December 19 and 20, 1980, the lump sum cost will be Final scheduling is to be decided by Mr. D. L. Roush of WPSC and Mr. D. E. Seely of BCM on December 18, 1980.

Delays caused by conditions beyond BCM's control, such as unfavorable weather conditions, partial or complete plant shutdowns, strikes, floods or forces which delay the project's completion, will be billed at an additional charge of per delay hour for the field sampling crew.

Every effort will be made to obtain results and convey them to WPSC by December 24, 1980, as requested by Mr. Roush.

Should you have any questions concerning this proposal or otherwise, please advise.

Very truly yours,

BETZ•CONVERSE•MURDOCH•INC.

Douglas E. Seely

Douglas E. Seely
Project Scientist

DES/dc

cc: Messrs. P. R. Charrington, M. D. Mueller
B. M. Lalli, D. L. Roush, D. E. Seely

FIELD SAMPLING PROCEDURES

APPENDIX B

.0 SAMPLING PROCEDURES

1.1 Test Station and Traverse Location

The test platform was located on the Coke Works Boiler Baghouse Outlet Stack approximately 88 feet above grade, approximately 5 diameters downstream and at least 8 stack diameters upstream from the nearest flow disturbance. To meet the requirements of EPA Method One, the tests sampled 40 points, 20 along each of two perpendicular diameters.

1.2 Gas Flow and Gas Temperature Measurements

The flow rate and temperature profiles for the gas streams were measured by conducting simultaneous velocity and temperature traverses. Gas velocity heads were measured with a calibrated "S" type Pitot tube which was connected to an inclined manometer. The static pressure was measured using the same Pitot tube and manometer. A Chromel-Alumel thermocouple attached to a THERMO-ELECTRIC CORPORATION digital potentiometer was used to measure the gas temperature at each of the traverse points. The gas flow and gas temperature measurements followed Method Two of the Federal Register.

1.3 Molecular Weight Determination

A Fisher-type B No. 10-605 Orsat analyzer was used to determine the molecular weight of the flue gas. The following parameters were measured in order to calculate molecular weight: volume percent carbon dioxide (CO_2), volume percent oxygen (O_2), and volume percent carbon monoxide (CO); the volume percentage of nitrogen (N_2) was determined by difference. These parameters were measured using the principle of gas absorption in specific absorbing solutions. A 100 ml flue gas sample was drawn through the glass manifold to the sample chamber by the use of the leveling bottle following aspiration of the sampling line. The system was then closed by adjusting the stopcock at the inlet of the manifold.

The sample was bubbled through three absorbing solutions which selectively collected different gaseous components of the stack gas in the following manner: carbon dioxide was collected in a potassium hydroxide solution in the first absorber, oxygen was collected in a potassium pyrogallate solution in the second absorber, and carbon monoxide was collected in a saturated cupric chloride solution in the third absorber. The volume of a specific gaseous component collected in an individual absorbing solution was determined by the change in volume of sample gas in the sample chamber after the bubbling process through that solution was complete. Since the original sample volume was 100 ml, any change in volume was also the percentage of the specific gaseous component found in the stack gas stream. Temperature effects in the sample chamber were minimized by a water jacket which surrounded it, maintaining the temperature at a constant level throughout the duration of the Orsat analysis.

1.4 Moisture Content Sampling

Sampling was conducted employing the principles presented in EPA Method Four and concurrently with particulate sampling. Parameters evaluated in order to determine the gas stream moisture content were: sample gas volume, sample gas temperature, sample gas pressure, impinger moisture gain, and silica gel moisture gain. Some minor modifications were made to the Method Four train to allow concurrent particulate and moisture content sampling; these modifications involved no deviations from sampling principles. Such modifications as the substitution of a glass fiber filter for Pyrex wool as a filtering medium and the substitution of a calibrated orifice for a rotameter as a flow metering device were incorporated.

1.5 Particulate Sampling

All sampling procedures and equipment utilized in the test program were those outlined in Method Five of the Federal Register. The size of the nozzle required to maintain isokinetic sampling was calculated from the results of the initial temperature and velocity traverses through the use of a nomograph. The sampling train utilized a stainless steel probe which was heated to 250°F by an internal heating element contained within a stainless steel sleeve. A nozzle of the calculated size was attached to the end of the probe which was inserted into the stack. A calibrated "S" type Pitot tube and a Chromel-Alumel thermocouple were clamped to the probe and were used to monitor the velocity head and the temperature at the traverse points during the sampling period.

Sample gas passed through the nozzle and the probe to a glass fiber filter for the removal of the suspended particulates. The filter was housed in a heated chamber whose temperature was maintained at about 250°F. The sample gas then passed through a transition line to the impinger train. The first two impingers each contained 150 ml of deionized water. The third impinger contained no reagents and was the knockout impinger. The fourth impinger contained approximately 200 grams of coarse silica gel which collected any moisture and/or vapors which had not been captured in the preceding impingers.

The second impinger was a standard Greenburg Smith, while the other three were modified by replacing the tip with a 1/2-inch glass tube. It should be noted that the entire impinger train was maintained at less than 70°F for all sample runs.

The sample gas was conducted from the impinger train through an umbilical cord to the control console, a Model 2343 RAC Stack Sampler, which contained the following pieces of equipment (listed in the order in which sample gas passed through them): a main

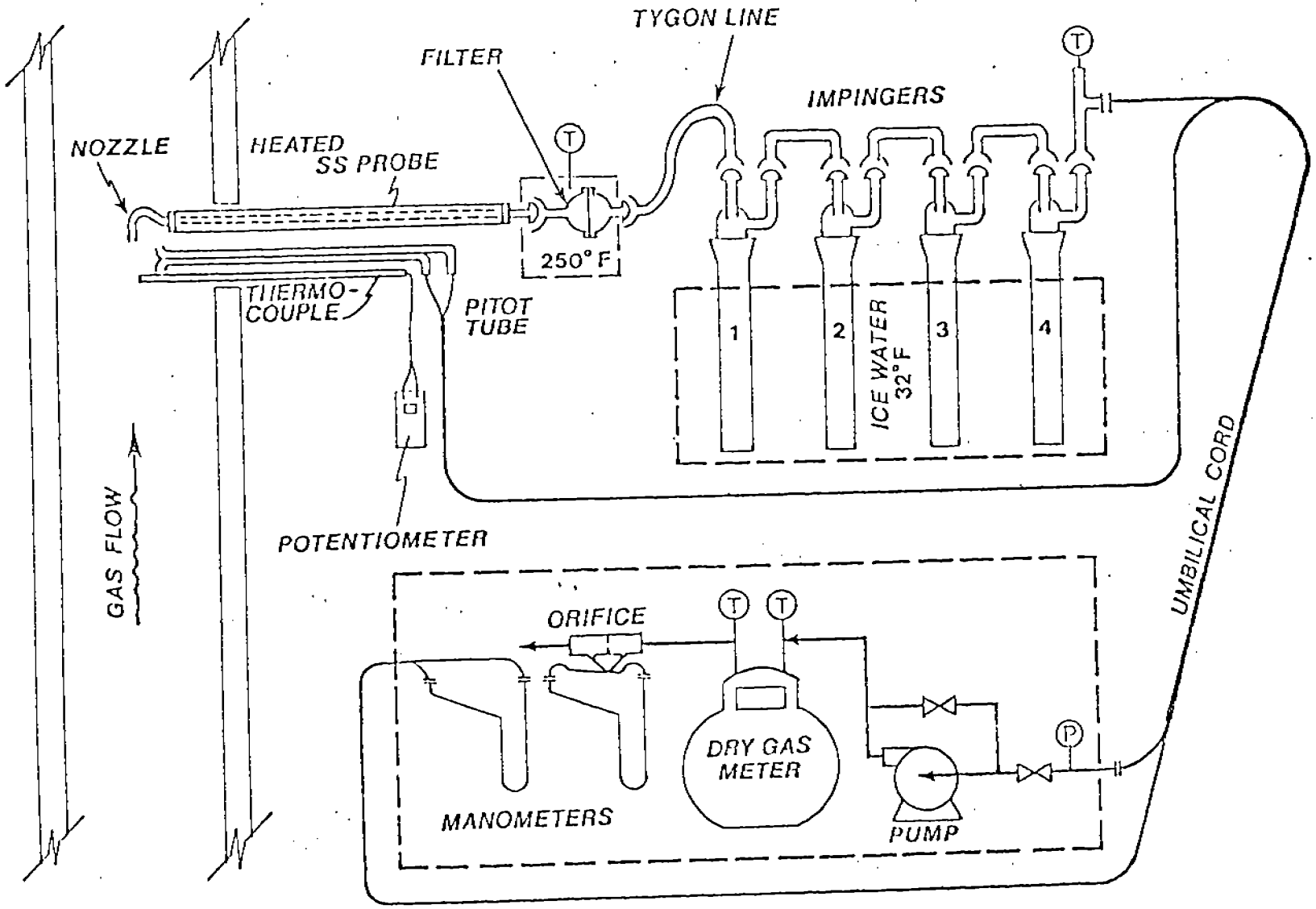
valve, a by-pass valve for flow adjustment, an air-tight vacuum pump, a calibrated dry gas meter, and a calibrated orifice. The orifice was equipped with pressure taps which were connected across an inclined manometer used to insure that isokinetic sampling conditions were maintained during the test. A schematic diagram of the sampling train is on page B-5 of this Appendix.

The sampling train was subjected to an optional leak check prior to each sample run. The entire sampling system was assembled and the probe and filter heating systems were allowed to stabilize at the desired operating temperatures. The nozzle inlet was plugged and a 15-inch mercury vacuum was pulled. The system was then checked and a leakage rate of less than 0.02 cfm was insured.

Upon completion of the test or at any time when a system component change, e.g., filter, was necessary, the system was subjected to a mandatory leak check. The procedure was identical to that stated above except that the leak check vacuum equalled or exceeded the maximum vacuum obtained during the test run. If the leakage rate was no greater than 0.02 cfm or four percent of the average sampling rate, the results were acceptable and no volume corrections were necessary. However, if a higher leakage rate was found, a volume correction was performed utilizing the criteria of Method Five.

2.0 Field Data Sheets

The gas velocity head, gas temperature, inlet and outlet gas meter temperatures, orifice differential pressure, sample volume, time and opacity were recorded during the testing program. Copies of these data sheets follow on pages B-6 to B-22 of this Appendix.



EPA METHOD 5 (filter only)

etz • Converse • Murdoch • Inc. BCM

VELOCITY DETERMINATIONS

: WP Follansbee Sample Port Location:

on: Coke Works Boiler Baghouse Outlet

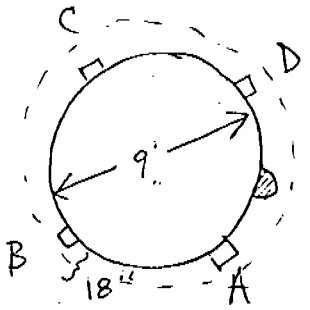
12/21/90

Pressure:

netric Pressure:

Factor:

eer:



Pitot/Temperature Readings 12/22/90

nt .	Distance (Inches) + 18"	Port A		Port B		Port C		Port		Port	
		ΔP	T	ΔP	T	ΔP	T	ΔP	T	ΔP	T
	19.4	.19	530	.18		34					
	22.2	.18		.17		.35					
	25.2	.17		.18		.34					
	28.5	.18		.18		.34					
	31.9	.18		.19		.33					
	35.8	.16	530	.19		.32					
	40.0					.30					
	45.0					.24					
	51.0					.13					
	60.0					.02					
AL											
G.			.18								

Betz • Converse • Murdoch • Inc. BCM

NOMOGRAPH DATA

PLANT WP Fallsbee

DATE 12/21/80

SAMPLING LOCATION Boiler

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	1.99
AVERAGE METER TEMPERATURE(AMBIENT+ 20°F), °F	$T_{m_{avg}}$	50°F
VOLUME PERCENT MOISTURE IN GAS	B_{wo}	10%
BAROMETRIC PRESSURE AT METER, in.Hg	P_m	
STACK STATIC PRESSURE, in.Hg ($P_m \pm 0.073$ x STACK GAUGE PRESSURE)	P_s	
PITOT CALIBRATION FACTOR	C_p	.81
AVERAGE STACK TEMPERATURE	T_s	330
AVERAGE VELOCITY HEAD, in. H_2O	ΔP_{avg}	.18
MAXIMUM VELOCITY HEAD, in. H_2O	ΔP_{max}	.20
C FACTOR		.90
CALCULATED NOZZLE DIAMETER, in.		.35
ACTUAL NOZZLE DIAMETER, in.		.32
REFERENCE Δp, in.H_2O		.29

BCM

FIELD DATA SHEET

PLANT: WP Tollansbee
DATE: 12/22/80
SAMPLING LOCATION: Boiler
SAMPLE TYPE: Particulate
RUN NUMBER: 1
OPERATOR: DES/DRP
AMBIENT TEMPERATURE: 30°F
BAROMETRIC PRESSURE:
STATIC PRESSURE, (P_s): -.72"
FILTER NUMBER (s): P-49
GEL NUMBER (S): 9 +12.4 +15

.017 cfm @ 16

ORSAT:
CO_2 3.5%
O_2 16.0%
CO

PROBE NUMBER AND TYPE:
NOZZLE I.D. AND NO. .270
ASSUMED MOISTURE, % 10%
SAMPLE BOX NUMBER 1
METER BOX NUMBER 9
METER $\Delta H_@$ 1.99
C FACTOR .9
PROBE HEATER SETTING 100
HEATER BOX SETTING 100
REFERENCE Δp .56
PITOT C_p AND NO. 9.7 .81

READ AND RECORD ALL DATA EVERY 3 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr CLOCK)		GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
					DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
	00	1313	391.850									
A-10	03	1316	393.5	.33	1.1	1.1	371	30	29	4	225	33
9	06	1319	395.1	.32	1.05	1.05	330	34	30	3.5	225	33
8	09	1322	396.7	.34	1.15	1.15	332	40	30	4	225	33
7	12	1325	398.4	.33	1.1	1.1	338	45	30	4	225	33
6	15	1328	399.9	.31	1.0	1.0	330	48	31	3.5	230	34
5	18	1331	401.5	.32	1.05	1.05	331	50	32	4	230	34
4	21	1334	403.0	.30	.98	.98	330	53	33	3.5	230	34
3	24	1337	404.4	.23	.76	.76	330	56	33	3.5	230	34
2	27	1340	405.5	.15	.50	.50	315	56	35	3	235	34
1	30	1343	406.629	.10	.33	.33	301	53	35	2	235	34
	30	1357	406.629	Chg. Parts								
B-10	33	1400	408.3	.32	1.05	1.05	372	40	35	4	235	34
9	36	1403	409.9	.33	1.1	1.1	318	44	36	4	230	35
8	39	1406	411.4	.33	1.1	1.1	327	49	36	4	230	34
7	42	1409	413.1	.35	1.15	1.15	325	54	36	4	230	34
6	45	1412	414.7	.31	1.0	1.0	321	56	37	4	235	34
5	48	1415	416.2	.30	.98	.98	379	59	37	4	235	35
4	51	1418	417.7	.27	.89	.89	379	62	39	4	235	35
3	54	1421	419.0	.22	.71	.71	378	61	39	3	235	35
2	57	1424	420.1	.14	.46	.46	365	59	40	2	235	35
1	60	1427	420.935	.09	.30	.30	217	58	40	2	235	35

	TIME, min	DECIMAL		Δp_s, in H_2O	Δp_{VH}, in H_2O		t_s, °F	INLET $t_{m\,in}$, °F	OUTLET $t_{m\,out}$, °F	in Hg	°F	°F
	60	1447	420.935		DESIRED	ACTUAL						
C-10	63	1450	422.4	.30	.98	.98	370	40	38	4	235	35
9	66	1453	424.0	.32	1.05	1.05	379	43	38	4	235	35
8	69	1456	425.6	.28	.92	.92	368	48	38	4	235	35
7	72	1459	427.1	.28	.92	.92	379	52	38	4	235	35
6	75	1502	428.5	.27	.89	.89	377	52	38	4	230	34
5	78	1505	430.1	.29	.95	.95	378	53	38	4	230	34
4	81	1508	431.5	.25	.83	.83	317	55	39	4	230	34
3	84	1511	432.8	.20	.67	.67	373	56	39	3	225	34
2	87	1514	433.8	.14	.46	.46	351	58	40	3	225	35
1	90	1517	434.738	.10	.33	.33	334	56	39	2	230	35
	90	1529	434.738									
B-10	93	1532	436.4	.32	1.05	1.05	372	40	37	5	230	33
9	96	1535	437.9	.32	1.05	1.05	376	44	38	4	235	33
8	99	1538	439.5	.33	1.1	1.1	376	50	38	4	230	33
7	102	1541	441.1	.33	1.1	1.1	379	54	38	4	230	33
6	105	1544	442.8	.32	1.05	1.05	377	56	38	4	230	33
5	108	1547	444.3	.28	.92	.92	376	59	39	4	230	34
4	111	1550	445.7	.28	.92	.92	377	58	40	3	225	34
3	114	1553	447.1	.23	.76	.76	373	59	40	3	225	34
2	117	1556	448.1	.15	.50	.50	362	58	40	2	225	34
1	120	1559	449.108	.10	.33	.33	345	56	40	2	225	34
			LEAK CHK.	.078" H_2O @	7"							
			4.258	.504								

BCM

FIELD DATA SHEET

PLANT LVP Foil.
DATE 12/23/80
SAMPLING LOCATION Boiler STK
SAMPLE TYPE Particulate
RUN NUMBER 2
OPERATOR DES / DRP
AMBIENT TEMPERATURE 35°F
BAROMETRIC PRESSURE
STATIC PRESSURE, (P_s) -.69"
FILTER NUMBER (s) D-53
GEL NUMBER (S) 12 457 +12

ORSAT:
CO_2 3.0
O_2 17.0
CO

PROBE NUMBER AND TYPE
NOZZLE I.D. AND NO. .270
ASSUMED MOISTURE, % 10%
SAMPLE BOX NUMBER 1
METER BOX NUMBER 9
METER $\Delta H_@$ 1.99
C FACTOR .9
PROBE HEATER SETTING 100
HEATER BOX SETTING 100
REFFRENCE Δp .56
PITOT C_p AND NO. .81, 17

.003 c/m @ 15"

READ AND RECORD ALL DATA EVERY 3 MINUTES

Soot Blow @ 900

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24 hr CLOCK)		GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
					DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
	00	0709	449.288									
B-10	03	0712	450.8	.29	.95	.95	372	35	34	3	215	34
9	06	0715	452.4	.29	.95	.95	377	38	34	3	215	34
8	09	0718	453.9	.28	.93	.93	376	43	34	3	210	32
7	12	0721	455.4	.29	.95	.95	375	47	35	3	210	31
6	15	0724	456.9	.28	.93	.93	375	50	35	3	215	30
5	18	0727	458.4	.27	.89	.89	374	52	36	3	215	31
4	21	0730	459.8	.26	.84	.84	373	53	36	3	215	31
3	24	0733	461.2	.21	~~.69~~	~~.69~~	372	54	37	3	220	31
2	27	0736	462.2	.14	.46	.46	365	54	38	2	225	31
1	30	0739	463.114	.10	.34	.34	363	56	38	2	225	32
	30	0753	463.114	Chg. Ports								
C-10	33	0956	464.7	.30	.98	.98	376	41	38	3	230	32
9	36	0959	466.2	.29	.95	.95	379	44	39	3	235	33
8	39	1002	467.8	.28	.93	.93	379	50	34	3	235	33
7	42	1005	469.2	.27	.89	.89	378	54	40	3	235	33
6	45	1008	470.7	.27	.89	.89	377	56	40	3	235	33
5	48	1011	472.2	.25	.83	.83	379	56	40	3	235	34
4	51	1014	473.6	.22	.72	.72	378	57	40	3	240	34
3	54	1017	474.8	.19	.62	.62	377	57	41	2	235	34
2	57	1020	475.9	.15	.50	.50	357	60	42	2	235	34
1	60	1023	476.900	.10	.34	.34	329	58	43	2	235	34

Chg. Ports + Soot Blow

B-10

POINT NUMBER	SAMPLING TIME, min	(24 hr CLOCK)	(V_m), ft^3	HEAD (Δp_s), in H_2O	DIFFERENTIAL (ΔH), in. H_2O		TEMPERATURE (T_s), °F	TEMPERATURE		in Hg	°F	°F
					DESIRED	ACTUAL		INLET $(T_{m\,in})$, °F	OUTLET $(T_{m\,out})$, °F			
	60	1052	476.900									
D-10	63	1055	478.6	.33	1.1	1.1	355	43	42	4	230	37
9	66	1058	480.3	.35	1.15	1.15	393	49	43	4	230	36
8	69	1101	481.8	.30	.98	.98	378	56	44	4	230	33
7	72	1104	483.4	.28	.93	.93	375	60	45	3	235	31
6	75	1107	484.9	.28	.93	.93	375	64	46	3	235	31
5	78	1110	486.3	.26	.84	.84	377	64	47	3	240	31
4	81	1113	487.8	.26	.84	.84	376	67	47	3	240	31
3	84	1116	489.1	.21	.69	.69	328	67	48	3	240	31
2	87	1119	490.2	.14	.46	.46	356	67	48	2	245	32
1	90	1122	491.050	.09	.30	.30	326	66	49	2	255	32
	90	1131	491.050	Clg. Run 3								
A-10	93	1134	492.6	.30	.98	.98	365	51	47	4	235	32
9	96	1137	494.3	.33	1.1	1.1	375	58	48	4	240	33
8	99	1140	495.8	.30	.98	.98	373	63	48	3	240	33
7	102	1143	497.4	.30	.98	.98	372	68	49	3	240	37
6	105	1146	498.9	.30	.98	.98	372	71	50	3	240	39
5	108	1149	500.6	.30	.98	.98	374	72	51	3	240	41
4	111	1152	502.1	.26	.84	.84	373	72	52	3	245	43
3	114	1155	503.4	.22	.72	.72	369	72	53	3	245	45
2	117	1158	504.5	.14	.46	.46	356	73	53	2	245	45
1	120	1201	505.340	.09	.30	.30	337	73	54	2	245	45
			.019 cfm @ 11									

BCM

FIELD DATA SHEET

PLANT WP Follansbee
DATE 12-23-80
SAMPLING LOCATION Boiler stk.
SAMPLE TYPE Particulate
RUN NUMBER 3
OPERATOR DESI DRP
AMBIENT TEMPERATURE 40
BAROMETRIC PRESSURE
STATIC PRESSURE, (P_s) -.62"
FILTER NUMBER (S) D-58
GEL NUMBER (S) 14 +13 +55

.004 ch @ 17"

ORSAT:
CO_2 3.0
O_2 16.5
CO

PROBE NUMBER AND TYPE
NOZZLE I.D. AND NO. .270
ASSUMED MOISTURE, % 10
SAMPLE BOX NUMBER 1
METER BOX NUMBER 9
METER $\Delta H_@$ 1.99
C FACTOR .9
PROBE HEATER SETTING 10t
HEATER BOX SETTING 10t
REFERENCE Δp .56
PITOT C_p AND NO. .81, 9.7

READ AND RECORD ALL DATA EVERY 3 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
					DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
	00	1316	505.846									
A-10	03	1319	507.5	.32	1.1	1.1	361	46	45	4	215	44
9	06	1322	509.1	.33	1.1	1.1	376	49	46	4	220	44
8	09	1325	510.7	.32	1.1	1.1	377	55	46	4	220	45
7	12	1328	512.4	.32	1.1	1.1	376	60	46	4	225	45
6	15	1331	513.9	.30	.98	.98	377	64	46	4	230	48
5	18	1334	515.5	.29	.95	.95	377	67	47	3	230	48
4	21	1337	517.0	.28	.93	.93	377	69	48	3	230	48
3	24	1340	518.4	.23	.76	.76	333	71	49	3	235	49
2	27	1343	519.5	.16	.53	.53	360	72	50	2	235	50
1	30	1346	520.478	.12	.40	.40	361	72	50	2	230	51
	30	1353	520.478	change	Ports							
D-10	33	1356	522.1	.32	1.1	1.1	351	55	49	4	235	50
9	36	1359	523.7	.31	1.0	1.0	377	60	51	4	235	50
8	39	1402	525.3	.30	.98	.98	377	64	50	4	240	50
7	42	1405	526.9	.30	.98	.98	378	67	51	4	240	50
6	45	1408	528.4	.29	.95	.95	379	70	51	4	240	51
5	48	1411	529.9	.27	.89	.89	377	72	51	3.5	235	53
4	51	1414	531.4	.25	.83	.83	377	74	52	3.5	235	53
3	54	1417	532.7	.22	.72	.72	376	73	52	3	235	54
2	57	1420	533.8	.15	.50	.50	351	72	52	2	235	51
1	60	1423	534.734	.10	.34	.34	336	72	52	2	230	47

Clg. Ports

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
					DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
	60	~~1431~~	534.734									
C-10	63	1434	536.4	.32	1.1	1.1	304	60	52	4	230	47
9	66	1437	538.0	.30	.98	.98	317	64	53	4	230	47
8	69	1440	539.6	.30	.98	.78	320	69	53	4	235	48
7	72	1443	541.2	.29	.95	.75	377	72	54	4	235	47
6	75	1446	542.7	.29	.95	.75	376	76	54	4	240	48
5	78	1449	544.2	.25	.83	.83	378	74	54	4	230	45
4	81	1452	545.5	.21	.69	.69	375	66	54	3.5	230	43
3	84	1455	546.6	.18	.59	.59	371	64	53	3	230	42
2	87	1458	547.6	.10	.34	.34	345	64	53	2	225	40
1	90	1501	548.451	.08	.27	.27	264	65	52	2	225	40
	90	1509	548.451	Clg. Pnts								
B-10	93	1512	550.1	.32	1.1	1.1	356	56	50	5	230	43
9	96	1515	551.7	.30	.98	.98	375	62	52	4	235	46
8	99	1518	553.3	.28	.93	.93	374	68	52	4	230	45
7	102	1521	554.8	.31	1.0	1.0	375	72	53	4	230	45
6	105	1524	556.4	.29	.95	.95	374	76	53	4	230	47
5	108	1527	557.3	.28	.93	.93	372	78	54	3	230	48
4	111	1530	558.9	.22	.72	.72	368	78	55	3	235	45
3	114	1533	560.5	.18	.59	.59	367	79	56	3	230	42
2	117	1536	561.5	.12	.40	.40	318	79	56	2	230	41
1	120	1539	562.368	.09	.30	.30	273	78	57	2	235	41
			.012	cfm @ 6"								
				.72" static								

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Consulting Engineers, Planners and Architects

Date 12/22/80 Location Name WHEELING-PITT. STEEL

Observer J. BISHOP Address FOLLANSBEE, W. VA.

Comments

Comments

on Point OLD COKE OVEN AREA
F BOILER STACK
tance from 150A Height 200'
E 0-10 Direction W
nstallation BOILER STACK

on Began 1020 Ended 1345

PARTLY CLOUDY SKY (20%)

READINGS START AGAIN AT 1315
W/ 50% CLOUD COVER

VIEW OF STACK OBSTRUCTED BY
STEAM PLUME

Smoke Density

	0	15	30	45		0	15	30	45	
1020 0	0	0	0	0	30	0	0	0	0	
1	0	0	0	0	31	0	0	0	0	
2	0	0	0	0	32	0	0	0	0	
3	0	0	0	0	1325 33	0	0	0	0	
4	0	0	0	0	34	0	0	0	0	
5	0	0	0	0	35	0	0	0	0	
6	0	0	0	0	36	0	0	0	0	
7	0	0	0	0	37	0	0	0	0	
8	0	0	0	0	1330 38	0	0	0	0	
8	0	0	0	0	39	0	0	0	0	
10	0	0	0	0	40	0	0	X	X	
11	0	0	0	0	41	X	X	0	0	
12	0	0	0	0	42	0	0	0	0	
13	0	0	0	0	1335 43	0	X	0	0	
14	0	0	0	0	44	0	0	0	0	
15	0	0	0	0	45	X	0	0	0	
16	0	0	0	0	46	0	0	0	0	
17	0	0	0	0	47	0	0	0	0	
18	0	0	0	0	1340 48	0	0	0	0	
19	0	0	0	0	49	0	0	0	0	
20	0	0	0	0	50	0	0	5	5	WHITE
21	0	0	0	0	51	5	0	0	0	
1042 22	0	0	0	0	52	0	0	0	0	
* 1315 23	0	0	0	0	1345 53	0	0	0	0	
24	0	0	0	0	54	0	0	0	0	
25	0	0	0	0	55	0	0	0	0	
26	0	0	0	0	56	0	0	0	0	
27	0	0	0	0	57	0	0	0	0	
1320 28	0	0	0	0	1350 58	0	0	0	0	
29	0	0	0	0	59	0	0	0	0	

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Consulting Engineers, Planners and Architects

Date 12/22/80 Location Name WHEELING - PITT. STEEL

server J. BISHOP Address FOLLANSBEE, W. VA.

on Point OLD COKE OVEN AREA
OF BOILER STACK
stance from 150ft Height 200'
ed 0-5 Direction
Installation BOILER STACK
AL
ion Began 1352 Ended 1452

<50% CLOUD COVER

X VIEW OBSTRUCTED BY STEAM PLUME

%) Smoke Density

Comments

Comments

	0	15	30	45		0	15	30	45
1352 0	0	0	0	0	30	0	0	0	0
1	0	0	0	0	31	0	0	0	0
2	0	0	0	0	32	0	0	0	0
1355 3	X	X	0	0	1425 33	0	0	0	0
4	0	0	0	0	34	0	0	0	0
5	0	0	0	0	35	0	0	0	0
6	0	0	0	0	36	0	0	0	0
7	0	0	0	0	37	0	0	0	0
1400 8	0	X	X	0	1430 38	0	0	0	0
9	0	0	0	0	39	0	0	0	0
10	0	0	0	0	40	0	0	0	0
11	0	0	0	0	41	0	0	0	0
12	0	0	0	0	42	0	0	0	0
1405 13	0	0	0	0	1435 43	0	0	0	0
14	0	0	0	0	44	0	0	0	0
15	0	0	0	0	45	0	0	0	0
16	0	0	0	0	46	0	0	0	0
17	0	0	0	0	47	0	0	0	0
1410 18	0	0	0	0	1440 48	0	0	0	0
19	0	0	0	0	49	0	0	0	0
20	0	0	0	0	50	0	0	0	0
21	0	0	0	0	51	0	0	0	0
22	0	0	0	0	52	0	0	0	0
1415 23	0	0	0	0	1445 53	0	0	0	0
24	0	0	0	0	54	0	0	0	0
25	0	0	0	0	55	0	0	0	0
26	0	0	0	0	56	0	0	0	0
27	0	0	0	0	57	0	0	0	0
1420 28	0	0	0	0	1450 58	0	0	0	0
29	0	0	0	0	59	0	0	0	0

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Consulting Engineers, Planners and Architects

Date 12/22/80 Location Name WHEELING-PITT STEEL

server J. BISHOP Address FOLLANSBEE, W. VA.

ion Point OLD COKE OVEN AREA
OF BOILER STACK
stance from 150 ft Height 200'
ed 0-5 Direction SW
Installation BOILER STACK

ion Began 1452 Ended 1552

50% PARTLY CLOUDY

) Smoke Density

Comments

Comments

	0	15	30	45		0	15	30	45
1452 0	0	0	0	0	30	0	0	0	0
1	0	0	0	0	31	0	0	0	0
2	0	0	0	0	32	0	0	0	0
1455 3	0	5	5	5	1525 33	0	0	0	0
WHITE 4	5	5	5	5	34	0	0	0	0
5	5	0	0	0	35	0	0	0	0
6	0	0	0	0	36	0	0	0	0
7	0	0	0	0	37	0	0	0	0
1500 8	0	0	0	0	1530 38	0	0	0	0
9	0	0	0	0	39	0	0	0	0
10	0	0	0	0	40	0	0	0	0
11	0	0	0	0	41	0	0	0	0
12	0	0	0	0	42	0	0	0	0
1505 13	0	0	0	0	1535 43	0	0	0	0
14	0	0	0	0	44	0	0	0	0
15	0	0	0	0	45	0	0	0	0
16	0	0	0	0	46	0	0	0	0
17	0	0	0	0	47	0	0	0	0
1510 18	0	0	0	0	1540 48	0	0	0	0
19	0	0	0	0	49	0	0	0	0
20	0	0	0	0	50	0	0	0	0
21	0	0	0	0	51	0	0	0	0
22	0	0	0	0	52	0	0	0	0
1515 23	0	0	0	0	1545 53	0	0	0	0
24	0	0	0	0	54	0	0	0	0
25	0	0	0	0	55	0	0	0	0
26	0	0	0	0	56	0	0	0	0
27	0	0	0	0	57	0	0	0	0
1520 28	0	0	0	0	1550 58	0	0	0	0
29	0	0	0	0	59	0	0	0	0

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Consulting Engineers, Planners and Architects

Date 12/23/80 Location Name WHEELING - PITT STEEL

Observer J. BISHOP Address FOLLANSBEE, W. VA.

tion Point OLD COKE OVEN AREA

t OF BOILER STACK

stance from 150 yds Height 200'

ed 0-5 Direction SW

Installation BOILER STACK

AL

ion Began 910 Ended 1010

OVERCAST SKY

) Smoke Density

	0	15	30	45	Comments
910 0	0	0	0	0	
1	0	0	0	0	
2	0	0	0	0	
3	0	0	0	0	
4	0	0	0	0	
915 5	0	0	0	0	
6	0	0	0	0	
7	0	0	0	0	
8	0	0	0	0	
920 10	0	0	0	0	
11	0	0	0	0	
12	0	0	0	5	WHITE
13	5	5	5	5	
14	5	0	0	0	
925 15	0	0	0	0	
16	0	0	0	0	
17	0	0	0	0	
18	5	5	5	5	LIGHT BROWN
19	5	5	5	5	
930 20	5	5	5	5	
21	5	5	5	5	
22	5	5	5	5	
23	5	5	0	0	
24	0	0	0	0	
935 25	0	0	0	0	
26	0	0	0	5	
27	5	5	5	5	LIGHT BROWN
28	5	5	5	0	
29	0	0	0	0	

	0	15	30	45	Comments
940 30	0	5	5	5	LIGHT BROWN
31	0	0	0	0	
32	0	0	0	0	
33	0	0	0	0	
34	0	0	0	0	
945 35	0	5	5	5	
36	5	5	0	0	
37	0	0	0	0	
38	0	0	0	0	
39	0	0	0	0	
950 40	5	5	5	5	
41	5	0	0	0	
42	0	0	0	0	
43	0	0	0	0	
44	0	0	0	0	
955 45	0	0	0	0	
46	0	0	0	0	
47	0	0	0	0	
48	0	0	0	0	
49	0	0	0	0	
1000 50	0	0	0	0	
51	5	5	5	5	WHITE
52	5	5	5	5	
53	0	0	5	5	
54	5	5	5	5	
1005 55	5	5	5	5	
56	5	5	5	5	
57	5	5	5	5	
58	5	5	5	6	
59	5	5	5	5	

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Consulting Engineers, Planners and Architects

Date 12/23/80

Location Name WHEELING-PITT STEEL

erver J. BISHOP

Address FOLLANSBEE, W. VA.

n Point OLD COKE OVEN AREA

F BOILER STACK

ance from 150YD Height 200'

0-S Direction SW

stallation BOILER STACK

L

n Began 1015 Ended 1110

TLY CLOUDY (50%)

INTERFERENCE FROM STEAM PLUME

Smoke Density

Comments

	0	15	30	45		0	15	30	45	Comments
1010 0	5	5	5	5	1040 30	5	5	5	5	WHITE
1	5	5	5	5	31	5	5	5	5	
2	5	5	5	5	32	5	5	5	5	
3	5	5	5	5	33	X	X	X	5	
4	5	5	5	5	34	5	5	X	X	
1015 5	5	5	5	5	1045 35	5	5	X	5	
6	5	5	5	5	36	5	5	5	5	
7	5	5	5	5	37	5	5	5	5	
8	5	5	5	5	38	5	5	5	5	
9	5	5	5	5	39	5	5	5	5	
1020 10	5	5	5	5	1050 40	5	5	5	5	
11	5	5	5	5	41	5	5	5	5	
12	5	5	5	5	42	5	5	5	5	
13	5	5	5	5	43	5	5	5	X	
14	5	5	5	5	44	X	5	5	5	
1025 15	5	5	5	5	1055 45	5	5	5	5	
16	5	5	5	5	46	5	5	5	5	
17	5	5	5	5	47	5	X	X	X	
18	5	5	5	5	48	X	5	X	X	
19	5	5	5	5	49	X	5	5	5	
1030 20	5	5	5	5	1100 50	5	5	5	5	
21	5	5	5	5	51	5	X	X	X	BYPASS
22	5	5	5	5	52	X	5	5	5	BLACK END
23	5	5	5	5	53	5	5	5	5	
24	5	5	5	5	54	5	5	5	X	WHITE
1035 25	5	5	5	5	1105 55	5	5	5	5	
26	5	5	5	5	56	5	5	5	5	
27	5	5	5	5	57	5	5	5	5	
28	5	5	5	5	58	5	5	5	5	
29	5	5	5	5	59	5	5	5	5	

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BCM

Consulting Engineers, Planners and Architects

Date 12/23/80

Location Name WHEELING-PITT STEEL

server J. BISHOP

Address FOLLANSBEE, W. VA

on Point OLD COKE OVEN AREA

NE BOILER STACK

tance from 150-up Height 200'

d 0-10 Direction SW

nstallation BOILER STACK

on Began 1110 Ended

CLEAR SKY

INTERFERENCE FROM STEAM PLUME

) Smoke Density

Comments

Comments

	0	15	30	45		0	15	30	45	
1110 0	5	5	5	5	1140 30	X	X	0	X	WHITE
1	5	5	5	5	31	0	5	5	5	WHITE
2	5	5	5	5	32	5	5	5	5	
3	5	5	5	5	33	X	X	X	5	
4	5	5	5	5	34	5	5	5	5	
1115 5	5	5	5	5	1145 35	5	5	0	0	
6	5	5	5	5	36	0	0	5	5	
7	5	5	5	5	37	5	5	5	5	
8	5	5	5	5	38	5	5	0	0	
9	5	5	5	5	39	0	0	0	0	
1120 10	5	5	5	5	1150 40	0	0	0	5	WHITE
11	5	5	5	5	41	5	X	5	5	
12	5	5	5	5	42	5	5	X	0	
13	5	5	5	5	43	0	0	0	5	
14	5	5	5	5	44	5	5	5	0	
1125 15	5	5	5	5	1155 45	0	0	0	0	
16	5	5	5	5	46	0	X	X	X	
17	0	0	0	5	47	0	0	5	5	WHITE
18	5	5	5	5	48	5	5	5	5	
19	5	5	5	5	49	5	0	0	0	
1130 20	5	5	X	5	1200 50	0	0	0	0	
21	5	5	5	5	51	0	0	0	5	WHITE
22	5	5	5	5	52	5	5	5	5	
23	5	5	5	5	53	5	5	5	5	
24	5	5	5	5	54					
1135 25	5	5	5	5	1205 55					
26	X	X	X	X	56					
27	X	X	5	5	57					
28	X	0	0	0	58					
29	X	5	X	X	59					

Betz • Converse • Murdoch • Inc.

BCM

Consulting Engineers, Planners and Architects

Date 12/23/90

Location Name WHEELING-PITT STEEL

erver J. BISHOP

Address FOLLANSBEE, W. VA

on Point OLD COKE OVEN

TH OF BOILER STACK

tance from 150 yd Height 200'

: 0-10 Direction SW

nstallation BOILER STACK

EL

on Began 1320 Ended 1420

GREY OVERCAST

INTERFERENCE FROM STEAM PLUME

) Smoke Density

	0	15	30	45	Comments
1200 0	0	0	0	0	
1	0	0	0	0	
2	0	0	0	0	
3	0	0	0	0	
4	5	5	5	5	TAN
1255 5	5	5	5	5	
6	5	5	5	5	
7	5	5	5	5	
8	5	5	5	5	
9	5	5	5	5	
1310	0	0	0	0	
11	0	0	0	0	
12	0	0	0	0	
13	0	0	0	0	
14	0	0	0	0	
1325 15	0	0	0	0	
16	0	0	0	5	
17	5	5	5	5	BROWN
18	5	5	5	X	
19	X	5	5	5	
1340 20	5	5	5	5	
21	5	5	5	5	
22	5	5	5	5	
23	5	5	5	5	
24	5	5	5	5	
1345 25	5	5	5	5	
26	5	5	5	5	
27	5	5	5	5	
28	5	5	5	5	
29	5	5	5	5	

	0	15	30	45	Comments
1350 30	5	5	5	5	BROWN
31	5	5	5	5	
32	5	5	5	5	
33	5	5	5	5	
34	5	5	5	5	
1355 35	5	5	5	5	
36	5	5	X	X	
37	X	X	5	5	
38	5	X	X	5	
39	5	5	5	5	
1400 40	5	5	5	5	
41	5	5	X	X	
42	5	5	5	5	
43	5	5	5	5	
44	5	5	5	5	
1405 45	5	5	5	5	
46	5	5	5	5	
47	5	5	5	5	
48	5	5	5	5	
49	5	5	5	5	
1410 50	5	5	5	5	
51	X	X	5	5	
52	5	5	5	5	
53	5	5	5	5	
54	5	5	5	5	
1415 55	5	5	5	5	
56	5	X	X	X	
57	5	5	5	5	
58	5	5	5	5	
59	X	5	X	X	

Betz • Converse • Murdoch • Inc. BCM

Consulting Engineers, Planners and Architects

Date 12/23/80 Location Name WHEELING-PITT STEEL

server J. BISHOP Address FOLLENSBEE, W. VA

on Point OLD COKE OVEN
UTH OF BOILER STACK
tance from 150ft Height 300'
d 0-10 Direction SW
nstallation BOILER STACK

AL

on Began 1420 Ended 1520

GREY OVERCAST

INTERFERENCE FROM STEAM PLUME

Smoke Density

Comments

	0	15	30	45
1420 0	X	5	5	X
1 WATER	5	5	5	5
2	5	5	5	5
3	5	5	5	5
4	5	5	5	5
225 5	5	5	5	5
6	X	5	5	5
7	5	5	X	5
8	5	5	5	5
8	5	5	X	X
230 10	5	5	5	5
11	X	5	X	5
12	5	5	5	5
13	5	5	5	5
14	5	5	5	5
235 15	5	X	X	X
16	5	5	5	5
17	5	5	5	5
18	5	5	5	5
19	5	5	5	5
240 20	5	5	5	5
21	5	5	5	5
22	5	5	5	5
23	5	5	5	5
24	5	5	5	5
245 25	5	5	5	5
26	5	5	5	5
27	5	5	5	5
28	5	5	5	5
29	5	5	5	5

Comments

	0	15	30	45
250 30	5	5	5	5
31	5	5	5	5
32	5	5	5	5
33	5	5	5	5
34	5	5	5	5
255 35	5	5	5	5
36	5	5	5	5
37	5	5	5	5
38	5	5	X	X
39	5	5	5	5
300 40	5	5	5	5
41	5	5	5	5
42	5	5	5	5
43	5	5	5	5
44	5	5	5	5
305 45	5	5	X	X
46	X	5	5	5
47	5	5	5	5
48	5	5	5	5
49	5	X	X	X
310 50	5	X	5	X
51	X	5	5	5
52	5	5	5	5
53	X	5	5	X
54	5	5	5	5
315 55	5	X	X	X
56	X	5	X	X
57	X	X	X	X
58	X	5	5	5
59	5	5	5	5

WHITE

Three Rivers Group

Betz • Converse • Murdoch • Inc. BCM

Consulting Engineers, Planners and Architects

Date 12-23-80 Location Name WHEELING-PITT STEEL

Observer J. BISHOP Address FOLLENSBEE, W. VA.

tion Point OLD COKE OVEN AREA
H OF BOILER STACK
stance from 150 YD Height 200'
eed 0-10 Direction SW
Installation BOILER STACK

SAL
tion Began 1520 Ended

GREY OVERCAST

X INTERFERENCE FROM STEAM PLUME

) Smoke Density

Comments

Comments

		0	15	30	45		0	15	30	45
WHITE	320 0	5	X	X	5	30				
	1	X	5	X	5	31				
	2	5	5	5	5	32				
	3	5	5	5	5	33				
	4	X	X	5	5	34				
	325 5	X	5	5	5	35				
	6	5	X	X	X	36				
	7	5	5	5	5	37				
	8	5	X	X	5	38				
	9	5	X	X	X	39				
	330 10	X	X	5	5	40				
	11	5	5	X	X	41				
	12	5	5	5	5	42				
	13	5	5	5	5	43				
	14	X	X	X	5	44				
	335 15	5	5	5	5	45				
	16	5	5	X	X	46				
	17	X	X	X	X	47				
	18	X	X	X	X	48				
	19	X	X	X	X	49				
	340 20	X	X	X	X	50				
	21					51				
	22					52				
	23					53				
	24					54				
	25					55				
	26					56				
	27					57				
	28					58				
	29					59				

PITOT CALIBRATION

Pitot No. 9-7 Date 12/10/20 Engineer DRP. JFA

Range	Run No.	ΔP_{std}	A SIDE ΔP	A SIDE C_p	A SIDE DEV.	B SIDE ΔP	B SIDE C_p	B SIDE DEV.	DIF.
1	1	.025	.03			.03			
	2	.025	.03			.03			
	3	.025	.03			.03			
	AVG.			.904			.904		.000
2	1	.17	.26	.801		.26	.801		
	2	.17	.25	.816		.26	.801		
	3	.17	.26	.801		.25	.816		
	AVG.			.806			.806		.000
3	1	.42	.63	.808		.64	.802		
	2	.42	.63	.808		.63	.808		
	3	.43	.64	.811		.64	.811		
	AVG.			.809			.807		.002
4	1	.59	.85	.825		.86	.820		
	2	.59	.85	.825		.85	.825		
	3	.59	.85	.825		.85	.825		
	AVG.			.825			.823		.002
5	1	.83	1.30	.791		1.30	.791		
	2	.83	1.30	.791		1.30	.791		
	3	.83	1.31	.789		1.30	.791		
	AVG.			.789			.791		.790
6	1	1.20	1.65	.844		1.65	.844		
	2	1.20	1.65	.844		1.66	.842		
	3	1.20	1.65	.844		1.65	.844		
	AVG.			.844			.843		.001
7	1	1.30	1.90	.819		1.88	.823		
	2	1.30	1.91	.817		1.90	.819		
	3	1.30	1.91	.817		1.90	.819		
	AVG.			.818			.820		.002

$$C_p = 0.99\sqrt{\frac{\Delta P_{std}}{\Delta P_{S}}}$$

$DEV. = C_p - \overline{C_p}$

$DEV. \leq 0.01$

$DIF. = \overline{C_{p(A)}} - \overline{C_{p(B)}}$

$DIF. \leq 0.01$

Man Orifice	CF w	CF d	T · W	IT d	OT d	Td Avg.	Time
0.5	4.998/5	5.088	58.6	67	59	63	13.50
1.0	4.997/5	5.180/4.997	58.6	83	64	73.5	9.50
2.0	10.002/10	10.556	58.6	97	72	84.5	14.13
4.0	10						
6.0	10						
8.0	10						

Date 10/25/80 Box No: 9 Inspector DES/DKP

Pump OK Oil OK Wick OK Pump Serial No. 6

Manometers OK Knobs OK Oil OK Tubing OK

Quick Connects OK Vacuum Gage OK Valves OK

Dry Gas Meter ✓ Volume 865 ft³ Serial No.

Thermometers ✓ In 58 °F Out 58 °F Ambient 58 °

Amphenol OK Lights OK Switches OK Variac OK

Leak Check - Max. Vacuum 23 in. Hg Leak Rate .000 Cf

Remarks

Pb 29.70

Tolerances:

Y = 0.99 - 1.00 - 1.

ΔH = 1.6 - 1.84 - 2.

$0.0317 \text{ (Man. orifice)} \left(\frac{(T_w + 460)^t}{CF_w}\right)$ / $P_b (OT_d + 460)$	Man.	$\Delta H_@$	$\frac{CF_w P_b (T_d \text{ avg.} + 460)}{\text{Man. orifice}}$ / $CF_d (P_b + 13.6 \quad (T_w + 460)$	Man.	Y
$0.01585 \left(\frac{(\quad + 460)\_\_\_^2}{\_\_\_}\right)$ / ____ (____ + 460)	.5	2.017	____ X ____ (____ + 460) / ____ (____ + 0.0368) (____ + 460)	.5	.989
$0.0317 \left(\frac{(\_\_\_\_ + 460)\_\_\_^2}{\_\_\_}\right)$ / ____ (____ + 460)	1.0	1.980	____ X ____ (____ + 460) / ____ (____ + 0.0737) (____ + 460)	1.0	.990
$0.0634 \left(\frac{(\_\_\_\_ + 460)\_\_\_^2}{\_\_\_}\right)$ / ____ (____ + 460)	2.0	2.156	____ X ____ (____ + 460) / ____ (____ + 0.147) (____ + 460)	2.0	.990

LABORATORY ANALYSIS AND CALCULATIONS

APPENDIX C

.0 ANALYTICAL METHOD

The following is a discussion of the methods employed by the BCM Laboratory in analyzing all samples generated during the testing program.

1.1 Moisture Content

The total volume of the impinger solution minus the original volume of reagents in the impingers plus the volume of moisture and/or vapors collected by the silica gel equalled the total moisture gain of the sampling train. This volume was used as the basis for percent moisture by volume calculations. The laboratory results of the moisture analyses appear concurrently with the results of the particulate testing program.

1.2 Particulate Samples

All glass fiber filters used in the particulate sampling program had been tare-weighed following a 24 hour desiccation period prior to their use in the field. Upon their return to the laboratory, they were again desiccated for 24 hours and reweighed to a constant weight. The weight difference was the amount of sample collected on the filter.

Nozzle, probe, and front half filter holder acetone washings were evaporated to dryness in a tared beaker. Any residue was the amount of particulate matter collected at these locations in the sampling train.

Acetone blanks were evaporated to dryness in tared beakers. Any residue which remained was a contaminant in the reagents and was considered as a blank weight in subsequent calculations. Laboratory results of the particulate sampling program are listed on page C-8 of this Appendix.

2.0 COMPUTER INPUT SHEET

The reduced data calculated from the field data sheets were combined with the laboratory results on the following Computer Input Data Sheet to facilitate programming. See page C-9 of the Appendix.

3.0 CALCULATIONS

The following series of equations were utilized to facilitate the calculations leading to the results of the test program.

3.1 Particulate/Moisture

EQUATIONS FOR PARTICULATE/MOISTURE CALCULATIONS

1. No system leakage
   $V_m\ (std) = 17.647\ (V_m)(Y)(P_{bar} + (\Delta H/13.6))/T_m$

1a. Leakage with no component change, substitute for V_m in 1.
   $V_{m1} = V_m - ((L_p - L_a)\ \theta)$

1b. Leakage with component change(s), substitute for V_m in 1.
   $V_{m2} = V_m - ((L_1 - L_a)\ \theta_1) - \sum_{i=2}^{n} ((L_i - L_a)\ \theta_i) - ((L_p - L_a)\ \theta_p)$

2. $V_{w(std)} = 0.04707\ (V_{lc})$

3. $B_{ws} = (V_{w(std)})/(V_{m(std)} + V_{w(std)})$

4. $C_a = (M_a)/((V_a)(P_a)$

5. $W_a = (C_a)\ (V_{aw})\ (P_a)$

6. $C_{sd} = 0.01543\ (M_n)/(V_{m(std)})$

7. $C_{sw} = 0.01543\ (M_n)/(V_{m(std)} + (V_{w(std)})$

8. $C_{sc} = 12\ (C_{sd})/(\%CO_2)$

9. $C_{ss} = (C_{sw})(528)(P_s)/((T_s)\ (29.92))$

10. $\%EA = 100\ (\%O_2 - 0.5(\%CO)/(0.264(\%N_2) - (\%O_2 - 0.5\ (\%CO))))$

11. $M_d = 0.44\ (\%\ CO_2) + 0.32\ (\%O_2) + 0.28\ (\%CO + \%\ N_2)$

12. $M_s = M_d\ (1-B_{ws}) + 18\ (B_{ws})$

13. $V_s = 85.49\ (C_p)\ ((\ P)^{0.5})_{avg}\ ((T_s)\ /\ P_sM_s)^{0.5}$

14. $Q_{sa} = 60\ (v_s)\ (A_s)$

15. $Q_{sd} = 1058.82\ (1-B_{ws})\ (v_s)\ (A_s)\ (P_s)/(T_s)$

16. $E_s = (Q_{sd})\ (C_{sd})\ (60)/(7000)$

17. $I = (0.0945\ (T_s)\ (V_{m(std)}))/((P_s)(v_s)(A_n)(0)(1-B_{ws}))$

LEGEND

A_s	=	Cross-sectional area of stack	ft^2
A_n	=	Cross-sectional area of nozzle	ft^2
B_{ws}	=	Water vapor in gas stream, proportion by volume	%
C_a	=	Acetone blank residue concentrations	mg/g
C_p	=	Pitot tube coefficient, dimensionless	
C_{sd}	=	Particulate concentration, dry basis	gr/DSCF
C_{sc}	=	Particulate concentration, corrected to 12% CO_2	gr/DSCF
C_{ss}	=	Particulate concentration, stack conditions	gr/ACF
C_{sw}	=	Particulate concentration, wet basis	gr/WSCF
E_s	=	Particulate emission rate	lb./hr.
I	=	Percent of isokinetic sampling	
L_1	=	Individual leakage rate, from beginning of run until first component change	cfm
L_a	=	Maximum acceptable leakage rate, 0.02 cfm or 4% average sampling rate, whichever is less	cfm
L_i	=	Individual leakage rate, between two successive component changes, beginning with second component change	cfm

L_p	=	Post test leakage rate	cfm
M_a	=	Mass of acetone residue after evaporation	mg
M_d	=	Dry molecular weight of stack gas	lb/lb-mole
M_n	=	Total collected particulate matter	mg
M_s	=	Wet molecular weight of stack gas	lb./lb-mole
P_{bar}	=	Barometric pressure at sampling site	in Hg
P_s	=	Absolute stack gas pressure	in Hg
P_{std}	=	Standard atmospheric pressure	29.92 in Hg
P_a	=	Density of acetone	mg/ml
Q_{sa}	=	Stack gas volumetric flow, stack conditions	ACFM
Q_{sd}	=	Stack gas volumetric flow, dry basis, standard	SCFM
T_m	=	Absolute average dry gas meter temperature	^oR
T_s	=	Absolute average stack gas temperature	^oR
T_{std}	=	Absolute standard temperature	528^oR
V_a	=	Volume of acetone blank	ml
V_{aw}	=	Volume of acetone used in wash	ml
V_{lc}	=	Total volume of liquid collected in impingers and silica gel	ml

V_m	=	Net test gas volume at gas meter	ft^3
$V_{m(std)}$	=	Net test gas volume at standard conditions	DSCF
v_s	=	Stack gas velocity	fps
$V_{w(std)}$	=	Volume of water vapor in gas sample, std. conditions	SCF
W_a	=	Weight of residue in acetone wash	mg
Y	=	Dry gas meter calibration factor	
%EA	=	Percent excess air	%
%CO	=	Percent carbon monoxide by volume, dry basis	%
$\%CO_2$	=	Percent carbon dioxide by volume, dry basis	%
$\%N_2$	=	Percent nitrogen by volume, dry basis	%
$\%O_2$	=	Percent oxygen be volume, dry basis	
ΔH	=	Average orifice pressure differential	in H_2O
ΔP	=	Velocity head of stack gas	in H_2O
θ	=	Total sampling time	min.
θ_1	=	Sampling time interval, from beginning of run until first component charge	min.
θ_i	=	Sampling time interval, between two successive component changes, beginning with interval between first and second changes	min.
θ_p	=	Sampling time interval, between last component change and end of test	min.

3.2 Equations for Sampling Equipment Calibration

Pitot Calibration

The pitot tubes were calibrated by measuring the velocity head in a duct with both a Type "S" pitot tube and a standard type pitot tube with a known coefficient. This was done at several different velocities. The pitot tube coefficient can be calculated:

$$C_p \text{ test} = (C_p \text{std}) \left((P_{std})/(P_{test})\right)^{0.5} \quad \text{eq. 1}$$

Where:

C_p test = Pitot tube coefficient of Type "S" pitot tube

C_p std = Pitot tube coefficient of standard type pitot tube

P_{std} = Velocity head measured by standard type pitot tube

P_{test} = Velocity head measured by type "S" pitot tube.

Dry Gas Meter and Orifice Meter

The dry gas meter and orifice were calibrated using a wet test meter. Gases were moved through the dry gas meter at Δ H's of 0.5, 1.0 and 2.0 inches of water. With the information obtained, v, the ratio of the accuracy of the wet test meter to the dry test meter, and Δ H @, the orifice differential that gives 0.75 cfm of air at 20°C and 29.92 inches of mercury, were calculated. The v has a tolerance of plus or minus 0.01 and the Δ H @ has a tolerance of plus or minus 0.15.

$$v = ((V_w)(P_b)(t_d+460))/((V_d)(P_b+H/13.6)(t_w+460))$$

Where:

P_b = Barometric Pressure

V_w = Volume wet test meter

t_d = Average temperature of dry gas meter in °F

V_d = Volume dry gas meter

t_w = Temperature wet test meter in °F

$$\Delta H@ = ((t_w+460)(\theta)/(V_w))\left((0.0317)(\Delta H)\right)/((P_b)(t_d+460))$$

Where:

θ = Time in minutes

ΔH = Manometer orifice pressure drop

Potentiometer Calibration

The Thermo Electric Potentiometers were calibrated using a known voltage source.

Table C-1

Laboratory Results*

	Run 1	Run 2	Run 3
Filter Number	D-53	D-58	D-49
Filter Final Weight	.3039	.3261	.3258
Filter Tare Weight	.2112	.2166	.2150
Front Half Acetone Wash	.0345	.0480	.0267
Impinger Gain	15	57	55
Silica Gel Number	9	12	14
Silica Gel Final Weight	212.4	212.0	213.0
Silica Gel Tare Weight	200.0	200.0	200.0
Total Front Half Particulate	.1272	.1575	.1375
Total Moisture	27.4	69.0	68.0

* All results are corrected for blanks and weights in grams

Number of Tests	3															
Test Identification	1		2		3											
Stack Area, IN^2	9161		9161		9161											
Stack Temperature, °F	333		369		358											
Sample Volume, Dry, CF	57.258		56.052		56.522											
Avg. Meter Temperature, °F	44		50		59											
Avg. Orifice (Δ H) IN H_2O	.864		.803		.826											
Nozzle, Dia. IN	.270		.270		.270											
Duration of Test, Min.	120		120		120											
CO_2	3.5		3.0		3.0											
CO	0		0		0											
O_2	16.0		17.0		16.5											
N_2	80.5		80.0		80.5											
Stack Pressure, IN Hg	30.22		30.22		30.22											
Barometric Pressure, IN. Hg	30.27		30.27		30.27											
Pitot Correction Factor	.81		.81		.81											
Pitot Traverse (Avg, $\sqrt{\Delta P}$) IN H_2O	.504		.488		.496											
Volume, H_2O Collected, ml	27.4		69.0		68.0											
Ml, SO_3	0		0		0											
Ml, SO_2	0		0		0											
Total Collected Weight, mg	127.2		157.5		137.5											
Normality of SO_3	0		0		0											
Normality of SO_2	0		0		0											
Motor Calibration Factor																

CLIENT: WP Follansbee
LOCATION: Coke Wake Boiler
JOB NO.: 00-5167-02

NAME OF FILE: WP FOLL2, UNN

AIRPOL 1 INPUT DATA SHEET

PARAMETERS		1	2	3
A OF BREECHING	(SQ IN)	9161.00	9161.00	9161.00
PLE VOLUME(DRY)	(STD CU FT)	60.18	58.21	57.69
STURE	(%)	2.0994	5.2877	5.2601
ECULAR WEIGHT	STACK GASES	28.96	28.57	28.55
TEMPERATURE	(F)	353	369	358
VELOCITY	(FPM)	1995	1986	1983
VOLUME	(SCFM)(DRY)	83477	77033	77874
VOLUME	(ACFM)	126807	126356	126126
TICULATE CONC :				
GRAINS/STD CU.	FOOT (DRY BASIS)	.0325	.0417	.0367
GRAINS/STD CU.	FOOT (WET BASIS)	.0319	.0395	.0348
GRAINS/STD CU.	FOOT 12% CO2	.1116	.1667	.1468
GRAINS/CU.	FOOT (STK COND)	.0214	.0254	.0227
POUNDS/HOUR		23.2860	27.5072	24.4978
AT ANALYSIS :				
CARBON DIOXIDE	(VOL %)	3.50	3.00	3.00
CARBON MONOXIDE	(VOL %)	.00	.00	.00
OXYGEN	(VOL %)	16.00	17.00	16.50
NITROGEN	(VOL %)	80.50	80.00	80.50
ESS AIR	(%)	304.65	412.62	347.22
KINETIC	(%)	96.18	100.82	98.83

PROCESS DATA

APPENDIX D

TEST	#5	#6	#7		12/22/80
T. CAP.	15,000/a	55,000	55,000		START TEST @ 1:13 P.M
	14,000/05	50,000/6	50,000		@ 1:15 PM
	14,000	49,000	49,000		@ 2:15 PM
	14,500	49,000	49,000		@ 3:15
	14,000	51,000	50,000		@ 4:15

TEST	#5	#6	#7	
23-80				START TEST @ 9:10 A.M.
. CAP.	15,000#	55,000#	55,000	
OUCING	14,000	50,000	52,000	@ 9:15
"	14,000	49,000	49,000	@ 10:15
"	14,000	49,500	50,000	@ 11:15
"	14,000	49,000	50,000	@ 12:15

TEST	#5	#6	#7	
				START TEST @ 1:22 P.M.
. CAP.	15,000	55,000	55,000	
	14,000	51,000	52,000	@ 1:25
"	14,500	52,000	51,000	@ 2:25
"	14,000	50,000	52,000	@ 3:25
"	14,000	49,000	50,000	@ 3:55