Bethlehem Steel Corporation
Bethlehem, Pennsylvania

Compliance Particulate Emission Determination of the Coal Crusher Rotoclone and Coke Screening Stacks

January 1992

BCM
Engineers, Planners, Scientists
and Laboratory Services

REPORT

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1.0 INTRODUCTION

The Bethlehem Steel Corporation (BCS) operates a coal crusher and a coke screening facility at the coke works of its Bethlehem, Pennsylvania facility. The Pennsylvania Department of Environmental Resources (PADER) conducted a particulate emissions test of the Rotoclone in May 1991, which indicated emission in excess of the allowable rate of 0.04 grains per dry standard cubic foot (dscf). BCM was retained by the Bethlehem Steel Corporation to conduct a particulate emission re-test of the Rotoclone and particulate emission testing of the East Coke Screening Station.

The actual particulate emission concentrations determined from each test run for each source are shown in Table 2.

2.0 SCOPE AND OBJECTIVES

The scope of the project was outlined in BCM Proposal No. 10-8460-00R dated November 22, 1991. The objectives of the sampling program were to determine the following parameters:

- Gas flow - acfm and scfm
- Gas temperature - °F
- Moisture - percent by volume
- Gas analysis - percent by volume - CO_2, O_2, N_2 (by difference)
- Particulate emissions - grains/dscf and lb/hr

3.0 PROCEDURES

3.1 FIELD WORK

Field testing was conducted on December 2 through December 6, 1991. the sampling team consisted of the following BCM personnel:

Nick Charno	Technician IV
Andrew Lavin	Engineer
Brendon McGillicuddy	Technician III

Larry Krieger of Bethlehem Steel acted as liaison between BCM and Bethlehem Steel and ensured process operating conditions were suitable for testing.

Emission testing was conducted according to procedures as outlined in U.S. Environmental Protection Agency (EPA) Reference Methods 1 through 5 found in the Federal Register, Volume 42, Number 160. The testing procedures also met the PADER requirements as outlined in the Agency's Bureau of Air Quality Control. "Source Testing Manual." Descriptions of these methodologies can be found in Appendix A of this report.

3.2 ANALYTICAL METHODS

All sample generated during the sampling program were analyzed by Air Quality Services, Inc. of Pittsburgh, Pennsylvania. An outline of the analytical methodologies is contained in Appendix B. Laboratory data are also presented in Appendix B.

3.3 CALCULATIONS

A personal computer, programmed to accept input in accordance with EPA calculation procedures, was used to perform all calculations. The reduced data appear on the computer input and output sheets which are presented in Appendix B. Appendix B also lists the equations used to determine the test results.

3.4 EQUIPMENT CALIBRATION

In accordance with accepted procedures published by the EPA, all gas velocity measuring equipment, gas volume metering equipment, and temperature measuring equipment had been calibrated within 60 days of the test program. Appendix C contains calibration data.

4.0 TEST RESULTS

4.1 GAS FLOW RATE DATA

All gas flow rate data obtained during the particulate test runs can be found in Table 1.

4.2 PARTICULATE EMISSION RESULTS

Particulate emission results of the three test runs are contained in Table 2. The allowable particulate emission rate for each source is also contained in Table 2.

TABLE 1

GAS FLOW RATE DATA

Process	Run No.	Stack Gas Temperature (F°)	Moisture Content (%)	Gas Velocity (ft/min)	Gas Flow Rate (dscfm)
Coal Crusher	1	55.9	1.50	4,640	43,800
	2	58.3	1.52	4,720	43,800
	3	54.9	1.13	4,780	45,200
	Avg.	56.4	1.38	4,710	44,300
Coke Screening	1	51.1	1.20	3,530	33,900
	2	50.4	0.510	3,320	36,500
	3	54.6	1.31	3,460	34,200
	Avg.	52.0	1.01	3,440	34,900

TABLE 2

PARTICULATE EMISSION RESULTS

Run No.	Coal Crusher			East Coke Screening		
	Allowable (gr/dscf)	Actual (gr/dscf)	Actual (lb/hr)	Allowable (gr/dscf)	Actual (gr/dscf)	Actual (lb/hr)
1	0.04	0.0266	10.0	0.02	0.0125	3.64
2	0.04	0.0256	9.60	0.02	0.0066	1.87
3	0.04	0.0275	10.7	0.02	0.0226	6.61
Avg.	---	0.0266	10.1	---	0.0139	4.04

5.0 DISCUSSION OF RESULTS

5.1 EAST COKE SCREENING STATION

Test results for the East Coke Screening Station Run No. 3 show that the actual particulate emissions exceeded the allowable emission standard by 13 percent. An analysis of the particulate distribution for Run No. 3 (see Table B-3 in the appendix) reveals an uncharacteristically high front half catch. However, there is no reason to doubt the laboratory analysis at this time.

The first two runs resulted in concentrations well below the maximum allowable concentration of 0.02 gr/dscf. The average concentration for all three runs was only 0.0139 gr/dscf, well below the permissible level.

5.2 COAL CRUSHER ROTOCLONE

All of the test runs at the Coal Crusher Rotoclone resulted in particulate concentrations below the allowable standard for this source, 0.04 gr/dscf.

APPENDIX A

FIELD SAMPLING PROGRAM

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APPENDIX A

FIELD SAMPLING PROGRAM

1.0 SAMPLING PROCEDURES

1.1 Test Station and Traverse Location

The internal diameter of the scrubber outlet stack was 60 inches. Two test ports were located in the same cross sectional plan 90 degree apart. The nearest downstream flow disturbance was located 44 feet, or 8.8 duct diameters, from the testing ports. The nearest upstream flow disturbance was the stack outlet and it was located 10 feet, or 2 duct diameters, from the testing ports. A total of 12 traverse points (6 per port) were utilized for the testing program.

1.2 Gas Flow and Temperature Determinations

The gas flow rate and temperature profiles were measured by conducting a simultaneous velocity and temperature traverse. Gas velocity heads were measured with a "S"-type pitot tube, which was connected to an inclined manometer. A Chromel-Alumel thermocouple connected to a potentiometer was used to determine the gas temperature.

1.3 Moisture Content

Moisture sampling was conducted employing the principles presented in EPA Method 4 and concurrently with particulate sampling. The parameters evaluated to determine the gas stream's 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 4 train to allow for concurrent sampling of particulate and moisture content. These modifications did not deviate from sampling principles.

Modifications, such 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.

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1.4 Particulate Sampling

The sampling procedures and sampling equipment used were those outlined in Method 5 of the Federal Register, Volume 42, No. 160, August 18, 1977. This methodology also complied with PADER testing regulations.

The size of the nozzle required to maintain isokinetic sampling was calculated from the results of a previously completed velocity and temperature traverse. The sampling train used a glass-lined stainless steel probe, heated to 250°F by an internal heating element. A nozzle of the calculated size was attached to the end of the probe, which was inserted into the stack. A "S"-type pitot tube and a Chromel-Alumel thermocouple were clamped to the probe and were used to monitor the velocity head and temperature at the traverse points during the sampling period. Sampled 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 with the temperature maintained at 248°F ±25°F. From the filter, the stack gas passed to the impinger train. The first two impingers each contained 150 milliliters (ml) of deionized (DI) water. The third impinger contained no reagents and was a knockout impinger. The fourth impinger contained approximately 200 grams of coarse silica gel, which collected any moisture and/or vapors that had not been captured in the preceding impingers.

The second impinger was a 500-ml Greenburg-Smith impinger, while the first, third, and fourth impingers were 500-ml impingers of the Greenburg-Smith design, modified by replacing the tip with a 1/2-inch inside diameter (ID) glass tube. The impinger train was immersed in an ice bath for the entire test period so that the exiting gas temperature would not exceed 68°F.

From the impinger train, the gas was conducted through an umbilical cord to the control console (an Andersen Universal Stack Sampler), which contained the following pieces of equipment (listed in the order in which sampled gas pass through them): a main valve, a bypass valve for flow adjustment, an airtight vacuum pump, a dry gas meter, and a calibrated orifice. The orifice was equipped with pressure taps which were connected across the inclined manometer used to ensure that isokinetic conditions were maintained. A schematic diagram of the sampling train appears at the end of this appendix.

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The sampling train was checked for leaks before and after each sample run. The inlet of the nozzle was plugged and the pump vacuum was held at the highest vacuum attained during that period of testing. In all cases the leakage rate was minimal and did not exceed the maximum allowable leakage rate of 0.02 cubic feed per minute (cfm).

Upon completion of a test, the soiled glass fiber filter was removed from its filter holder and placed in a petri dish, which was subsequently sealed. The probe and nozzle were washed internally, first with DI water and then with acetone. The particulate matter remaining in the probe was removed with a nylon brush attached to a polyethylene line. The front half of the glass filter holder was also rinsed with distilled water and acetone. The washings obtained were added to those collected from the nozzle and the probe. All distilled water and acetone washings were stored in separate sealed polyethylene sample bottles.

The silica gel used in the fourth impinger was removed, placed in its sample bottle, and a final weight was obtained. The contents of the first, second, and third impingers were combined, measured volumetrically, and placed in sealed sample bottles. The impingers were finally rinsed with acetone and the washings placed in separate bottles.

All test program samples, as well as blanks of the distilled water and acetone used during the testing, were submitted to Air Quality Services Inc. for analysis.

1.5 Molecular Weight Determination

An Orsat gas analyzer was used to determine the molecular weight of the exhaust gas at the scrubber outlet. The following parameters were measured in order to calculate molecular weight: volume percent carbon dioxide (CO_2) and volume percent oxygen (O_2). Volume percent nitrogen (N_2) was determined by difference.

2.0 FIELD DATA SHEETS

The flue gas velocity head, flue gas temperature, inlet and outlet dry gas meter temperatures, orifice pressure differential, sample volume, sampling time, pump vacuum, filter temperature, and the impinger train outlet gas temperature were recorded during the sampling program. The field data sheets generated during the program follow.

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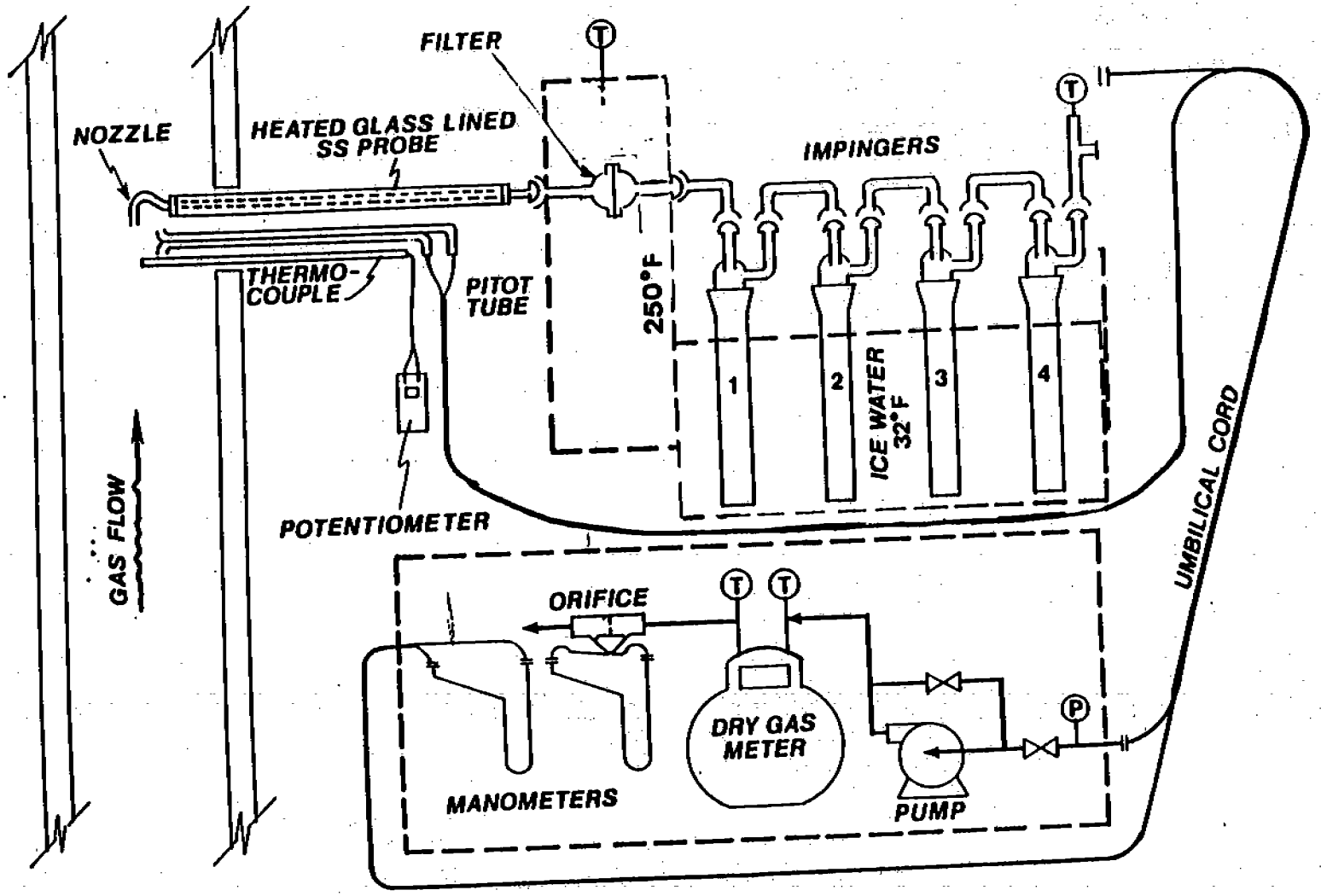

Figure 1
EPA Method 5

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NOMOGRAPH DATA

PLANT Bethlehem Steel

DATE 12-2-91

SAMPLING LOCATION COAL CRUSHER

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	1.80
AVERAGE METER TEMPERATURE (AMBIENT + 20 °F), °F	$T_{m_{avg.}}$	80
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B_{wo}	27%
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	30.02
STATIC PRESSURE IN STACK, in. Hg ($P_m \pm 0.073$ x STACK GAUGE PRESSURE in in. H_2O)	P_s	
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	
AVERAGE STACK TEMPERATURE, °F	$T_{s_{avg.}}$	60
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	1.94
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	
C FACTOR		1.0
CALCULATED NOZZLE DIAMETER, in.		.170
ACTUAL NOZZLE DIAMETER, in.		.190
REFERENCE Δp, in. H_2O		1.3

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VELOCITY DETERMINATIONS

Client: Bethlehem Steel

Location: Coal Crusher

Date: 12-2-91

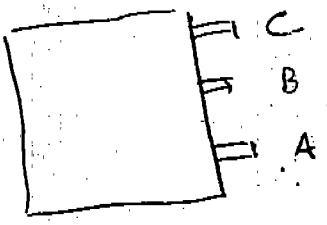
Stack Pressure: +1.0"

Barometric Pressure: 30.07

Pitot Factor: .84

Engineer: NC

Sample Port Location:



Pitot/Temperature Readings

Point No.	Distance (Inches)	Port A		Port B		Port C		Port__		Port__	
		ΔP	T	ΔP	T	ΔP	T	ΔP	T	ΔP	T
1		2.2	59.8	1.5	60.4	1.3	60.2				
2		2.2	60.2	1.6	60.2	1.6	60.2				
3		2.1	60.0	1.7	60.2	1.7	60.5				
4		2.3	59.8	2.2	60.6	1.8	60.2				
5		2.8	60.4	2.5	60.5	1.6	59.8				
		ΔP = 1.94									
		$\sqrt{\Delta P}$ = 1.385									
		T_s = 60.2									
TOTAL											
AVG.											

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TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

Particulate

PLANT Beth Steel
DATE 12-2-91
SAMPLING LOCATION COAL CRUSHER
INSIDE OF FAR WALL TO
OUTSIDE OF NIPPLE. (DISTANCE A) _____
INSIDE OF NEAR WALL TO
OUTSIDE OF NIPPLE. (DISTANCE B) _____
STACK I.D.. (DISTANCE A - DISTANCE B) _____
NEAREST UPSTREAM DISTURBANCE _____
NEAREST DOWNSTREAM DISTURBANCE _____
CALCULATOR _____

SCHEMATIC OF SAMPLING LOCATION

TRAVERSE POINT NUMBER	FRACTION OF STACK I.D.	STACK I.D.	PRODUCT OF COLUMNS 2 AND 3 (TO NEAREST 1 / 8 INCH)	DISTANCE B	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5)
			2"	5 1/4	7 1/4
1			6		11 1/4
2			10		15 1/4
3			14		19 1/4
4			18		23 1/4
5			22		27 1/4
6			26		31 1/4
7			28		33 1/4
8					

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TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

Velocity

PLANT Beth Steel
DATE 12-2-91
SAMPLING LOCATION COAL CRUSHER
INSIDE OF FAR WALL TO OUTSIDE OF NIPPLE. (DISTANCE A) _____
INSIDE OF NEAR WALL TO OUTSIDE OF NIPPLE. (DISTANCE B) _____
STACK I.D.. (DISTANCE A - DISTANCE B) _____
NEAREST UPSTREAM DISTURBANCE _____
NEAREST DOWNSTREAM DISTURBANCE _____
CALCULATOR _____

SCHEMATIC OF SAMPLING LOCATION

TRAVERSE POINT NUMBER	FRACTION OF STACK I.D.	STACK I.D.	PRODUCT OF COLUMNS 2 AND 3 (TO NEAREST 1/8 INCH)	DISTANCE B	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5)
1			3 3/16	5 4/16	8 7/16
2			9 9/16		14 13/16
3			15 15/16		21 3/16
4			22 5/16		27 9/16
5			28 11/16		33 15/16

PLANT Bethlehem Steel
DATE 12-3-91
SAMPLING LOCATION COAL CRUSHER
SAMPLE TYPE
RUN NUMBER 1 OPERATOR NC
BAROMETRIC PRESSURE 30.02 STATIC PRESSURE
FILTER NUMBER(S)
GEL NUMBER(S) +20.8
THIMBLE NUMBER PLATE NUMBER
H_2O PICKUP (ml) +5 ml

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ORSAT:
CO_2 0, 0
O_2 21.0, 21.0
CO

PYROMETER NUMBER
THERMOCOUPLE NUMBER
PROBE NUMBER TYPE
NOZZLE NUMBER Metal SS I.D. .190
METER BOX NUMBER 420 $\Delta H_@$ 1.800
PITOT NUMBER C_p
SAMPLE BOX NUMBER(S)
ASSUMED MOISTURE (%) 2.7
ASSUMED METER TEMPERATURE
C FACTOR 1.0 REFERENCE Δp 1.3

READ AND RECORD ALL DATA EVERY 05 MINUTES 03

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 / 834	558.748				(3.1)					
A 1	05 / 839	562.9	2.1	2.5	2.5	49	52	41	9	250	38
2	10 / 844	567.6	2.1	2.5	2.5	49	70	45	9	250	40
3	15 / 849	572.2	2.1	2.5	2.5	49	74	50	9	250	46
4	18 / 852	574.8	2.0	2.8	2.8	49	80	53	8	250	46
5	21 / 855	577.3	2.3	3.3	3.3	49	82	53	8	250	46
6	24 / 858	580.8	2.2	3.2	3.2	49	89	57	10	250	46
7	/ 900	581.888	power failure								
7	24 / 902	"	2.5	3.5	3.5	49	87	61	12	250	46
8	27 / 905	585.1	2.7	3.8	3.8	49	89	62	12	250	46
8	30 / 908	588.588	2.7	3.8	3.8	49	89	62	12	250	
		change ports									
B	30 / 919	588.588	1.5	2.1	2.1	60	62	60	7	270	47
1	33 / 922	591.2	1.6	2.3	2.3	60	74	60	8	290	47
2	36 / 925	594.1	1.6	2.3	2.3	60	80	60	8	280	47
3	39 / 928	597.0	1.7	2.4	2.4	60	85	61	9	260	47
4	42 / 931	599.2	1.9	2.7	2.7	60	88	62	10	260	47
5	45 / 934	601.8	2.5	3.5	3.5	60	89	63	10	240	47
6	48 / 937	606.0	2.5	3.5	3.5	60	92	65	11	260	47
7	51 / 940	609.1	2.5	3.5	3.5	60	94	66	12	260	47
8	54 / 943	612.788									

.83 CF/M x MMS = SCFM

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PLANT Bethlehem DATE 12-3-91 RUN NUMBER COM CRUSHER RUN 2

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			
	54	949	612.288									
C 1	57	952	615.1	1.5	2.1	2.1	60	68	65	7	260	47
2	60	955	617.4	1.5	2.1	2.1	60	82	65	7	270	45
3	63	958	619.5	1.7	2.4	2.4	60	84	65 87	7	270	45
4	66	1001	622.160	1.7	2.4	2.4	60	85	66	7	270	45
			stop test ; trunk									
	66	1036	622.160									
C 5	69	1039	625.2	1.7	2.4	2.4	60	66	55	8	270 260	45 45
6	72	1042	627.7	1.7	2.4	2.4	60	68	55	8		
7	75	1045	631.0	1.8	2.6	2.6	60	86	58	8	260	45
8	78	1048	634.336	1.8	2.6	2.6	60	84	58	8	260	45
			stop end test @ 15" Hg = .01 CFM									

PLANT Bethlehem Steel
DATE 12-3-91
SAMPLING LOCATION COAL CRUSHER
SAMPLE TYPE PM PTCLT
RUN NUMBER PM10 OPERATOR NC
BAROMETRIC PRESSURE 29.54 STATIC PRESSURE
FILTER NUMBER(S)
GEL NUMBER(S) +14.3
THIMBLE NUMBER PLATE NUMBER
H_2O PICKUP (ml) + 8 ml

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ORSAT:
CO_2 1.9
O_2 20.6, 20.8
CO

PYROMETER NUMBER
THERMOCOUPLE NUMBER
PROBE NUMBER TYPE
NOZZLE NUMBER S I.D. .190
METER BOX NUMBER 420 $\Delta H_@$ 1.80
PITOT NUMBER S C_p .84
SAMPLE BOX NUMBER(S)
ASSUMED MOISTURE (%)
ASSUMED METER TEMPERATURE
C FACTOR 1.0 REFERENCE Δp 1.3

READ AND RECORD ALL DATA EVERY 03 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	1329	634.816									
A 1	03	1332	637.8	2.0	2.9	2.9	58	48	48	7	260	42
2	06	1335	641.0	1.9	2.8	2.8	58	64	48	7	280	42
3	09	1338	644.0	2.2	3.2	3.2	59	70	49	7	280	42
4	12	1341	646.4	2.2	3.2	3.2	58	74	50	7	260	42
5	15	1344	649.6	2.1	3.0	3.0	58	67	52	7	260	42
6	18	1347	653.5	2.3	3.3	3.3	58	80	54	8	250	42
7	21	1350	655.7	2.3	3.3	3.3	58	84	56	8	270	42
8	24	1353	658.703	2.6	3.7	3.7	58	88	71	9	270	42
			change point									
	24	1357	658.703									
B 1	27	1400	661.3	1.7	2.4	2.4	58	68	51	6	260	42
2	30	1403	663.9	1.7	2.4	2.4	59	92	60	6	290	42
3	33	1406	666.6	1.7	2.4	2.4	58	86	61	6	290	42
4	36	1409	669.5	1.8	2.6	2.6	58	87	61	6	290	42
5	39	1412	672.3	2.0	2.9	2.9	58	90	63	7	290	42
6	42	1415	676.0	2.2	3.2	3.2	59	92	64	7	290	42
7	45	1418	678.0	2.6	3.7	3.7	58	92	64	7	290	42
8	48	1421	681.885	2.7	3.8	3.8	58	94	63	9	250	43

PLANT Beth DATE 12-3-91 RUN NUMBER Coal Crusher Run 2

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft³	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			
	48 / 1425	681.885									
C 1	51 / 1428	684.1	1.6	2.3	2.3	58	75	65	5	270	43
2	54 / 1431	687.0	1.6	2.3	2.3	58	84	65	5	270	43
3	57 / 1434	689.6	1.7	2.4	2.4	58	88	69	6	270	43
4	60 / 1437	692.4	1.7	2.4	2.4	59	90	66	6	270	43
5	63 / 1440	695.1	1.7	2.4	2.4	59	91	66	6	270	44
6	66 / 1443	697.8	1.7	2.4	2.4	59	93	72	6	270	43
7	69 / 1446	700.9	1.8	2.6	2.6	59	93	67	6	270	43
8	72 / 1449	703.522	1.8	2.6	2.6	59	92	68	6	270	43

end test : leak check @ 15" Hg = .005 CFM

PLANT Bethl Steel
DATE 12-4-97
SAMPLING LOCATION Coal Crusher
SAMPLE TYPE PA PTCLT
RUN NUMBER THREE OPERATOR NC
BAROMETRIC PRESSURE 29.45 STATIC PRESSURE
FILTER NUMBER(S)
GEL NUMBER(S) +16.7
THIMBLE NUMBER PLATE NUMBER
H_2O PICKUP (ml) 0

BCM

ORSAT:
CO_2 0.0
O_2 21.0, 20.8
CO

PYROMETER NUMBER
THERMOCOUPLE NUMBER
PROBE NUMBER TYPE
NOZZLE NUMBER 55 I.D. .190
METER BOX NUMBER 420 $\Delta H_@$ 1.80
PITOT NUMBER C_p .84
SAMPLE BOX NUMBER(S)
ASSUMED MOISTURE (%) 3%
ASSUMED METER TEMPERATURE
C FACTOR 1.0 REFERENCE Δp 1.3

READ AND RECORD ALL DATA EVERY 03 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 DESIRED	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
	00 / 0818	704.153									
A 1	03 / 0815	708.0	2.3	3.3	3.3	54.8	55	55	4	300	38
2	06 / 0818	710.6	2.3	3.3	3.3	55	74	55	4	300	38
3	09 / 0821	713.8	2.4	3.4	3.4	55	78	56	4	290	36
4	12 / 0824	716.6	2.3	3.3	3.3	55	83	57	4	280	36
5	15 / 0827	719.9	2.3	3.3	3.3	55	84	59	4	250	36
6	18 / 0830	722.8	2.4	3.4	3.4	55	87	60	4	240	36
7	21 / 0833	726.2	2.4	3.4	3.4	55	88	61	4	260	36
8	24 / 0836	729.144	2.5	3.5	3.5	55	90	63	4	260	36
B 1	24 / 0840	729.144									
1	27 / 0843	732.2	1.8	2.6	2.6	54	72	64	3	240	37
2	30 / 0846	734.9	1.8	2.6	2.6	54	84	65	3	250	37
3	33 / 0849	737.9	1.8	2.6	2.6	55	88	66	3	250	36
4	36 / 0852	740.9	1.9	2.7	2.7	55	90	66	3	250	36
5	39 / 0855	744.0	2.0	2.9	2.9	55	92	67	3	250	36
6	42 / 0858	747.0	2.3	3.3	3.3	55	94	68	4	250	36
7	45 / 0901	749.6	2.5	3.5	3.5	55	94	69	4	250	36
8	48 / 0904	752.816	2.7	3.8	3.8	55	94	69	4	250	36

PLANT Bethlehem Steel DATE 12-4-91 RUN NUMBER PA PTCLT COAL CRUSHER RUN 3

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			
	48 / ~~0923~~	752.816									
C 1	51 / 0911	755.7	1.6	2.3	2.3	55	73	68	3	280	38
2	54 / 0914	758.3	1.6	2.3	2.3	55	87	69	3	280	37
3	57 / 0917	760.9	1.7	2.4	2.4	55	90	69	3	280	38
4	60 / 0920	763.6	1.7	2.4	2.4	55	92	70	3	280	38
5	63 / 0923	766.5	1.8	2.6	2.6	55	93	70	3	280	36
6	66 / 0926	769.2	1.8	2.6	2.6	55	95	71	3	280	36
7	69 / 0929	772.3	1.8	2.6	2.6	55	93	72	3	280	36
8	72 / 0932	774.996	1.9	2.7	2.7	55	98	73	3	280	37
		end test; post test leak check @ 15" Hg = .01 CFM									

Betz • Converse • Murdoch • Inc. BCM

NOMOGRAPH DATA

PLANT Bethlehem Steel

DATE 12-4-91

SAMPLING LOCATION EAST COKE SCREENING

420

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	1.80
AVERAGE METER TEMPERATURE (AMBIENT + 20°F), °F	$T_{m_{avg.}}$	50
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B_{wo}	2.3
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	29.52
STATIC PRESSURE IN STACK, in. Hg ~~29.92~~ 29.52 ($P_m \pm 0.073$ x STACK GAUGE PRESSURE in in. H_2O)	P_s	29.59
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	
AVERAGE STACK TEMPERATURE, °F	$T_{s_{avg.}}$	54
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	1.09
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	1.50
C FACTOR		1.0
CALCULATED NOZZLE DIAMETER, in.		0.20
ACTUAL NOZZLE DIAMETER, in.		0.190
REFERENCE Δp, in. H_2O		1.20

Betz • Corvus Murdoch • Inc. BCM

VELOCITY DETERMINATIONS

Client: Bethlehem Steel

Location: Coke Screening East

Date: 12-4-91

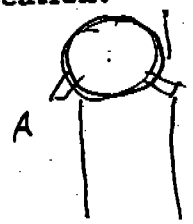
Stack Pressure: +.90

Barometric Pressure: 29.52

Pitot Factor: NC

Engineer: SY

Sample Port Location:



Pitot/Temperature Readings

Point No.	Distance (Inches)	Port A		Port B		Port__		Port__		Port__	
		ΔP	T	ΔP	T	ΔP	T	ΔP	T	ΔP	T
		.65	51	.52	52						
		1.40	52	.90	54						
		1.50	52	1.20	55						
		1.20	53	1.40	56						
		1.10	54	1.30	56						
		.80	53	1.10	56						
		$\overline{\Delta P}$ = 1.092 ✓									
		T_s = 54									
TOTAL											
AVG.											

776 / 39   1.13 80

60.5

BCM

PLANT: Bethlehem Steel
DATE: [illegible]
SAMPLING LOCATION: Coke Screening: East
SAMPLE TYPE: PA PCLY
RUN NUMBER: ONE
OPERATOR: NC
BAROMETRIC PRESSURE: 29.52
STATIC PRESSURE: +.90
FILTER NUMBER(S):
GEL NUMBER(S): +13.9
PLATE NUMBER:
THIMBLE NUMBER:
[illegible] (ml): 0

ORSAT:
CO_2: 6.6
O_2: 21.0, 21.0
CO:

[illegible] NUMBER:
[illegible] NUMBER:
[illegible] NUMBER: — TYPE:
NOZZLE NUMBER: 55 — I.D.: .190
METER BOX NUMBER: 470 — $\Delta H_@$: 1.80
PITOT NUMBER: — C_p:
SAMPLE BOX NUMBER(S):
ASSUMED MOISTURE (%): 2.3
ASSUMED METER TEMPERATURE:
C FACTOR: 1.0 — REFERENCE Δp: 1.2

READ AND RECORD ALL DATA EVERY 6 MINUTES

SAMPLING TIME, min	CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
0	1333	776.784	0.80	1.2	1.2	57	45	40	3	250	29
6	1339	780.6	0.98	1.5	1.5	55	61	42	4	280	29
12	1346	784.5	1.20	1.9	1.9	55	64	43	5	270	29
18	1351	789.0	1.10	1.9	1.9	56	70	46	5	270	29
24	1357	793.7	1.40	2.2	2.2	56	71	49	5	270	29
30	1403	798.4	1.40	2.2	2.2	56	74	51	5	270	29
36	1409	802.965									
		stop test change ports									
36	1529	802.965	.74	1.2	1.2	46	37	37	4	300	56
42	1534	807.0	.85	1.4	1.4	45	58	39	4	300	58
48	1540	811.0	1.10	1.7	1.7	45	67	42	5	295	[illegible]
54	1546	815.5	1.40	2.2	2.2	45	73	44	6	290	[illegible]
60	1552	820.2	1.40	2.2	2.2	45	79	49	6	290	[illegible]
66	1558	825.2	1.60	[illegible]	[illegible]	52	85	54	6	290	50
72	1604	829.652									
		end: post test leak check [illegible]									

TYPE
I.D. ~~.190~~ .190
$\Delta H_@$ ~~1.80~~ 1.80
C_p .84

[illegible] DA [illegible]
[illegible] TWD [illegible]
BAROMETRIC PRESSURE 30.?8 STATIC PRESSURE -.90
[illegible] NUMBER(S)
[illegible] NUMBER(S) 9.0
THIMBLE NUMBER PLATE NUMBER
H_2O PICKUP (ml) -3

CO_2 [illegible]
O_2 21.0, 21.0
CO

[illegible] NUMBER 420
[illegible] NUMBER
SAMPLE BOX NUMBER(S)
ASSUMED MOISTURE (%)
ASSUMED METER TEMPERATURE 50
REFERENCE Δp 1.2
C FACTOR 1.0

READ AND RECORD ALL DATA EVERY 07 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
	00	918	830.038	0.70	1.1	1.1	49	39	36	3	250	35
	07	925	834.3	.80	1.3	1.3	49	50	38	3	250	35
	14	932	838.0	1.20	1.9	1.9	49	63	40	5	250	35
	21	939	843.1	1.20	1.9	1.9	50 49	65	42	5	250	35
	28	946	849.0	1.30	2.0	2.0	47	68	46	5	250	38
	35	953	854.6	1.10	1.7	1.7	53	69	48	4	250	38
	40	900	859.248									
								43	42	4	240	39
	[illegible]	912	859.248	.95	1.3	1.3						
	[illegible]	919	863.2	1.10	1.7							
	[illegible]	926		STOP	[illegible]							
5	[illegible]	923	[illegible]							22	[illegible]	37
				1.10	1.7	1.7		62	[illegible]	22	[illegible]	39
6	53	932		1.10	1.7	1.7	51	54	42	20	[illegible]	
5	56	935	[illegible]	1.10	1.7	1.7	52	66	43	20	[illegible]	
4	63	942	872.?	1.20	1.9	1.9	58	67	46	9	250	
3	70	949	877.8	0.95	1.5	1.5	52	73	49	8	250	
2	77	956	882.8	0.90	1.4	1.4	52	71	50			
1	84	1003	887.568									

post test leak check @ 25" Hg = .01 CFM

PLANT [illegible]

DATE [illegible]

SAMPLING LOCATION [illegible]

SAMPLE TYPE PA [illegible]

RUN NUMBER THREE

OPERATOR NC

BAROMETRIC PRESSURE 29.9 / 30.54

STATIC PRESSURE

FILTER NUMBER(S)

GEL NUMBER(S) 14.9

THIMBLE NUMBER

PLATE NUMBER

[illegible] +27

CO2 [illegible]

O2 21.0

CO

PYROMETER NUMBER

THERMOCOUPLE NUMBER

PROBE NUMBER

TYPE

NOZZLE NUMBER 35

I.D. .190

METER BOX NUMBER 420

$\Delta H_@$ 1.80

PITOT NUMBER

C_p .84

SAMPLE BOX NUMBER(S)

ASSUMED MOISTURE (%) 2.3

ASSUMED METER TEMPERATURE

C FACTOR 1.0

REFERENCE Δp 1.2

READ AND RECORD ALL DATA EVERY 07 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH, in. H_2O) DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m_{in}}$), °F	OUTLET ($T_{m_{out}}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
[illegible]	0	1134	887.825				54	45	39	5	250	55
[illegible]	7	1141	891.9	.75	1.5	1.5	54	61	41	6	250	52
[illegible]	14	1148	897.1	1.10	1.8	1.8	54	68	44	6	260	52
[illegible]	21	1155	902.8	1.30	2.0	2.0	55	74	48	7	270	53
[illegible]	28	1202	907.7	1.30	2.0	2.0	55	76	53	5	270	53
[illegible]	35	1209	913.0	1.10	1.8	1.8	55	77	54	5	270	[illegible]
[illegible]	42	1216	918.277	1.00	1.6	1.6	55					
			change ports									
[illegible]	42	1230	918.277				52	52	51	4	225	
[illegible]	49	1237	923.8	.70	1.1	1.1	52	67	52	4	250	[illegible]
[illegible]	56	1243	926.8	.90	1.4	1.4	54	74	54	5	250	
[illegible]	63	1249	932.1	1.20	1.9	1.9	57	79	56	6	250	
[illegible]	70	1256	936.7	1.40	2.2	2.2	57	82	58	6	250	
5	77	1303	942.6	1.40	2.2	2.2	56	82	59	4	250	
6	84	1310	947.663	1.00	1.6	1.6						

post test leak check @ 10" Hg = .005 CFM

METHOD 2

STACK GAS VELOCITY CALCULATIONS

Plant Bethlehem Steel

Date

Test No.

Area of stack (ft^2) = A = 9.33 ft^2

note $A = \pi r^2$ when r is in feet or $A = \pi (\frac{r}{12})$ when r is in inches

Pitot tube coefficient, type S = C_p = .84

Absolute temperature (average) of stack (°F + 460) = T_s = 520.2

Average of square root of velocity head (in H_2O)$^{\frac{1}{2}}$ = $\sqrt{\Delta p}$ = 1.385

Absolute pressure of stack gas in Hg 30.02 = P_s = 30.09

note P_s = Barometric pressure (in. Hg) ± [gauge pressure (in. H_2O)/13.6]

Water vapor in gas stream, proportion by volume = B_{ws} = 2.7

Molecular weight of stack gas (lbs/lb mole) = M_s = 28.55

note $M_s = M_d (1 - B_{ws}) + 18 B_{ws}$

V_s = stack gas velocity (f.p.s.)

$$V_s = 85.49 \times C_p \times \sqrt{\frac{T_s}{P_s \times M_s}} \times (\sqrt{\Delta p})ave$$

.84 $\sqrt{\frac{520}{30.09(28.55}}$ 77.39 f/s

V_s = 85.49 x ____ x $\sqrt{\frac{}{x}}$ x ____ = ____ ft/sec

Q_{sd} = volumetric flow rate (dscf/hr)

$$Q_{sd} = 3600 \times (1 - B_{ws}) V_s \times A \times (\frac{528}{T_s}) \times (\frac{P_s}{29.92})$$

Q_{sd} = 3600 x (1 - ____) x ____ x ($\frac{528}{}$) x ($\frac{}{29.92}$) = ____ dscf/hr

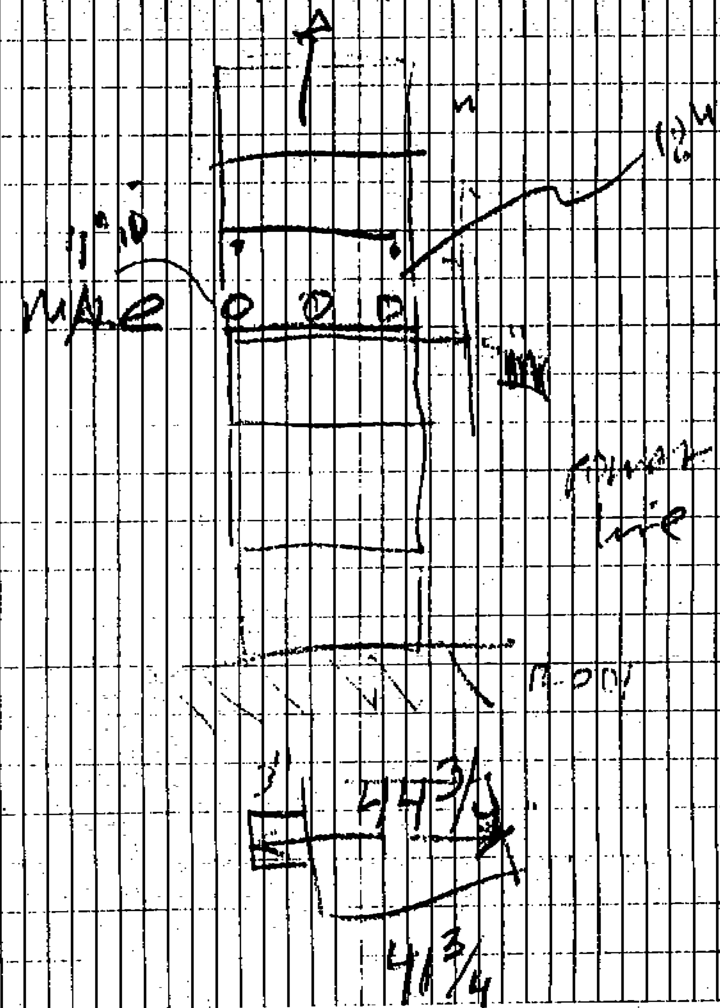
2581701.366 dscfH

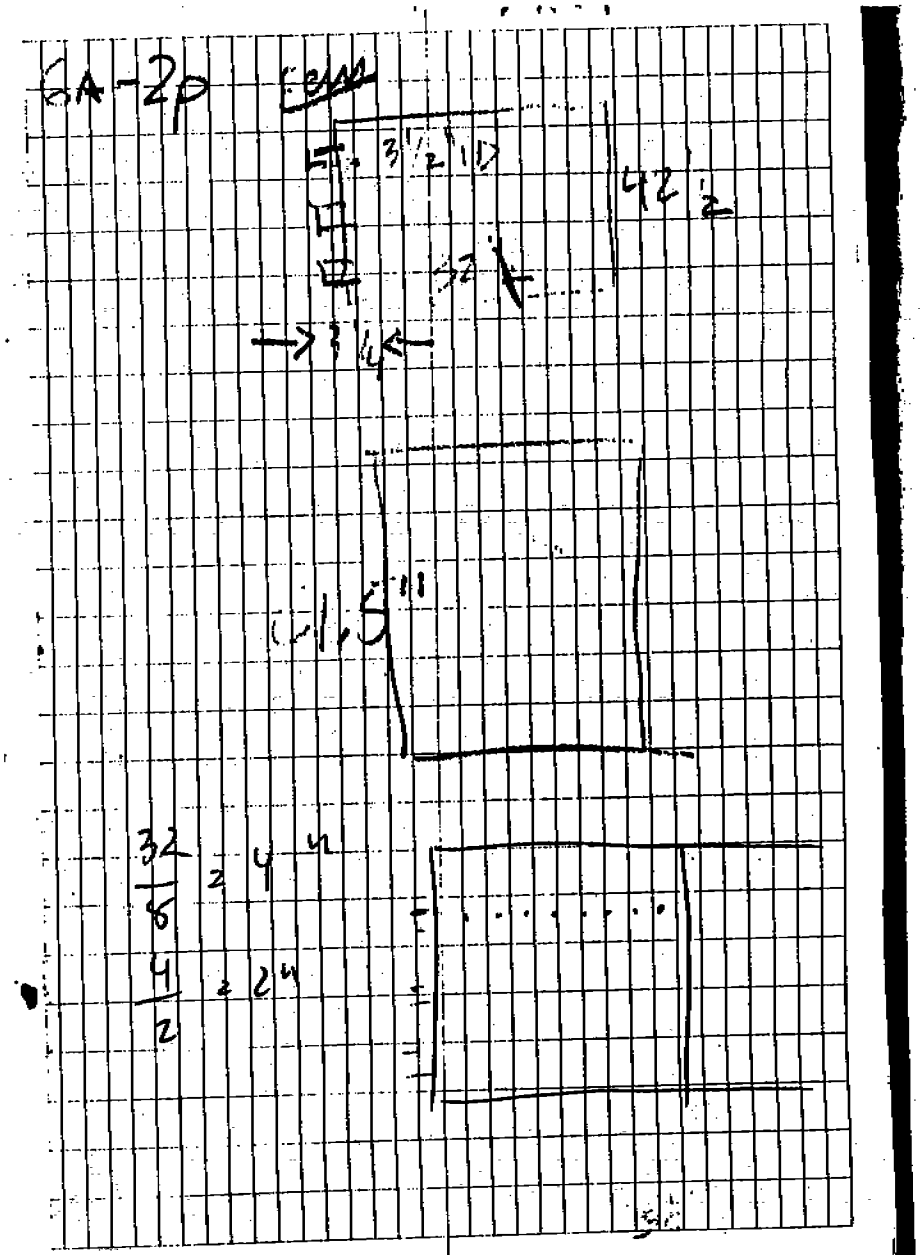
43 028.3561 dscfM

COKE SCREENING East

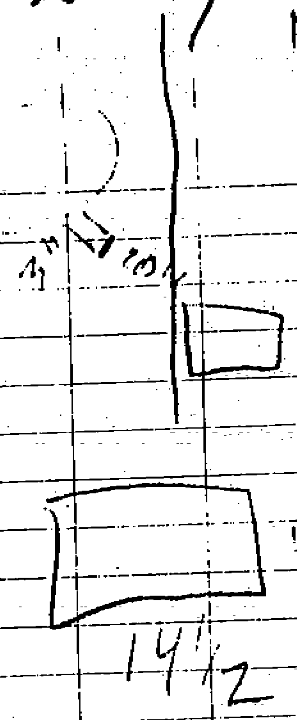
UP STEPS BOX INSIDE

RUNS 2C (howard) ???




6A-2P
Beam
3 1/2 in
42 in
32 in
1.5 in
32/8 = 4
4/2 = 2

Rick Begley DETR ILSTER



Beth Steel

Coal Crusher $D_E = \frac{2 \times 32 \times 42}{32 + 42}$

$= \frac{2688}{74} = 36.32 \cong 36"$ $\cong 3'$

\$1.2 - 2.700 Co 7.30

RMSK 1543 week 344

Mi [illegible]

APPENDIX B

LABORATORY ANALYSIS AND DATA REDUCTION

APPENDIX B

LABORATORY ANALYSIS AND DATA REDUCTION

1.0 ANALYTICAL METHODS

All samples generated during the test program were analyzed by Air Quality Services Inc., located in Pittsburgh, Pennsylvania. The following discussions describe the analytical methods employed.

1.1 Particulate Samples

Prior to their use in the field, all glass fiber filters used in the sampling program had been tare-weighed following heating to 900°F and a 24-hour desiccation period. Upon their return to the laboratory, the filters were desiccated and reweighed. The weight difference was the amount of sample collected.

Nozzle, probe, and filter holder distilled water and acetone washings were evaporated to dryness in separate tared beakers. The residue was desiccated, and the beakers were reweighed to a constant weight. The weight difference was the amount of particulate matter collected at those locations in the sampling train. Impinger solutions, as well as front-half water washes prior to evaporation, were filtered through a 0.22-micron filter to determine the insoluble back-half particulate.

The impinger solution filtrate and the acetone wash of the impingers were dried separately to determine the soluble back-half particulate catch. In accordance with PADER test requirements, this portion of the particulate catch is reported but not included in the particulate loading calculations.

Acetone and distilled water blanks were evaporated to dryness in tared beakers and were desiccated and reweighed. Any residue that remained was a contaminant in the reagent and was considered a blank weight used as a correction factor in subsequent calculations. The laboratory results of the particulate sampling program are listed in Tables B-1, B-2, B-3, and B-4.

2.0 EQUATIONS FOR THE CALCULATIONS OF TEST RESULTS

The equations following Tables B-1, B-2, B-3, and B-4 were programmed into a personal computer to facilitate the calculation of the test program results. The equations were prescribed in EPA Methods 2, 3, 4, and 5 of 40 CFR 60, Appendix 1, Reference Test Methods, and were used to calculate the results of particulate, flow temperature, and static pressure testing.

3.0 PARTICULATE TEST RESULTS

The complete results of the computer analyses of the data generated from the particulate test program are presented on the computer printout following the equations.

TABLE B-1

COAL CRUSHER ROTOCLONE
FRONT HALF AND INSOLUBLE BACK HALF
PARTICULATE LABORATORY RESULTS (mg)[1]

Run No.	Filter	Acetone Wash	Insoluble Water Wash	Soluble Water Wash	Water Insoluble Back Half	Total Calculated Particulate
1	75.7	24.2	24.2	6.50	1.20	132.
2	45.5	12.9	9.60	43.7	1.10	113.
3	48.7	26.4	18.6	28.2	0.900	123.

[1] Results were blank corrected.

TABLE B-2

COAL CRUSHER ROTOCLONE
SOLUBLE BACK-HALF PARTICULATE (mg)[1]

Run No.	Water Wash	Acetone Wash	Total
1	18.1	1.10	19.2
2	24.6	3.70	28.3
3	25.3	4.40	29.7

[1] Results were blank corrected.

TABLE B-3

EAST COKE SCREENING STATION
FRONT HALF AND INSOLUBLE BACK-HALF
PARTICULATE LABORATORY RESULTS (mg)[1]

Run No.	Filter	Acetone Wash	Insoluble Water Wash	Soluble Water Wash	Water Insoluble Back Half	Total Calculated Particulate
1	6.6	9.00	3.90	23.3	1.00	43.8
2	7.8	6.5, 10.5[2]	- - -	- - -	1.10	25.9
3	7.8	25.6	42.8	14.8	0.500	91.5

[1] Results were blank corrected.
[2] Inadvertently two acetone washes were performed and no water wash.

TABLE B-4

EAST COKE SCREENING STATION
SOLUBLE BACK-HALF PARTICULATE (mg)[1]

Run No.	Water Wash	Acetone Wash	Total
1	2.90	1.70	4.60
2	8.90	5.20	14.1
3	1.30	4.90	6.20

[1] Results were blank corrected.

EQUATIONS FOR PARTICULATE, MOISTURE, AND FLOW CALCULATIONS

(BASED ON STANDARD CONDITIONS OF 68°F AND 29.92"Hg)

1. $V_{w(std)} = 0.0471\ V_{wc}$

2. $V_{m(std)} = 17.64\ V_m \dfrac{P_{bar} + .07355\ \Delta H}{T_m + 460}\ \gamma$

3. $B_{wo} = \dfrac{V_{w(std)}}{V_{m(std)} + V_{w(std)}}$

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

5. $M_s = M_d\ (1 - B_{wo}) + 18\ B_{wo}$

6. $EA = \dfrac{(\%O_2) - 0.5(\%CO)}{0.264(\%N_2) - (\%O_2) + 0.5(\%CO)}\ 100$

7. $V_s = (85.49)(60)(C_p)\sqrt{\Delta P}\sqrt{\dfrac{T_s + 460}{(P_s)(M_s)}}$

8. $Q_s = \dfrac{(V_s)(A_s)}{144}$

9. $Q_{s(std)} = Q_s(1 - B_{wo})\ 17.64\ \dfrac{P_s}{T_s + 460}$

10. $C'_s = 0.0154\ \dfrac{W_t}{V_{m(std)}}$

11. $C'_w = 0.0154\ \dfrac{W_t}{V_{m(std)} + V_{w(std)}}$

12. $C'_c = \dfrac{12\ C'_s}{\%CO_2}$

13. $C'_a = W_w\ \dfrac{(T_s + 460)(29.92)}{(528)(P_s)}$

14. $E = 0.00857\ Q_{s(std)}\ C'_s$

15. $A_n = \dfrac{(\pi)(D_n)^2}{(144)(4)}$

16. $I = \dfrac{(60)(1.667)(T_s + 460)(0.00267\ V_{wc} + V_{m(std)}/17.64)}{(\Theta)(V_s)(P_s)(A_n)}$

LEGEND

A_n	=	Area of nozzle, ft^2
A_s	=	Area of stack, in^2
B_{wo}	=	Moisture content of gas stream, dimensionless
C_p	=	Pitot correction factor, dimensionless
C'_a	=	Particulate concentration (stack conditions), gr/ft^3
C'_c	=	Particulate concentration at 12% CO_2 (dry), gr/dscf
C'_s	=	Particulate concentration (dry), gr/dscf
C'_w	=	Particulate concentration (wet), gr/scf
D_n	=	Diameter of nozzle, in.
E	=	Particulate emission rate, lb/hr
EA	=	Excess air, percent
ΔH	=	Orifice pressure drop, in. H_2O
I	=	Isokinetic ratio, percent
M_d	=	Dry molecular weight of stack gas, lb/lb-mole
M_s	=	Molecular weight of stack gas, lb/lb-mole
P_{bar}	=	Barometric pressure, in. Hg
P_s	=	Stack pressure (absolute), in. Hg
$\sqrt{\Delta P}$	=	Average of square roots of pitot pressure differential, in. H_2O
Q_s	=	Stack gas flow, acfm
$Q_{s(std)}$	=	Stack gas flow, scfm
T_m	=	Average dry gas meter temperarure, ^oF
T_s	=	Average stack temperature, ^oF
V_m	=	Dry sample volume (meter conditions), ft^3
$V_{m(std)}$	=	Dry sample volume (standard conditions), ft^3

V_s = Stack velocity, ft/min

V_{wc} = Volume of liquid collected in impingers and silica gel, ml

$V_{w(std)}$ = Volume of liquid collected, ft^3

W_t = Total weight of particulates collected, mg

θ = Duration of test, min.

CCR1.XLS

Particulate Run 1
Results Summary

BCM Project #	00-4021-35
Plant	BETHLEHEM STEEL
Date	12/2/91
Location	Coal Crusher Rotoclone
Run Number	Particulate Run 1
Operator	NC

Barometric Pressure:	30.02	" Hg
Static Pressure:	1	" H^2O
Stack Pressure:	30.09	" Hg

Water Pickup		
silica gel:	20.8	grams
impinger:	5	ml

Start Time	08:34	
Duration	78.00	Min

ORSAT:

CO2 =	0	%
O2 =	21	%
CO =	0	%
N2=	79	%

Duct Diameter		inches
Duct Width	32	inches
Duct Length	42	inches
Duct Area	9.33	sq.ft.
Pitot Factor	0.840	
Meter Box Factor	1.003	
Nozzle In. Diam.	0.190	inches
Nozzle Area	1.97E-04	sq.ft.
Isokinetic Ratio	105.9	

Average Stack Temp	55.9	deg F
Average Gas Meter Temp	69.2	deg F
Avg Square Root of Pitot Press	1.392	inches water
Orifice Pressure Drop	2.775	inches water
Meter Dry Sample Volume	75.588	DACF
Dry Sample Volume, Corrected, Std Conditions	76.377	DSCF
Dry Molecular Weight of Stack Gas	28.84	lb/lb-mole
Molecular Weight of Stack Gas	28.677	lb/lb-mole
Stack Gas Velocity	4,635.6	ft/min
Stack Gas Flow Rate	43,266.0	ACFM
Stack Gas Flow Rate, dry, Std. Conditions	43,854.3	DSCFM
Stack Gas Flow Rate, Std. Conditions	44,522.0	SCFM
Volume of Moisture Collected	1.216	SCF
Moisture Content Calculated: 1.57 %	1.50	%
Saturated: 1.50 %		
Mass of Particulate Collected	131.80	mg
Concentration of Particulate; standard conditions	0.0266	gr/dscf
Mass Emission Rate of Particulate	10.010	lb/hr

CCR2.XLS

Particulate Run 2
Results Summary

BCM Project #	00-4021-35
Plant	BETHLEHEM STEEL
Date	12/3/91
Location	Coal Crusher Rotoclone
Run Number	Particulate Run 2
Operator	NC

Barometric Pressure:	29.54	" Hg
Static Pressure:	1	" H^2O
Stack Pressure:	29.61	" Hg
Water Pickup		
silica gel:	14.3	grams
impinger:	8	ml
Start Time	13:29	
Duration	72.00	Min

ORSAT:

CO2 =	0	%
O2 =	20.8	%
CO =	0	%
N2=	79.2	%

Duct Diameter		inches
Duct Width	32	inches
Duct Length	42	inches
Duct Area	9.33	sq.ft.
Pitot Factor	0.840	
Meter Box Factor	1.003	
Nozzle In. Diam.	0.190	inches
Nozzle Area	1.97E-04	sq.ft.
Isokinetic Ratio	102.4	

Average Stack Temp	58.3	deg F
Average Gas Meter Temp	71.3	deg F
Avg Square Root of Pitot Press	1.404	inches water
Orifice Pressure Drop	2.842	inches water
Meter Dry Sample Volume	68.706	DACF
Dry Sample Volume, Corrected, Std Conditions	68.069	DSCF
Dry Molecular Weight of Stack Gas	28.832	lb/lb-mole
Molecular Weight of Stack Gas	28.667	lb/lb-mole
Stack Gas Velocity	4,725.5	ft/min
Stack Gas Flow Rate	44,104.7	ACFM
Stack Gas Flow Rate, dry, Std. Conditions	43,780.5	DSCFM
Stack Gas Flow Rate, Std. Conditions	44,456.4	SCFM
Volume of Moisture Collected	1.051	SCF
Moisture Content Calculated: 1.52 %	1.52	%
Saturated: 1.66 %		
Mass of Particulate Collected	112.80	mg
Concentration of Particulate; standard conditions	0.0256	gr/dscf
Mass Emission Rate of Particulate	9.597	lb/hr

CCR3.XLS

Particulate Run 3
Results Summary

BCM Project #	00-4021-35
Plant	BETHLEHEM STEEL
Date	12/4/91
Location	Coal Crusher Rotoclone
Run Number	Particulate Run 3
Operator	NC

Barometric Pressure:	29.85	" Hg
Static Pressure:	1	" H_2O
Stack Pressure:	29.92	" Hg

Water Pickup silica gel:	16.7	grams
impinger:	0	ml

Start Time	08:12	
Duration	72.00	Min

ORSAT:

CO2 =	0	%
O2 =	20.9	%
CO =	0	%
N2=	79.1	%

Duct Diameter		inches
Duct Width	32	inches
Duct Length	42	inches
Duct Area	9.33	sq.ft.
Pitot Factor	0.840	
Meter Box Factor	0.981	
Nozzle In. Diam.	0.190	inches
Nozzle Area	1.97E-04	sq.ft.
Isokinetic Ratio	100.2	

Average Stack Temp	54.9	deg F
Average Gas Meter Temp	75.6	deg F
Avg Square Root of Pitot Press	1.433	inches water
Orifice Pressure Drop	2.950	inches water
Meter Dry Sample Volume	70.843	DACF
Dry Sample Volume, Corrected, Std Conditions	68.825	DSCF
Dry Molecular Weight of Stack Gas	28.836	lb/lb-mole
Molecular Weight of Stack Gas	28.713	lb/lb-mole
Stack Gas Velocity	4,780.1	ft/min
Stack Gas Flow Rate	44,614.6	ACFM
Stack Gas Flow Rate, dry, Std. Conditions	45,218.0	DSCFM
Stack Gas Flow Rate, Std. Conditions	45,735.3	SCFM
Volume of Moisture Collected	0.787	SCF
Moisture Content Calculated:	1.13	%
Saturated:	1.46	%
Mass of Particulate Collected	122.80	mg
Concentration of Particulate; standard conditions	0.0275	gr/dscf
Mass Emission Rate of Particulate	10.672	lb/hr

CSE1.XLS

Particulate Run 1
Results Summary

BCM Project #	00-4021-35
Plant	BETHLEHEM STEEL
Date	12/4/91
Location	Coke Screening East
Run Number	Particulate Run 1
Operator	NC

Barometric Pressure:	29.52	" Hg
Static Pressure:	0.90	" H_2O
Stack Pressure:	29.59	" Hg

Water Pickup		
silica gel:	13.9	grams
impinger:	0	ml

Start Time	13:33
Duration	72.00 Min

ORSAT:

CO2 =	0	%
O2 =	21	%
CO =	0	%
N2=	79	%

Duct Diameter	41.75	inches
Duct Width	---	inches
Duct Length	---	inches
Duct Area	9.51	sq.ft.
Pitot Factor	0.840	
Meter Box Factor	1.003	
Nozzle In. Diam.	0.190	inches
Nozzle Area	1.97E-04	sq.ft.
Isokinetic Ratio	106.6	

Average Stack Temp	51.1	deg F
Average Gas Meter Temp	54.9	deg F
Avg Square Root of Pitot Press	1.057	inches water
Orifice Pressure Drop	1.783	inches water
Meter Dry Sample Volume	52.868	DACF
Dry Sample Volume, Corrected, Std Conditions	53.864	DSCF
Dry Molecular Weight of Stack Gas	28.84	lb/lb-mole
Molecular Weight of Stack Gas	28.710	lb/lb-mole
Stack Gas Velocity	3,533.2	ft/min
Stack Gas Flow Rate	33,589.9	ACFM
Stack Gas Flow Rate, dry, Std. Conditions	33,888.5	DSCFM
Stack Gas Flow Rate, Std. Conditions	34,300.8	SCFM
Volume of Moisture Collected	0.655	SCF
Moisture Content Calculated: 1.20 %	1.20	%
Saturated: 1.28 %		
Mass of Particulate Collected	43.80	mg
Concentration of Particulate; standard conditions	0.0125	gr/dscf
Mass Emission Rate of Particulate	3.645	lb/hr

CSE2.XLS

Particulate Run 2
Results Summary

BCM Project #	00-4021-35
Plant	BETHLEHEM STEEL
Date	12/5/91
Location	Coke Screening East
Run Number	Particulate Run 2
Operator	NC

Barometric Pressure:	30.58	" Hg
Static Pressure:	0.90	" H^2O
Stack Pressure:	30.65	" Hg

Water Pickup		
silica gel:	9.6	grams
impinger:	-3	ml

Start Time	08:18
Duration	84.00 Min

ORSAT:

CO2 =	0	%
O2 =	21	%
CO =	0	%
N2=	79	%

Duct Diameter	41.75	inches
Duct Width	—	inches
Duct Length	—	inches
Duct Area	9.51	sq.ft.
Pitot Factor	0.840	
Meter Box Factor	1.003	
Nozzle In. Diam.	0.19	inches
Nozzle Area	1.97E-04	sq.ft.
Isokinetic Ratio	105.5	

Average Stack Temp	50.4	deg F
Average Gas Meter Temp	52.4	deg F
Avg Square Root of Pitot Press	1.012	inches water
Orifice Pressure Drop	1.617	inches water
Meter Dry Sample Volume	57.53	DACF
Dry Sample Volume, Corrected, Std Conditions	60.981	DSCF
Dry Molecular Weight of Stack Gas	28.84	lb/lb-mole
Molecular Weight of Stack Gas	28.785	lb/lb-mole
Stack Gas Velocity	3,318.3	ft/min
Stack Gas Flow Rate	31,546.4	ACFM
Stack Gas Flow Rate, dry, Std. Conditions	33,242.0	DSCFM
Stack Gas Flow Rate, Std. Conditions	33,411.8	SCFM
Volume of Moisture Collected	0.311	SCF
Moisture Content Calculated:	0.51 %	0.51 %
Saturated:	1.20 %	
Mass of Particulate Collected	25.90	mg
Concentration of Particulate; standard conditions	0.0066	gr/dscf
Mass Emission Rate of Particulate	1.868	lb/hr

CSE3.XLS

Particulate Run 3
Results Summary

BCM Project #	00-4021-35
Plant	BETHLEHEM STEEL
Date	12/5/91
Location	Coke Screening East
Run Number	Particulate Run 3
Operator	NC

Barometric Pressure:	30.56	" Hg
Static Pressure:	0.90	" H_2O
Stack Pressure:	30.63	" Hg
Water Pickup		
silica gel:	14.9	grams
impinger:	2.7	ml
Start Time	11:34	
Duration	84.00	Min

ORSAT:

CO2 =	0	%
O2 =	21	%
CO =	0	%
N2=	79	%

Duct Diameter	41.75	inches
Duct Width	—	inches
Duct Length	—	inches
Duct Area	9.51	sq.ft.
Pitot Factor	0.840	
Meter Box Factor	1.003	
Nozzle In. Diam.	0.190	inches
Nozzle Area	1.97E-04	sq.ft.
Isokinetic Ratio	105.3	

Average Stack Temp			54.6 deg F
Average Gas Meter Temp			60.2 deg F
Avg Square Root of Pitot Press			1.050 inches water
Orifice Pressure Drop			1.758 inches water
Meter Dry Sample Volume			59.838 DACF
Dry Sample Volume, Corrected, Std Conditions			62.458 DSCF
Dry Molecular Weight of Stack Gas			28.84 lb/lb-mole
Molecular Weight of Stack Gas			28.698 lb/lb-mole
Stack Gas Velocity			3,461.7 ft/min
Stack Gas Flow Rate			32,910.0 ACFM
Stack Gas Flow Rate, dry, Std. Conditions			34,098.3 DSCFM
Stack Gas Flow Rate, Std. Conditions			34,551.2 SCFM
Volume of Moisture Collected			0.830 SCF
Moisture Content Calculated:	1.31	%	1.31 %
Saturated:	1.41	%	
Mass of Particulate Collected			91.50 mg
Concentration of Particulate; standard conditions			0.0226 gr/dscf
Mass Emission Rate of Particulate			6.608 lb/hr

APPENDIX C

EQUIPMENT CALIBRATION

1.0 PITOT CALIBRATION

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

$$C_{p(test)} = C_{p(std)} \sqrt{\frac{\Delta P_{std}}{\Delta P_{test}}}$$

Where:

$C_{p(test)}$ = Pitot tube coefficient of "S" type pitot

$C_{p(std)}$ = Pitot tube coefficient of standard pitot

ΔP_{test} = Velocity head measured by "S" type pitot

ΔP_{std} = Velocity head measured by standard pitot

Coefficients were determined for each leg of the "S" type pitot. No C_p may deviate more than ± 0.01 from the average C_p, and the difference between the average C_p for each leg must be ≤ 0.01.

2.0 DRY GAS METER AND ORIFICE METER

The dry gas meter and orific were calibrated using a wet test meter. Gases were moved through the dry gas meter at orifice pressure differentials (ΔH's) of 0.5, 1.0, and 2.0 inches of water. With the information obtained, γ, the ratio of accuracy of wet test meter to dry test meter; and $\Delta H_@$, the orifice pressure

differential that gives 0.75 cfm of air at 68°F and 29.92 inches of mercury, were calculated. The γ has a tolerance of 1.00 ±0.01 and the $\Delta H_@$ has a tolerance of 1.84 +0.26 -0.24. The γ and $\Delta H_@$ are determined as follows:

$$\gamma = \frac{V_w P_b (t_d + 460)}{V_d [P_b + .07353 (\Delta H)] (t_w + 460)}$$

$$\Delta H_@ = \frac{0.0317 (\Delta H)}{P_b (t_d + 460)} \left(\frac{(T_w + 460)\ \theta}{V_w} \right)^2$$

Where:

ΔH = Orifice pressure differential, in H_2O

P_b = Barometric pressure, in Hg

t_d = Average temperature of dry gas meter, °F

t_w = Average temperature of wet test meter, °F

θ = Duration of test, min.

V_d = Dry gas meter volume, ft^3

V_w = Wet test meter volume, ft^3

3.0 POTENTIOMETER CALIBRATION

The Thermo - Electron potentiometers were calibrated by using a known voltage source as an input to the potentiometer.

4.0 PROBE CALIBRATION

The probes were calibrated by measuring the outlet temperatures at various variable transformer settings while passing air through at approximately 0.75 cubic feet per minute.

BCM

METER BOX CALIBRATION SHEET

Date 10-28-91 Box No. 420 Inspector J. STETINA

Pump _____ Oil _____ Wick _____ Pump Serial No. _____

Manometers _____ Knobs _____ Oil _____ Tubing _____

Quick Connects _____ Vacuum Gage _____ Valves _____

Dry Gas Meter _____ Volume _____ ft^3 Serial No. _____

Thermometers _____ In _____ °F Out _____ °F Ambient _____ °F

Amphenol _____ Lights _____ Switches _____ Variac _____

Leak Check - Max. Vacuum 28 in. Hg Leak Rate .001 CFM

Remarks Repaired manometer, Reconfigured mnf'ld, Replaced bypass ferrules, cleaned lines, cleaned pump vanes & housing, re-oiled.

Man. Orifice	CF_w	CF_d	T_w	IT_d	OT_d	T_d	Time θ
0.5	5.000	5.104	71	96	78	87	12:50 / 12.83
1.0	5.004	5.144	71	103	82	92.5	8:56 / 8.93
2.0	10.004	10.402	71	108	85	96.5	12:47 / 12.78

Tolerances: $1.6 \leq \Delta H_@ \leq 2.1$ $\quad 0.99 \leq \gamma \leq 1.01$

$\Delta H_@ =$	$\gamma =$
$\dfrac{(0.0317)(\Delta H)}{(P_b)(OT_d+460)}\left[\dfrac{(T_w+460)(\theta)}{(CF_w)}\right]^2$	$\dfrac{(CF_w)(P_b)(T_d+460)}{(CF_d)(P_b+\Delta H/13.6)(T_w+460)}$
$\dfrac{(0.0317)(0.5)}{(29.76)(\underset{538}{78}+460)}\left[\dfrac{(\underset{531}{71}+460)(12.83)}{(5)}\right]^2$	$\dfrac{(5.000)(29.76)(\underset{547}{87}+460)}{(5.104)(29.76+\underset{29.7968}{0.0368})(\underset{531}{71}+460)}$
1.838	1.008
$\dfrac{(0.0317)(1.0)}{(29.76)(\underset{542}{82}+460)}\left[\dfrac{(\underset{531}{71}+460)(8.93)}{(5.004)}\right]^2$	$\dfrac{(5.004)(29.76)(\underset{552.5}{92.5}+460)}{(5.144)(29.76+\underset{29.8337}{0.0737})(\underset{531}{71}+460)}$
1.765	1.010
$\dfrac{(0.0317)(2.0)}{(29.76)(\underset{545}{85}+460)}\left[\dfrac{(\underset{531}{71}+460)(12.78)}{(10.004)}\right]^2$	$\dfrac{(10.004)(29.76)(\underset{556.5}{96.5}+460)}{(10.402)(29.76+\underset{29.907}{0.147})(\underset{531}{71}+460)}$
1.799	1.003