REPORT

TO

BETHLEHEM STRUCTURAL PRODUCTS CORPORATION
BETHLEHEM, PENNSYLVANIA

FOR

COMPLIANCE PARTICULATE EMISSION DETERMINATION OF THE "A" COKE OVEN BATTERY PUSHING EMISSIONS CONTROL BAGHOUSE OUTLET STACK

SEPTEMBER 1994

BCM PROJECT NO. 00-4021-3901

PREPARED BY

Joel Stetina

JOEL STETINA
PROJECT LEADER

AND

Philip C. Burg

PHILIP C. BURG
SECTION MANAGER

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Engineers, Planners, Scientists and Laboratory Services
One Plymouth Meeting • Plymouth Meeting, PA 19462 • Phone: (215) 825-3800

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1.0 EXECUTIVE SUMMARY

Bethlehem Structural Products Corporation (Bethlehem Steel) operates a coke oven battery, designated as "A" Battery, which uses a pushing shed and baghouse for controlling particulate emissions at its facility in Bethlehem, Pennsylvania. BCM Engineers Inc. (BCM) was retained to determine the compliance status of the baghouse outlet stack during normal operations with respect to its allowable particulate emission limit of 0.006 gr/dscf, Pennsylvania Department of Environmental Resources (PADER) operating Permit No. 48-305-001B. Testing conformed to all PADER technical requirements for particulate source testing. One three-hour test was performed continuously during normal pushing operations. Test results show a particulate emission rate of 0.001 gr/dscf, demonstrating compliance with the PADER-issued operating permit.

2.0 SCOPE AND OBJECTIVES

The scope of the project was outlined in BCM's "A" Battery Shed Baghouse Testing Protocol, dated June 10, 1994. A copy of the protocol, as well as related correspondence, is included in Appendix A. The objective of the sampling program was to determine the following parameters:

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

3.0 PROCEDURES

3.1 FIELD WORK

Field testing was conducted on August 18, 1994. The sampling team consisted of the following BCM personnel::

- Philip C. Burg, Project Manager
- Steven Reigner, Technician

Mr. Carl Liedke 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, 40 CFR Part 60, Appendix A. 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 B of this report.

3.2 ANALYTICAL METHODS

All samples generated during the sampling program were analyzed at the BCM laboratory located in Norristown, Pennsylvania. An outline of the analytical methodologies, as well as laboratory data, are contained in Appendix C.

3.3 CALCULATIONS

A personal computer, programmed to accept input data 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 C. Appendix C 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. Additionally, a post test metering system calibration check was performed at the average orifice pressure recorded during the test. During this procedure the vacuum was set to equal the highest achieved while the test was in progress. Appendix D contains equipment calibration data.

3.5 COKE OVEN PUSHING LOG

A list of the sequence of ovens pushed and their corresponding times is contained in Appendix E.

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4.0 TEST RESULTS

4.1 GAS FLOW RATE DATA AND PARTICULATE EMISSION RESULTS

All gas flow rate and particulate emission data obtained during the evaluation test run can be found in Table 1.

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TABLE 1

Gas Flow Rate Data and Particulate Emission Results

Test date	8/18/94
Test time start	0913
Test time stop	1223
Carbon Dioxide Emission Concentration (%)	0.0
Oxygen Emission Concentration (%)	20.9
Carbon Monoxide Emission Concentration (%)	0.0
Moisture Content (%)	2.9
Gas Temperature (°F)	118
Gas Velocity (fpm)	3,918
Stack Gas Flow Rate (acfm)	520,000
Stack Gas Flow Rate (dscfm)	450,000
Particulate Emission Concentration (gr/acf)	0.001
Particulate Emission Concentration (gr/dscf)	0.001
Particulate Emission Rate (lb/hr)	2.6

During sampling, 15 ovens were pushed

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5.0 DISCUSSION OF RESULTS

Emission testing went well with no problems encountered. The pre- and post-test leak checks and isokinetic deviations were within allowable limits. Pushing operations were at normal conditions during testing.

Particulate emission results of 0.001 gr/dscf demonstrated during the emission testing represents 16.7% of the 0.006 gr/dscf allowable limit.

Prior to emission sampling, the gas velocity pressure and temperature at the baghouse inlet duct were measured with a pitot tube and thermocouple. The gas flow rates determined from the measurements were 500,000 acfm and 447,000 dscfm. The baghouse, therefore, was operating within the specified limit of 500,000 acfm. Furthermore, comparison of the inlet flow rate of 447,000 dscfm and the outlet flow rate of 450,000 dscfm, shows that little dilution of the stack gas caused by air infiltration was occurring. Baghouse inlet gas flow rate calculations are included in Appendix C.

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APPENDIX A

TEST PROTOCOL AND RELATED CORRESPONDENCE

SAMPLING PROTOCOL

FOR

PARTICULATE EMISSIONS EVALUATION OF THE A BATTERY SHED BAGHOUSE EXHAUST

FOR

BETHLEHEM STEEL CORPORATION
BETHLEHEM, PENNSYLVANIA

BCM PROJECT NO. 00-4021-3901

PREPARED BY

PHILIP C. BURG
SECTION MANAGER

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Engineers, Planners, Scientists and Laboratory Services
One Plymouth Meeting • Plymouth Meeting, PA 19462 • Phone: (215) 825-3800

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1.0 INTRODUCTION

The procedures used for sampling the pushing emission shed and baghouse control system for Coke Oven "A" Battery at Bethlehem Steel Corporation, located in Bethlehem, Pennsylvania will conform to the procedures described in the Pennsylvania Department of Environmental Resources (PADER), Bureau of Air Quality Control, Division of Technical Services and Monitoring, "Source Testing Manual", Revision No. 1, January, 1983. One sample run will be conducted and the particulate emission rate will be based on the total "front half" and insoluble "back half" of the sampling train particulate catch according to PADER procedures.

Testing will be conducted in order to show compliance with the PADER Operating Permit No. 48-305-001B particulate emission limit of 0.006 gr/dscf during continuous operation (see attached page 3 of 5 of permit). All sampling will be conducted during normal pushing operations.

2.0 SAMPLING LOCATION

The sampling location is located on the baghouse exhaust stack. The exhaust stack internal diameter is 13.0 feet. The nearest upstream disturbance is the inlet plenum which is 55.0 feet or 4.2 duct diameters from the sampling test ports. The nearest downstream is the stack exhaust which is 26.5 feet or 2.0 diameters from the sampling test ports. There are four three-inch flanged sampling test ports located 90^{o} to center at the sampling location. Twenty-four traverse points will be selected according to the procedures of EPA Method 1. Six traverse points at each of the four test ports will be sampled. There is a safe platform to work from and safe access by a caged ladder.

3.0 SAMPLING PROCEDURES

Particulate matter mass emissions sampling and analyses will be conducted and reported using 40 CFR Part 60, Appendix A, Methods 1 through 5 and will incorporate PADER sampling procedures. The following presents a brief description of particulate sampling procedures:

1. Sampling will be conducted continuously with a total sampling time of 3 hours which will result in an approximate sample volume of 135 dscf. With an emission concentration of 0.006 gr/dscf and a sample volume of 135 dscf, the amount of particulate collected would be 52 mg. BCM believes, therefore, that a 3 hour sampling time will meet the Method 5 analytical detection limits.

2. An unheated Teflon flex line will be placed between the filter and the first impinger.

3. Sample recovery will utilize a distilled water rinse followed by an acetone rinse as described in the PADER "Source Testing Manual," 1983, Revision No. 3. The flex line will be cleaned in the same manor as the rest of the "Back Half".

4. The "back half" catch will be analyzed according to procedures described in the PADER "Source Testing Manual," 1983, Revision No. 3, and the "Back-half" insoluble catch will be included in the emission calculation. The soluble catch will be reported but not included in the emission calculation.

4.0 SAMPLING REPORT

The sampling report will include a discussion of the sampling methods used, tabulation of field and laboratory data and test results, copies of all field data sheets, and copies of all sampling equipment calibration data. The report will generally conform to reporting requirements of the PADER and will additionally include a log of the coke ovens pushed during sampling;

5.0 COMPLIANCE CALCULATION

Compliance will be based on demonstrating that the Baghouse particulate emissions will not exceed 0.006 gr/dscf.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
Post Office Box 8468
Harrisburg, Pennsylvania 17105-8468
June 21, 1994

PENNSYLVANIA DER

Bureau of Air Quality Control 717-772-2304

4021-3901

Mr. T. E. Kreichelt
Superintendent
Environmental, Safety & Health
Bethlehem Structural Products Corporation
501 E. Third Street
Bethlehem, PA 18016-7599

Dear Mr. Kreichelt:

This letter is in response to your letter dated June 8, 1994 regarding the change in testing procedure for the pushing emission shed and baghouse control system for Coke Oven "A" Battery. The particulate testing methodology, as submitted, is acceptable to the Department.

I would like to take this opportunity to inform you that once the revisions to Chapter 139 of the Rules and Regulations have been approved, a new Source Testing Manual will be published which will require that three test runs be perform. Until that time, however, a single test run for sources not covered by the EPA's New Source Performance Standard is still acceptable.

Final acceptance of the test report will be contingent upon fulfilling all applicable sections of Chapter 139 of the Department of Environmental Resources' Rules and Regulations, the Source Testing Manual and any special conditions specified in Plan Approval 48-305-001B.

Should you have any questions regarding this matter, please feel free to contact me.

Sincerely,

Richard St. Louis
Chief, Source Testing Section
Division of Source Testing & Monitoring

: Mr. Philip Berg
BCM Engineers
One Plymouth Meeting
Plymouth Meeting, PA 19462

CC: Bill Nuver, Bethlehem District Office, Northeast Region
48-305-001B
Reading File - Source Testing

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APPENDIX B

FIELD SAMPLING PROGRAM

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1.0 SAMPLING PROCEDURES

1.1 TEST STATION AND TRAVERSE LOCATION

The internal diameter of the baghouse outlet stack was 13.0 feet (156 inches). Four test ports were located in the same cross sectional plane 90 degrees apart. The nearest upstream flow disturbance was the stack inlet plenum and was located 55 feet, or 4.2 duct diameters, from the testing ports. The nearest downstream flow disturbance was the stack outlet which was located 26.5 feet, or 2.0 duct diameters, from the testing ports. A total of 24 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 velocity and temperature traverse concurrently with particulate sampling. Gas velocity heads were measured with an "S"-type pitot tube, which was connected to an inclined manometer. The absence of cyclonic flow was verified during a cyclonic flow angle check. The average flow angle determined during the cyclonic flow check was 8 degrees. 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 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 accepted 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.

1.4 PARTICULATE SAMPLING

The sampling procedures and analysis used were those outlined in the Federal Register, 40 CFR Part 60, Appendix A, Method 5 and PADER's Source Testing Manual. The following provides a description of the sampling procedures:

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. An "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 passed 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.

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 a sealed sample bottle. The impingers were rinsed with DI water and the washings were placed in the sample bottle containing the impinger water. The impingers were finally rinsed with acetone and the washings placed in a separate bottle.

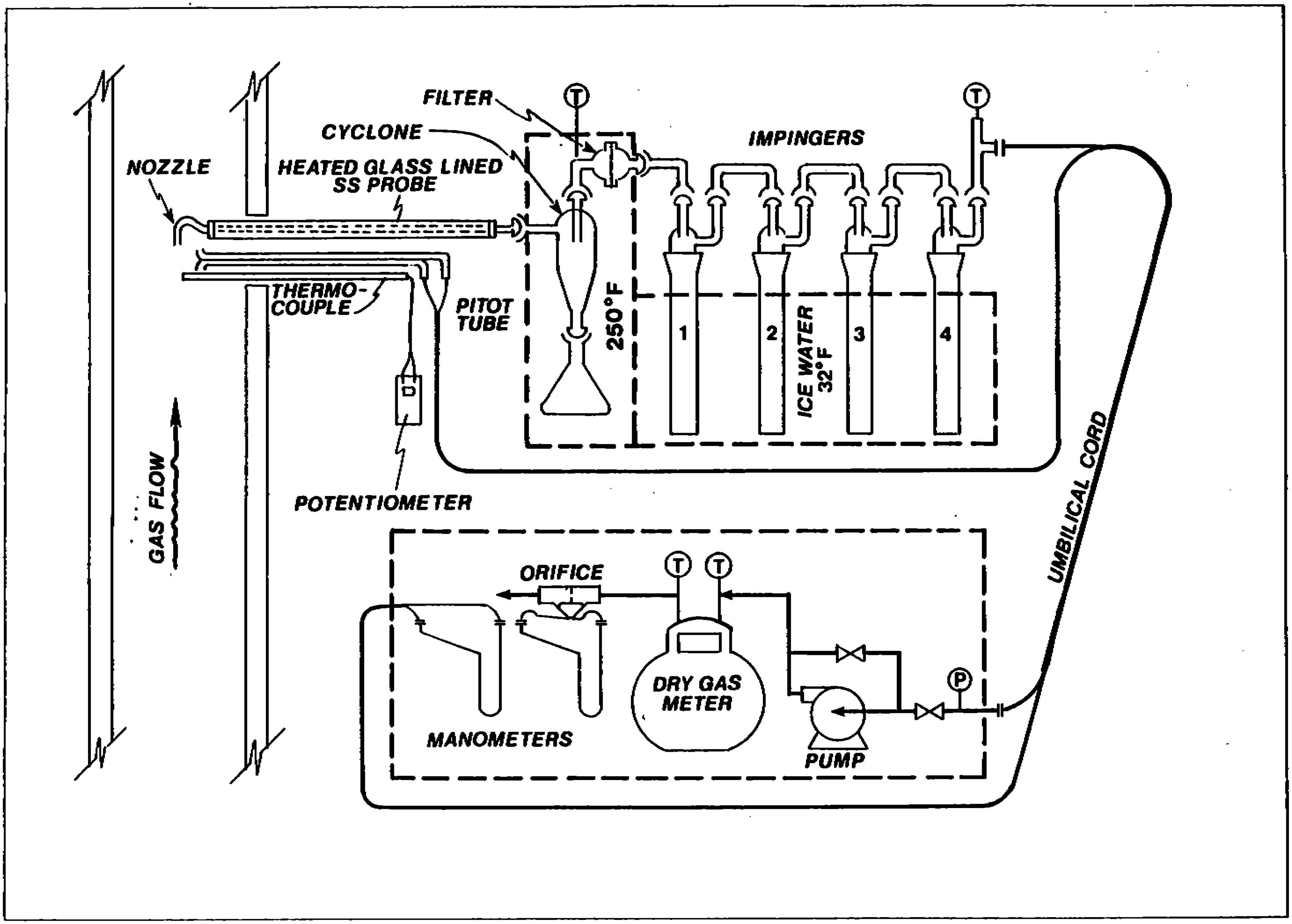
All test program samples, as well as blanks of the distilled water and acetone used during the testing, were submitted to BCM laboratory for analysis.

1.5 MOLECULAR WEIGHT DETERMINATION

Concurrently during emission sampling, an integrated sample of the exhaust gas was collected in a Tedlar bag. An Orsat gas analyzer was used to determine the molecular weight of the exhaust gas collected. 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 follows the EPA Method 5 schematic.


FILTER
CYCLONE
NOZZLE
HEATED GLASS LINED SS PROBE
IMPINGERS
T
T
THERMO-COUPLE
PITOT TUBE
250°F
1
2
3
4
ICE WATER 32°F
GAS FLOW
POTENTIOMETER
UMBILICAL CORD
ORIFICE
T
T
P
DRY GAS METER
MANOMETERS
PUMP

EPA METHOD 5

BCM

PLANT Bethlehem Steel
DATE 8/18/94
SAMPLING LOCATION A Battery Baghouse Outlet
SAMPLE TYPE PA Part.
RUN NUMBER One OPERATOR PCB/SR
BAROMETRIC PRESSURE ______ STATIC PRESSURE -.65
FILTER NUMBER(S) ______
GEL NUMBER(S) +25ml
THIMBLE NUMBER ______ PLATE NUMBER ______
H_2O PICKUP (ml) + 55ml water

ORSAT:
CO_2 ______
O_2 ______
CO ______

PYROMETER NUMBER ______
THERMOCOUPLE NUMBER ______
PROBE NUMBER ______ TYPE ______
NOZZLE NUMBER ______ I.D. .193
METER BOX NUMBER 419 $\Delta H_@$ 1.95 γ = 1.02
PITOT NUMBER ______ C_p .84
SAMPLE BOX NUMBER(S) ______
ASSUMED MOISTURE (%) 2
ASSUMED METER TEMPERATURE 105
C FACTOR 1.15 REFERENCE Δp ______

READ AND RECORD ALL DATA EVERY 3 3/4 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	~~0913~~	507.990									
A-6	03 3/4	0916	510	1.1	1.80	1.80	108	86	81	6.0	236	56
6	07 1/2	0920 1/2	512.3	1.1	1.80	1.80	112	93	81	6.0	228	54
5 2	10 3/4		514.5	1.0	1.70	1.70	115	97	82	6.0	225	52
5 2	15		517.5	1.0	1.70	1.70	112	101	83	6.0	230	52
4 3	18 3/4	0931 3/4		.95	1.60	1.60	119	104	85	6.0	228	52
4 3	22 1/2	0935 1/2	522.5	.95	1.60	1.60	116	105	85	5.5	224	53
3 4	26 1/4		524.9	.90	1.50	1.50	118	107	89	5.0	226	52
3 4	30	0943	527.4	.90	1.50	1.50	121	108	89	5.0	228	52
2	33 3/4		529.8	.80	1.35	1.35	117	108	90	5.0	225	52
2	37 1/2		532.1	.85	1.45	1.45	121	108	92	5.0	229	52
1	41 1/4	0954 1/2	534.0	.75	1.25	1.25	124	108	92	4.0	228	52
1	45	0958	537.056	.75	1.25	1.25	118	108	92	4.0	229	52
			Stop	test, change		ports	Ts̄ = .931	Tm̄ =	.958			
	00	1002	537.056									
B-1	03 3/4	1005 3/4	539.2	.90	1.50	1.50	123	100	93	5.0	227	50
1	07 1/2	1009	541.7	.90	1.50	1.50	119	106	93	5.0	225	48
2	11 1/4	1013 1/4	544.3	1.0	1.65	1.65	116	110	94	5.0	230	48
2	15	1017	546.7	1.0	1.65	1.65	115	111	94	5.0	228	48
3	18 3/4		549.5	1.1	1.85	1.85	121	112	97	6.0	230	50
3	22 1/2	1024 1/2	552.2	1.1	1.85	1.85	113	115	95	6.0	235	

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PLANT Bethlehem Steel DATE 8/18/94 RUN NUMBER One

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
	~~22½~~	~~1024¼~~	552.2									
4	~~220~~ 26¼	1028¼	554.9	1.2	2.0	2.0	111	116	~~8~~95	6.0	230	50
4	~~230~~ 30	1032	558.0	1.1	1.85	1.85	121	114	96	6.0	228	50
5 3	~~240~~ 33¾	1035¾	560.6 ~~258.250~~	1.2	2.0	2.0	115	114	96	6.0	232	50
5 3	37½	1039½	563.4	1.2	2.0	2.0	112	115	97	6.5	245	50
6 2	41¼	1043¼	566.6	1.3	2.15	2.15	115	119	97	7.0	265	50
6 2	45	1047	569.410	1.3	2.15	2.15	119	118	97	7.0	270	50
			Stop test, change ports				$\overline{\Delta P}$ = 1.108	$\sqrt{\Delta P}$	=1.051			
	00	1050	569.410									
C-6	03¾	1053¾	572.1	1.0	1.70	1.70	118	107	95	6.0	250	50
6	7½	1057½	575.2	1.4	2.35	2.35	117	114	96	7.5	230	50
5	11¼	1101¼	578.6	1.6	2.70	2.70	120	115	98	8.5	250	50
5	15	1105	582.1	1.6	2.70	2.70	130	119	97	8.5	260	50
4	18¾	1108¾	585.3	1.7	2.80	2.80	123	120	98	9.0	260	50
4	22½	1112½	588.8	1.6	2.70	2.70	126	120	98	8.5	260	50
3	26¼	1116¼	592.3	1.7	2.80	2.80	128	121	99	8.5	250	50
3	30	1120	595.6	1.6	2.70	2.70	122	121	99	8.0	250	50
2	33¾	1123¾	598.6	1.6	2.70	2.70	130	121	100	8.0	245	50
2	37½	1127½	601.5	1.6	2.70	2.70	126	121	100	8.5	240	50
1	41¼	1131¼	605.2	1.3	2.15	2.15	120	119	100	7.5	240	50
1	45	1135	608.015	1.3	2.15	2.15	116	118	101	7.5	240	50
				$\overline{\Delta P}$=1.5		$\sqrt{\Delta P}$=	1.222					
	00	1138	608.015									
1	03¾	1141¾	610.8	1.2	2.0	2.0	122	113	99	6.0	235	50
1	7½	1145½	613.8	1.2	2.0	2.0	122	113	99	6.0	240	50
2	11¼	1149¼	616.7	1.4	2.3	2.3	116	116	98	7.0	238	50
2	15	1153	619.6	1.2	2.0	2.0	122	116	98	6.0	240	50
3	18¾	1156¾	622	1.3	2.15	2.15	123	116	98	6.5	225	50
3	22½	1200½	625.7	1.3	2.15	2.15	120	117	98	6.5	250	50
4	26¼	1204¼	628.6	1.4	2.35	2.35	115	117	98	6.5	250	50
4	30	1208	631.8	1.4	2.35	2.35	113	117	98	6.5	250	50
5	33¾	1211¾	634.7	1.3	2.15	2.15	112	118	98	6.5	260	50
5	37½	1215½	637.8	1.4	2.35	2.35	110	117	98	7.0	265	50
6	41¼	1219¼	640.7	1.2	2.00	2.00	109	117	99	6.0	260	50
6	45	1223	643.575	1.2	2.00	2.00	108	116	99	6.0	255	50
								$\sqrt{\Delta P}$ =	1.136			

Smoke readers time is 2 minutes behind stack test

ORSAT ANALYSIS DATA SHEET

CLIENT: BETHLEHEM STEEL

SAMPLING LOCATION: A-BATTERY BAGHOUSE OUTLET

RUN NO.: 1

DATE: 8-18-94

TIME: 13:00

ANALYST: Steven J Reigner

GAS \ RUN	1		2		3		AVERAGE NET VOLUME
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET	
CO_2	Ø	Ø	Ø	Ø	Ø	Ø	Ø
O_2 (Net is Actual O_2 Reading Minus Actual CO_2 Reading)	20.6	20.6	20.8	20.8	20.7	20.7	20.7
CO (Net is Actual CO Reading Minus Actual O_2 Reading)							
N_2 (Net is 100 Minus Actual CO Reading)	79.4			79.2		79.3	79.3

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VELOCITY DETERMINATIONS

Client: Bethlehem Steel

Sample Port Location:

Location: A-Battery Baghouse Outlet

Date: 8/18/94

Stack Pressure:

Barometric Pressure:

Pitot Factor: .84

Engineer: PCB / SJR

Time 0900

Pitot/Temperature Readings

Point No.	Distance (Inches)	Port C		Port B		Port A		Port D		Port __	
		ΔP	T	ΔP	T	ΔP	T	ΔP	T	ΔP	T
1		1.6	98	1.2	102	.80	104	1.0	105		
2		1.7	101	1.3	102	.85	106	1.4	107		
3		1.9	104	1.5	103	.95	108	1.4	108		
4		1.8	104	1.5	103	1.0	110	1.4	108		
5		1.8	104	1.5	104	1.2	111	1.3	109		
6		1.7	103	1.5	103	1.3	112	1.5	109		
TOTAL											
AVG.											

Betz • Converse • Murdoch • Inc. BCM

VELOCITY DETERMINATIONS

Client: BETHLEHEM STEEL

Location: A BATTERY BAGHOUSE OUTLET

Date: 8-19-94

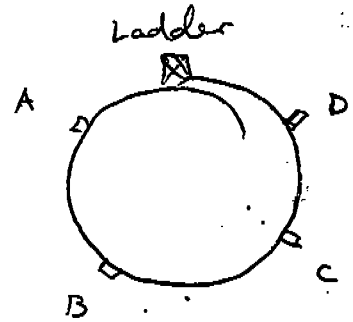
Stack Pressure: NA

Barometric Pressure: NA

Pitot Factor: .84 PITOT 6-1

Engineer: JS/SR

Sample Port Location:



CYCLONIC FLOW CHECK

Pitot/Temperature Readings

Point No.	Distance (Inches)	Port A		Port B		Port C		Port D		Port __	
		ΔP	°∠	ΔP	°∠	ΔP	°∠	ΔP	°∠	ΔP	T
1		Ø	-10°	Ø	-3°	Ø	-10°	Ø	-10°		
2		Ø	-10	Ø	-5°	Ø	-10°	Ø	-10°		
3		Ø	-11°	Ø	-10°	Ø	-15°	Ø	-10°		
4		Ø	+5°	Ø	-5°	Ø	-10°	Ø	-10°		
5		Ø	-5°	Ø	-10°	Ø	-7°	Ø	-10°		
6		Ø	0°	Ø	-7°	Ø	-5°	Ø	-12°		
TOTAL											
AVG.											

− = COUNTER CLOCKWISE } FACING PORT
+ = CLOCKWISE

BCM

APPENDIX C

LABORATORY ANALYSIS AND DATA REDUCTION

BCM

1.0 ANALYTICAL METHODS

All samples generated during the test program were analyzed at the BCM laboratory, located in Norristown, Pennsylvania. The following discussion describes the analytical method 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. Entire impinger solutions were filtered through tared 0.8-micron and 0.22-micron filters to determine the insoluble back-half particulate. The total particulate catch used to calculate particulate emissions equaled the sum of the particulate collected on the filter, in the water and acetone front-half washes, and on the 0.8 and 0.22-micron filters.

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 emission 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 summarized on the computer printout sheet presented in this appendix.

2.0 EQUATIONS FOR THE CALCULATIONS OF TEST RESULTS

The equations following this page 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 A, 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. Included are particulate laboratory results of the PA particulate and back-half soluble particulate analyses.

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.

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

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

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

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

PADER Particulate Emission Calculations

Plant: Bethlehem Steel
Test Location: A Battery Baghouse Outlet Duct

BCM Project No: 00-4021-3901
Testing Personnel: P. Burg/S. Reigner

	Run No. 1
Test date	8/18/94
Test time start	0913
Test time stop	1223
Elapsed sampling time, min	180
Vwc - Volume of liquid collected, ml	80.0
Vw (std) - Volume of liquid collected @ std. cond., ml	3.768
Vm - Dry sample volume- meter conditions, dacf	135.585
Pbar - Barometric pressure, in. Hg	29.25
Δ H - Orifice pressure drop, in. H2O	2.01
γ - Dry gas meter coefficent	1.02
Tm - Average dry gas meter temperature, °F	99
Vm (std) - Dry sample volume, dscf	128.206
Bwo - Moisture content of gas stream. %	2.9
CO2 emission concentration, %	0.0
O2 emission concentration, %	20.9
CO emission concentration, %	0.0
N2 emission concentration, %	79.1
Md - Dry molecular weigt of stack gas, lb/lb-mole	28.84
Ms - Molecular weigt of stack gas, lb/lb-mole	28.53
Duct diameter, inches	156.00
Duct width, inches	
Duct length, inches	
As - Duct area, sq. ft	132.73
Ps - Stack static pressure, in. H2O	-0.7
Ps - Stack absolute pressure, in. Hg	29.20
Ts - Average stack gas temperature, °F	118
$\sqrt{\Delta P}$ - Average square root of pitot pressure differencial, in. H2O	1.092
Cp - Pitot correction factor, dimensionless	0.84
Vs - Stack gas velocity, ft/min	3,918
Qs - Stack gas flow, acfm	520,000
Qs(std) - Stack gas flow, wet scfm	463,000
Qs(std) - Stack gas flow, dry scfm	450,000
Dn - Diameter of nozzle, in	0.193
An - Area of nozzle, sq ft	2.03E-04
Isokinetic derivation, %	103.4

Cont.

PADER Particulate Emission Calculations

Plant: Bethlehem Steel
Test Location: A Battery Baghouse OutletDuct

BCM Project No: 00-4021-3901
Operator: P. Burg/S. Reigner

	Run No. 1
Weight of soluble particulate collected in back-half acetone wash, mg	18.4
Weight of soluble particulate collected in back-half filtrate, mg	6.60
Total weight of soluble particulate collected, mg (not used in emission calculations)	25.00
Weight of particulate collected on filter, mg	-0.5
Weight of particulate collected in front-half acetone wash, mg	2.8
Weight of particulate collected in front-half water wash, mg	2.2
Weight of insoluble particulate collected on 0.8 u filter, mg	1.2
Weight of insoluble particulate collected on 0.22 u filter, mg	0.0
Wt - Total weight of PADER particulate collected, mg	5.7
C's - Particulate concentration at standard conditions (dry), gr/dscf	0.001
C'w - Particulate concentration at standard conditions (wet), gr/scf	0.001
C'a - Particulate concentration at stack conditions, gr/acf	0.001
E - Particulate emission rate, lb/hr	2.6

Note:The main filter and .22 micron filter exhibited smaller final weights then their initial ; a gain of zero for each was used in the calculations .

Gas Flow Rate
And Moisture Field Data

Test Location: A Battery Baghouse Outlet Duct
Run No: One
Barametric pressure: 29.25
Volume of water collected: 80.0

	Meter Reading	Meter Temp (°F) Inlet	Outlet	Traverse Point Port	No.	Δ H	Δ P	$\sqrt{\Delta P}$	Ts (°F)
Start:	507.990	86	81	A	1	1.80	1.10	1.049	108
		93	81		1	1.80	1.10	1.049	112
		97	82		2	1.70	1.00	1.000	115
		101	83		2	1.70	1.00	1.000	112
		104	85		3	1.60	0.95	0.975	119
		105	85		3	1.60	0.95	0.975	116
		107	89		4	1.50	0.90	0.949	118
		108	89		4	1.50	0.90	0.949	121
		108	90		5	1.35	0.80	0.894	117
Stop:	643.575	108	92		5	1.45	0.85	0.922	121
Start:		108	92		6	1.25	0.75	0.866	124
		108	92		6	1.25	0.75	0.866	118
		100	93	B	1	1.50	0.90	0.949	123
		106	93		1	1.50	0.90	0.949	119
		110	94		2	1.65	1.00	1.000	116
		111	97		2	1.65	1.00	1.000	115
		112	95		3	1.85	1.10	1.049	121
		115	95		3	1.85	1.10	1.049	113
		116	96		4	2.00	1.20	1.095	111
		114	96		4	1.85	1.10	1.049	121
		114	97		5	2.00	1.20	1.095	115
		115	97		5	2.00	1.20	1.095	112
		119	97		6	2.15	1.30	1.140	115
		118	97		6	2.15	1.30	1.140	118
		107	95	C	1	1.70	1.00	1.000	118
		114	96		1	2.35	1.40	1.183	117
		115	98		2	2.70	1.60	1.265	120
		119	97		2	2.70	1.60	1.265	130
		120	98		3	2.80	1.70	1.304	123
		120	98		3	2.70	1.60	1.265	126
		121	99		4	2.80	1.70	1.304	128
		121	99		4	2.70	1.60	1.265	122
		121	100		5	2.70	1.60	1.265	130
		121	100		5	2.70	1.60	1.265	126
		119	100		6	2.15	1.30	1.140	120
		118	101		6	2.15	1.30	1.140	116
		113	99	D	1	2.00	1.20	1.095	122
		113	99		1	2.00	1.20	1.095	122

	116	98	2	2.30	1.40	1.183	116
	116	98	2	2.00	1.20	1.095	122
	116	98	3	2.15	1.30	1.140	123
	117	98	3	2.15	1.30	1.140	120
	117	98	4	2.35	1.40	1.183	115
	117	98	4	2.35	1.40	1.183	113
	118	98	5	2.15	1.30	1.140	112
	117	98	5	2.35	1.40	1.183	110
	117	99	6	2.00	1.20	1.095	109
	116	99	6	2.00	1.20	1.095	108
Vm: 135.585		99	Ave:	2.01	1.205	1.092	118

A Battery Baghouse Inlet Duct Gas Flow Rates

	Run No. 1
Test date	8/18/94
Vwc - Volume of liquid collected, ml	80.0
Vw (std) - Volume of liquid collected @ std. cond., ml	3.768
Vm - Dry sample volume- meter conditions, dacf	135.585
Pbar - Barometric pressure, in. Hg	29.25
Δ H - Orifice pressure drop, in. H2O	2.01
γ - Dry gas meter coefficent	1.02
Tm - Average dry gas meter temperature, °F	99
Vm (std) - Dry sample volume, dscf	128.206
Bwo - Moisture content of gas stream. %	2.9
CO2 emission concentration, %	0.0
O2 emission concentration, %	20.9
CO emission concentration, %	0.0
N2 emission concentration, %	79.1
Md - Dry molecular weigt of stack gas, lb/lb-mole	28.84
Ms - Molecular weigt of stack gas, lb/lb-mole	28.52
Duct diameter, inches	150.00
Duct width, inches	
Duct length, inches	
As - Duct area, sq. ft	122.72
Ps - Stack static pressure, in. H2O	-0.65
Ps - Stack absolute pressure, in. Hg	29.20
Ts - Average stack gas temperature, °F	100
$\sqrt{\Delta P}$ - Average square root of pitot pressure differencial, in. H2O	1.153
Cp - Pitot correction factor, dimensionless	0.84
Vs - Stack gas velocity, ft/min	4,074
Qs - Stack gas flow, acfm	500,000
Qs(std) - Stack gas flow, wet scfm	460,000
Qs(std) - Stack gas flow, dry scfm	447,000

Note: Gas moistue data from outlet stack test

BCM

APPENDIX D

EQUIPMENT CALIBRATION

BCM

POST TEST
METER BOX CALIBRATION SHEET

Date 8-17-94 Box No. 419 Inspector S. Reigner

Pump ✓ Oil ✓ Wick ✓ Pump Serial No. ____

Manometers ✓ Knobs ✓ Oil ✓ Tubing ✓

Quick Connects ✓ Vacuum Gage ✓ Valves ✓

Dry Gas Meter ✓ Volume 485.6 ft^3 Serial No. ____

Thermometers ✓ In 77 °F Out 77 °F Ambient 77 °F

Amphenol ✓ Lights ✓ Switches ✓ Variac ✓

Leak Check - Max. Vacuum ~~485.6~~ in. Hg Leak Rate .001 CFM

Remarks P_b = 29.68 28"

Man. Orifice	CF_w	CF_d	T_w	IT_d	OT_d	T_d	Time θ
0.5	5.00	4.975	75	96	85	91	12.82 12.49
1.0	5.00	5.00	75	93	82	87	9.28 9.17
2.0	10.00	10.060	75	103	84	93	13.48 13.29

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

$\Delta H_@ =$	$\frac{(0.0317)(\Delta H)}{(P_b)(OT_d+460)}\left[\frac{(T_w+460)(\theta)}{(CF_w)}\right]^2$	$\gamma =$	$\frac{(CF_w)(P_b)(T_d+460)}{(CF_d)(P_b+\Delta H/13.6)(T_w+460)}$
1.84	$\frac{(0.0317)(0.5)}{(29.68)(85+460)}\left[\frac{(75+460)(12.82)}{(5)}\right]^2$ (545; 535)	1.02 ~~1.100~~	$\frac{(5)(29.68)(91+460)}{(4.975)(29.68+0.0368)(75+460)}$ (551; 29.0168; 535)
1.94	$\frac{(0.0317)(1.0)}{(29.68)(82+460)}\left[\frac{(75+460)(9.28)}{(5)}\right]^2$ (542; 535)	1.01	$\frac{(5)(29.68)(87+460)}{(5)(29.68+0.0737)(75+460)}$ (547; 29.7537; 535)
2.04	$\frac{(0.0317)(2.0)}{(29.68)(84+460)}\left[\frac{(75+460)(13.48)}{(10.00)}\right]^2$ (544; 535)	1.02	$\frac{(10.00)(29.68)(93+460)}{(10.060)(29.68+0.147)(75+460)}$ (553; 29.827; 535)

BCM

POST TEST
METER BOX CALIBRATION SHEET

Date 8-22-94 Box No. 419 Inspector Steven Regner

Pump ✓ Oil ✓ Wick ✓ Pump Serial No. ____

Manometers ✓ Knobs ✓ Oil ✓ Tubing ✓

Quick Connects ✓ Vacuum Gage ✓ Valves ✓

Dry Gas Meter ✓ Volume 651.1 ft^3 Serial No. ____

Thermometers ✓ In 73 °F Out 73 °F Ambient 73 °F

Amphenol ✓ Lights ✓ Switches ✓ Variac ____

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

Remarks Pb 29.26" Hg

Vacuum	Man. Orifice	CF_w	CF_d	T_w	IT_d	OT_d	T_d	Time θ
9" Hg	2.8	5.000	5.166	74	97	77	87	5.62 5:37
9" Hg	2.8	5.000	5.162	74	97	79	88	5.65 5:39
9" Hg	2.8	5.000	5.177	74	97	81	89	5.65 5:39

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

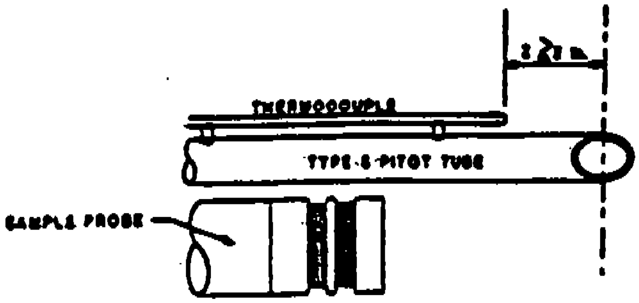
$\Delta H_@ =$	$\frac{(0.0317)(\Delta H)}{(P_b)(OT_d+460)}\left[\frac{(T_w+460)(\theta)}{(CF_w)}\right]^2$	$\gamma =$	$\frac{(CF_w)(P_b)(T_d+460)}{(CF_d)(P_b+\Delta H/13.6)(T_w+460)}$
	$\frac{(0.0317)(\quad)}{(\quad)(\quad+460)}\left[\frac{(\quad+460)(\quad)}{(\quad)}\right]^2$	.984	$\frac{(5)(29.26)(87+460)}{(5.166)(29.26+.206)(74+460)}$
	$\frac{(0.0317)(\quad)}{(\quad)(\quad+460)}\left[\frac{(\quad+460)(\quad)}{(\quad)}\right]^2$	.987	$\frac{(5)(29.26)(88+460)}{(5.162)(29.26+.206)(74+460)}$
	$\frac{(0.0317)(\quad)}{(\quad)(\quad+460)}\left[\frac{(\quad+460)(\quad)}{(\quad)}\right]^2$	.987	$\frac{(5)(29.26)(89+460)}{(5.177)(29.26+.206)(74+460)}$

TYPE S PITOT TUBE ALIGNMENT SPECIFICATIONS

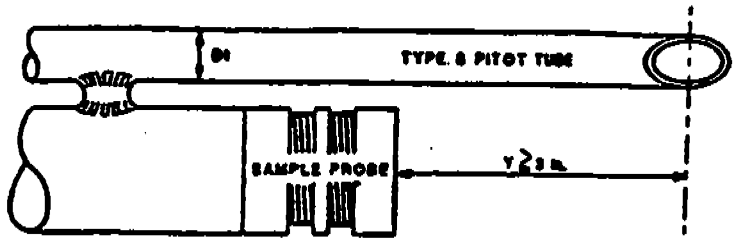
Type S - Pitot Tube No. PM - 6-10
BCM Project No.
Client Bethlehem Steel
Location A-Battery Baghouse
Date
Technician Steven J Reigner

PITOT ALIGNMENT STANDARDS :

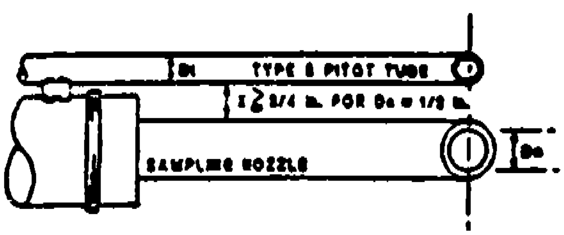
1. X ≧ 3/4 in.
2. Ip must be higher than Np
3. Z ≧ 1.90 cm
4. Y ≧ 3 in.



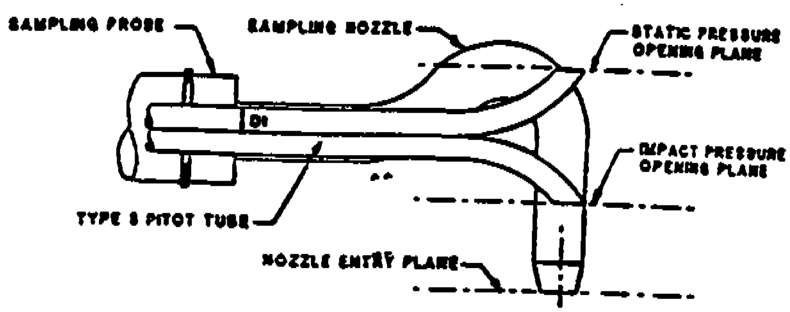
Z = 2"



Y = 5"



X = .780"



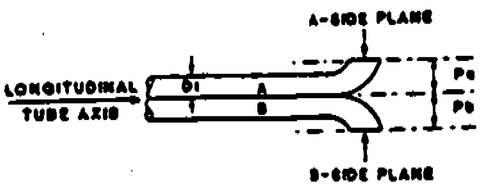
Is Ip higher than Np = Yes

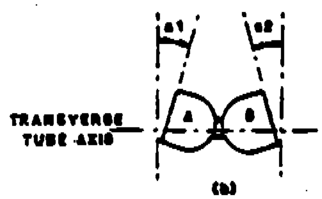
TYPE S PITOT TUBE CONSTRUCTION SPECIFICATIONS

TYPE S PITOT TUBE NO. PM 6-10 DATE 8-22-94 TECHNICIAN S. Reigner

CONSTRUCTION STANDARDS :

1. Dt - between 0.48 and 0.95 centimeters
2. Pa = Pb 1.05 Dt ≦ P ≦ 1.50 Dt
3. a1 , a2 < 10°
4. B1 , B2 < 5°
5. Z ≦ 0.32 cm
6. W ≦ 0.08 cm





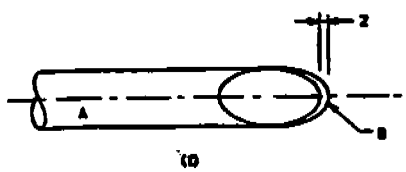
Dt = .375

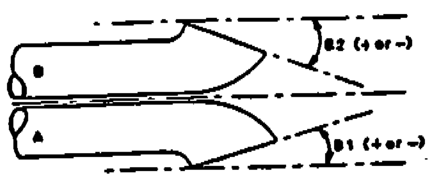
Pa = .515

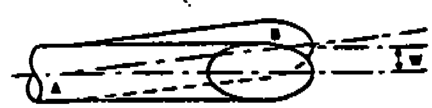
Pb = .516

a1 = Ø

a2 = Ø







B1 = Ø

B2 = Ø

Z = Ø

W = Ø

PYROMETER CALIBRATION SHEET

Pyrometer OMEGA 873F T-35048 Date 8-22-94 Inspector Steven J Reigner

Indicated Temperature (From pyrometer)	Actual Temperature (From standard)	Difference
100	99	1
200	199	1
300	299	1
400	397	3
500	499	1
600	599	1
700	700	0
800	800	0
900	900	0
1000	999	1
1100	1099	1
1200	1197	3
1300	1299	1
1400	1399	1
1500	1499	1
1600	1599	1
1700	1699	1
1800	1799	1
1900	1899	1
2000		
Avg.		-1.05

TEMPERATURE GAGE FIELD CHECK SHEET

BCM Project No.: 4021-3901

Client: Bethlehem Steel

Location: A-Battery Baghouse Outlet

Date: 8-22-94

Technician: Steven J Reigner

TEMPERATURE POINT	GAGE TEMPERATURE	REFERENCE TEMPERATURE	% DIFFERENCE
Stack	72.8	72	.73
Meter Inlet	73	72	.73
Meter Outlet	73	72	.73
Sample Box	74	73	
Impinger Outlet	72	72	Ø

PRE - TEST

NOZZLE CALIBRATION

Date 8-17-94 Calibrated by S. Fexner

Nozzle identification number	D_1, in.	D_2, in.	D_3, in.	ΔD, in.	D_{avg}
	.194	.194	.192	.002	.193

where:

$D_{1,2,3,}$ = nozzle diameter measured on a different diameter, in. Tolerance = measure within 0.001 in.

ΔD = maximum difference in any two measurements, in. Tolerance = 0.004 in.

D_{avg} = average of D_1, D_2, and D_3.

Nozzle calibration data.

NOZZLE CALIBRATION

BCM Project No.: 4021-3901
Client: Bethlehem Steel
Location: ~~B~~ A-Battery Baghouse
Date: 8-22-94 (POST)
Test Method:

Technician: Steven Reigner
Visual Inspection:
Damaged No ✓
Yes
Repaired No ✓
Yes

Nozzle Identification No.	D_1, in.	D_2, in.	D_3, in.	ΔD, in.	D Average
	.192	.194	.194	.002	.193

where:

$D_{1,2,3}$ = nozzle diameter measured on a different diameter, in.
Tolerance = measure within 0.001 in.

ΔD = maximum difference in any two measurements, in.
Tolerance - 0.004

D_{avg} = average of D_1, D_2, and D_3

STACK GAS THERMOCOUPLE CALIBRATION

BCM Project No.:

Client:

Location:

Date:

Technician:

TEMPERATURE SOURCE	TEMPERATURE	REFERENCE	% DIFFERENCE
Ambient Air	73°F	73°F	Ø
Ice Bath	33°F	33°F	Ø
Boiling Water	210°F	212°F	.94

APPENDIX E

COKE OVEN PUSHING LOG

PUSHER REPORT—COKE OVENS DEPARTMENT

F0020400 (Rev. D 3-70)

Battery No. A — Bethlehem Plant — Northampton Division — 08-18 199? — [signature]

	Shift No. 1 Oven No.	Sched.	Pushed	Charged	Coking Hr.	Coking Min.	Amp.	Shift No. 2 Oven No.	Sched.	Pushed	Charged	Coking Hr.	Coking Min.	Amp.	Shift No. 3 Oven No.	Sched.	Pushed	Charged	Coking Hr.	Coking Min.	Amp.
1	38	1110	1128	18	23	42	285	45	716	730	15	23	39	350	22	358	403	16	24	05	300
2	48	1124	1142	18	23	42	280	55	725	753	28	23	40	310	32	359	415	16	24	05	260
3	58	1136	1155	17	23	32	290	65	750	810	20	23	27	280	42	410	429	19	24	01	290
4	68	1152	1220	28	23	22	250	75	807	842	35	23	32	250	52	424	441	17	23	57	290
5	78	1217	1235	18	23	42	280	85	839	853	14	23	51	280	62	438	450	12	23	59	270
6	88	1231	1248	17	23	42	310	7	850	908	18	23	29	270	72	447	505	18	23	53	270
7	1	1245	1203	18	23	42	240	17	905	918	13	23	36	240	82	501	512	11	23	52	280
8	11	1259	117	18	23	32	300	27	915	929	14	23	36	240	4	605	619	14	24	34	250
9	21	117	131	18	23	31	270	37	925	939	14	23	29	270	14	615	635	20	24	26	260
10	41	128	147	19	23	32	260	47	[illegible]	952	16	23	25	250	24	631	650	19	24	27	250
11	51	143	200	17	46	46	270	57	949	1003	14	23	29	270	34	647	702	15	24	32	290
12	61	157	215	18	23	37	270	67	959	1020	21	23	25	280	44	659	726	27	24	16	290
13	71	211	241	30	23	26	280	77	1016	1032	17	23	30	280	54	723	737	14	24	23	280
14	81	238	257	19	23	49	320	87	1027	1040	13	23	23	280	64	733	750	17	24	16	260
15	3	254	212	18	23	52	285	9	1051	1104	13	23	31	260	74	745	801	16	24	16	260
16	13	308	326	18	23	50	320	[redacted]	XX	XX	XX	X	X	XX	84	756	816	20	24	12	330
17	23	323	340	17	23	40	330	39	1100	1113	13	23	22	270	6	812	828	16	24	24	210
18	33	337	406	29	23	37	270	49	1110	1124	14	23	21	270	16	824	840	16	24	—	280
19	43	403	420	17	23	48	260	59	1120	1141	21	23	19	280	26	836	852	16	23	58	240
20	63	417	435	18	23	45	300	69	1138	1154	16	23	27	240	36	849	905	16	23	55	310
21	73	431	448	17	23	25	320	79	1150	1200	10	23	25	310	46	902	915	13	23	59	270
22	83	445	514	29	23	33	310	2	[illegible]	[illegible]	13	23	24	240	56	912	928	16	23	58	330
23	5	511	530	19	23	39	250	12	1230	1244	12	23	26	240	66	925	940	15	23	58	310
24	15	526	543	17	23	38	300	19	1241	1251	10	23	31	250	76	937	948	11	24	01	280
25	25	540	602	22	23	36	290								86	945	958	13	23	56	260
26	35	558	613	15	23	30	350								8	955	1008	13	23	51	280
27															18	1004	1016	12	24	—	250
28															28	1013	1026	13	X	X	200
29															29	X	[illegible]	X	X	X	X
30																					
31																					
32																					
33																					
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Coal Weight — Coal Weight — Coal Weight —

AP-42 Section 12.2
Reference
Report Sect. 4
Reference 40

Reviewed

EMISSION EVALUATION

OF THE

"A" BATTERY PUSH EMISSION SCRUBBER

FOR

BETHLEHEM STEEL CORPORATION
BETHLEHEM, PENNSYLVANIA

NOVEMBER 1987

BCM PROJECT NO. 00-4021-12

PREPARED BY

DAVID S. LIVINGSTONE
SCIENTIST

AND

ASHOK K. SONI, P.E.
ASSISTANT VICE PRESIDENT

Commonwealth of Pennsylvania
Environmental Resources
December 11, 1987

Subject: Source Test Review

To: Data File
Bethlehem Steel Corporation
Bethlehem, Northampton County

From: John S. Pitulski J.S.P.
Air Quality Program Specialist
Division of Technical Services and Monitoring
Bureau of Air Quality Control

Through: Chief, Source Testing and Monitoring Section RM

Coke Oven Battery "A" at Bethlehem Steel Corporation is an 80-oven battery of 6 meter high ovens having double gas collector mains. Coke is pushed from the oven into a conventional moving quench car. The emissions generated during the pushing operation are captured by a hood mounted on the door machine. The hood is connected to a land based duct system which conveys the captured gases and particulate to a venturi scrubber and cyclonic separator located at the west end of the battery. The gases from the separator are then exhausted through an induced draft fan to the stack.

On August 27, 1987 particulate emission testing was conducted by BCM, Inc. at the battery exhaust stack. The test was conducted in accordance with pre-approved procedures and is acceptable to the Department. The nature of the source prohibits the sample volume and sampling time from meeting the requirements of Chapter 139 of the Department of Environmental Resources' Rules and Regulations. The calculations are correct and the results appear to be valid.

The following information was extracted from the test report:

Number of Ovens Pushed During Test	16
Coke Pushed During Test (dry tons/oven)	23.45
Volumetric Flowrate (dscfm)	152447
Emission Rate (lb/hr)	4.69
Allowable Emission Rate (lb/hr)	4.74
Percent Isokinetic	107

BETHLEHEM STEEL CORPORATION
BETHLEHEM PLANT

"A" Battery Pushing Emission Control System
Particulate Emissions Evaluation

Pursuant to the requirements of DER Regulations Chapter 139, particulate emission tests were conducted on the "A" Coke Oven Battery pushing emission control system stack on August 27, 1987. Testing and analyses were performed in a manner similar to the procedure outlined for the evaluation of the one spot car at our Plant's No. 5 Coke Oven Battery. Use of this procedure has been approved by Mr. R. St. Louis of the Department's Testing branch.

Source Description

"A" Battery is an 80 oven battery of 6 meter high ovens having double gas collector mains. Coke is pushed from the ovens into a conventional moving quench car. The emissions generated during the pushing operation are captured by a hood mounted on the door machine. This hood is connected to a land based duct system which conveys the captured gases and particulate to a venturi scrubber and cyclonic separator system at the west end of the battery. The gases from the system are then exhausted through the induced draft fans to the stack.

During these tests the average net coking time was 24.0 hours. The ovens pushed during the testing periods are identified on Attachment 1. The average tonnage of coke pushed on the battery during the test was 23.45 tons per oven.

Venturi pressure drops during the test were 36 and 33 inches of water on the north and south scrubber respectively. During the test, water flow rates averaged 590 and 610 GPM to the north and south venturis.

Test Procedure

All equipment and analytical procedures conformed to EPA Method 5. Sixteen pushes were sampled during the tests. Sampling commenced at the movement of the coke mass and terminated 30 seconds after the completion of the push. Each push was sampled at a different point, with 8 points on each diameter. Location of the test ports is identified on Attachment 2.

Sampling Results

Test results are summarized in BCM's test report, Attachment 3. The total particulate loading (front half plus back half insolubles) for the test was calculated as 4.65 lb./hr. The calculated allowable limit is 4.74 lb./hr. The calculations for the allowable and actual emission loading are presented on Attachment 4.

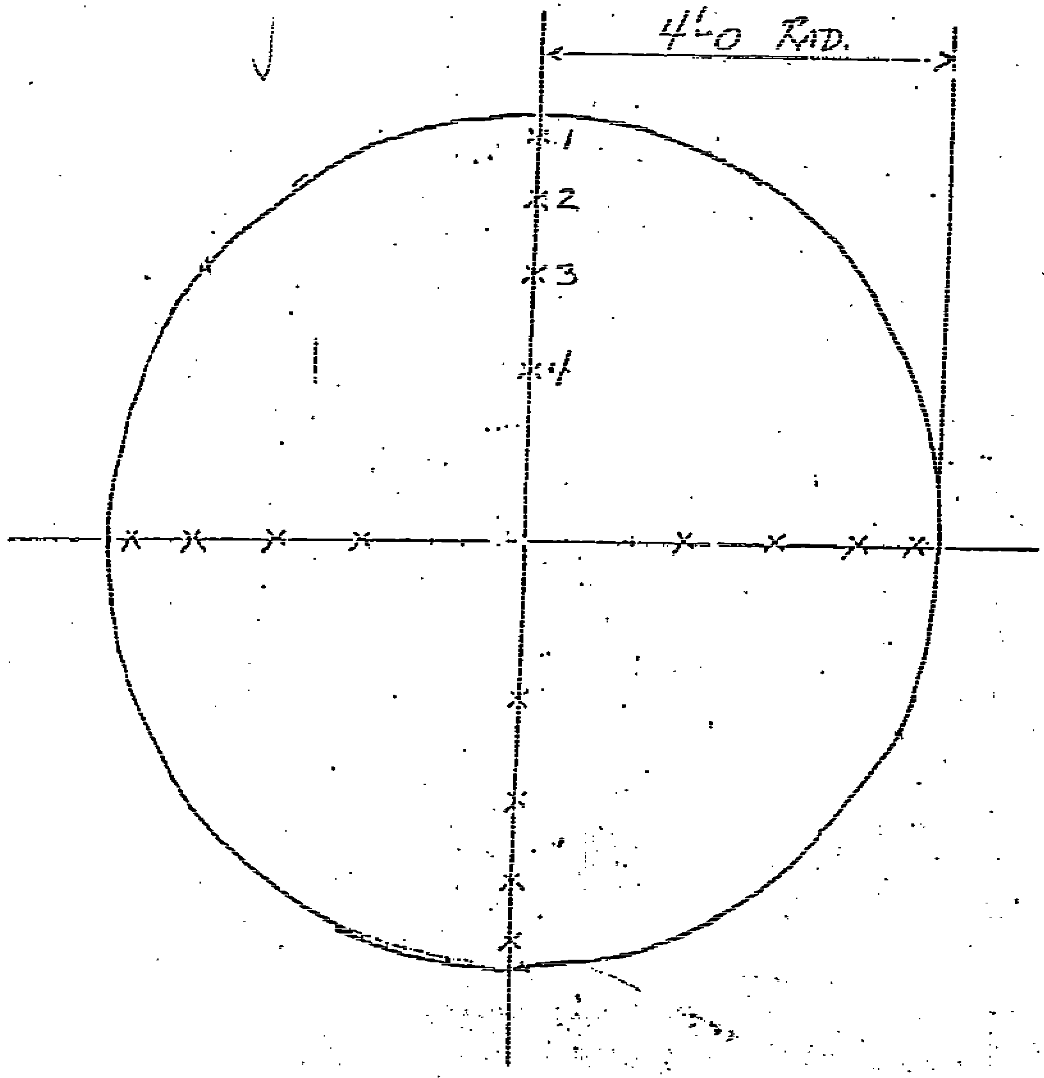
Attachment 1

"A" Battery Scrubber Test 08/27/87
Ovens Pushed

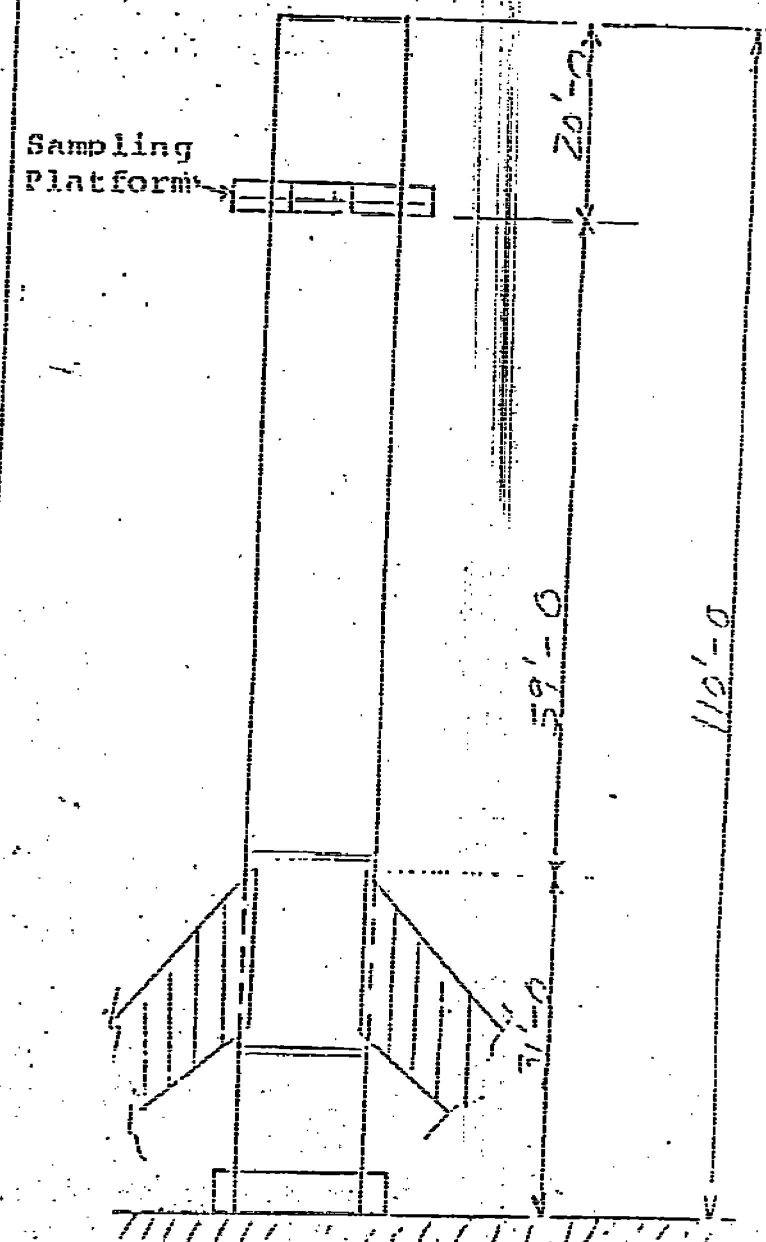
Oven No.	Time
8	11:34
18	11:46
38	12:09
48	12:18
58	12:35
68	12:49
78	15:15
88	15:23
11	15:47
21	16:04
51	17:12
61	17:23
71	17:38
81	17:50
3	18:01
13	18:36

Attachment 2

After Stack Stuffer Replaced Fan Outlet Silencers
March 1986.



Horizontal Cross Section



Vertical Position On Stack

Attachment 4

"A" Battery Scrubber Test 08/27/87
Loading Calculations

Average coke time = 24.0 hours

No. of oven pushed per day = 80 ovens/day

Average tons of coke per oven = 23.45 dry tons/oven

Average number of pushes per hour = 3.33 oven/hr.

Number of pushes for test = 16 pushes

Total amount of test time = 23' 15" (23.25 min.)

Total amount of push time per hour = 4.83 min./hr.

Allowable Loading

W = (23.45 tons of coke/oven) X (3.33 Oven/hr.) = 78.09 tons/hr.

E = (78.09 tons/hr.) X (1 lb. emissions/ton coke) = 78.09 lb./hr.

$A = 0.76(E)^{0.42} = 0.76(78.09 \text{ lb./hr.})^{0.42} = \underline{4.74 \text{ lb./hr.}}$

Actual Loading

$$\text{Loading (lb./hr.)} = \frac{(\text{gr/scfd})\ (\text{Qstpd})\ (\text{min./hr.})}{7000}$$

$$\text{Loading (lb./hr.)} = \frac{(0.0445 \text{ gr/scfd})\ (151284 \text{ scfmd})\ (4.83 \text{ min./hr.})}{7000}$$

Loading (lb.hr.) = 4.65 lb./hr.

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1.0 EXECUTIVE SUMMARY

Bethlehem Steel Corporation (Bethlehem Steel) retained BCM Eastern Inc. (BCM) to conduct an emission evaluation of the "A" Battery Push Emission Scrubber at its Bethlehem Plant. Testing was conducted on the outlet stack to determine compliance with Pennsylvania Department of Environmental Resources (PADER) air pollution regulations. On August 27, 1987, BCM conducted a particulate test that consisted of collecting emissions from 16 coke oven pushes.

The results of the test indicate that the "A" Battery Push Emission Scrubber exhaust stack emission rate was 57.76 lb/hr.

BCM

2.0 SCOPE AND OBJECTIVES

The scope of the project was discussed by Mr. Bruce Sandmaier of Bethlehem Steel, and Mr. James Antonik of BCM. The objective of the sampling program was to determine the following parameters:

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

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3.0 PROCEDURES

3.1 FIELDWORK

Field testing was conducted on August 27, 1987. The sampling team consisted of the following personnel:

Thomas Bernstiel - Scientist
William Kesack - Engineer
David Livingstone - Scientist

Mr. Bruce Sandmaier acted as liaison between BCM and Bethlehem Steel, and ensured that the process operated normally during the test period.

The following methods of sampling were employed in the test program:

1. Sampling and traverse locations were determined in accordance with Method 1 of the Federal Register, Volume 42, Number 160, August 18, 1977 (see Appendix 1).

2. Gas flow, gas temperature, and static pressure measurements were made in accordance with Method 2 of the Federal Register, Volume 42, Number 160, August 18, 1977 (see Appendix 1).

3. Particulate sampling was conducted in accordance with PADER Methodology, and Method 5 of the Federal Register, Volume 42, Number 160, August 18, 1977 (see Appendix 1).

4. A Fyrite gas analyzer was used to determine the molecular weight of the flue gas. The following parameters were measured to calculate the molecular weight of the dry flue gas: volume percent carbon dioxide, and volume percent oxygen. The volume percent nitrogen was determined by difference. The specific procedure is outlined in Appendix 1.

5. Moisture content sampling was conducted in accordance with Method 4 of the Federal Register, Volume 42, Number 160, August 18, 1977. The methodology is outlined in Appendix 1.

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3.2 EQUIPMENT CALIBRATION

In accordance with the procedures established by the U.S. 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 test date. Calibration data are included in Appendix 3.

3.3 ANALYTICAL METHODS

All samples generated during the sampling program were returned to the BCM Laboratory in Norristown, Pennsylvania, for analyses. Laboratory data are reported in Appendix 2.

3.4 CALCULATIONS

All particulate concentrations, moisture content, gas flow, and molecular weight calculations were prepared by computer. Raw data generated during the field sampling program and the results of the laboratory analyses were introduced into equations presented in Methods 2, 3, 4, and 5 of the Federal Register, Volume 42, Number 160, August 18, 1977. Computer input and all other data appear in Appendix 2.

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5.0 DISCUSSION OF RESULTS

5.1 GENERAL

The testing program was comprised of one particulate test on the "A" Battery Push Emission Scrubber exhaust stack.

5.2 PARTICULATE TESTING

The particulate emission concentration was 0.0445 grain/dry standard cubic foot (gr/dscf), and the emission rate was 57.76 pounds/hour (lb/hr). These data will be used by Bethlehem Steel personnel to compare actual emission rates with applicable standards set forth in PADER Regulations, Chapter 123.13.

APPENDIX 1

FIELD SAMPLING PROGRAM

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APPENDIX 1

FIELD SAMPLING PROGRAM

1.0 SAMPLING PROCEDURES

1.1 Test Station and Traverse Locations - Particulate Testing

The locations of the sampling stations and traverse points are critical to the performance of the project. An explanation of the sampling points used during the project follows.

The internal diameter of the "A" Battery Push Emission Scrubber exhaust stack was 96 inches. Four test ports were located 90 degrees apart for optimum sampling. Sixteen traverse points were selected (4 per port) to account for each of the 16 coke oven pushes.

1.2 Gas Flow and Gas Temperature Determinations

The gas flow rate and temperature profile were measured at each location by conducting a simultaneous velocity and temperature traverse. Gas velocity heads were measured with a calibrated "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 Cyclonic Flow Determinations

A check for the presence of cyclonic flow in the outlet stack was performed using an "S"-type pitot, an inclined portable manometer, and a precision protractor. The direction parallel to the duct walls was assigned a reference value of zero, and the deviation of the stack gas flow (in ± degrees from zero) was recorded for each traverse point. The absolute values of these angles were then averaged and compared to the maximum allowable deviation (10 degrees).

1.4 Moisture Content

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 the 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.

1.5 Particulate Sampling

The sampling procedures and equipment employed were those outlined in Method 5 of the Federal Register, Volume 42, Number 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 the previously completed velocity and temperature traverses. The sampling train used a 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 calibrated "S"-type pitot tube and a Chromel-Alumel thermocouple were clamped to the probe, and 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 the glass fiber filter for removal of suspended particulates. The filter was housed in a heated chamber where the temperature was maintained at 248°F $\pm$25 degrees. From the filter, the stack gas passed to the impinger train. The first two impingers each contained 150 ml of deionized 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 units of the Greenburg-Smith design, modified by replacing the tip with a 1/2-inch ID glass tube. The impinger train was immersed in an ice bath for the entire test period so that the exit gas temperature would not exceed 68°F.

From the impinger train, the gas was conducted through an umbilical cord to the control console (a Model 2343 RAC Stak Samplr), which contained the following pieces of equipment (listed in the order in which sampled gas passed 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 that were connected across the inclined manometer and used to ensure that isokinetic conditions were being maintained. A schematic diagram of the sampling train appears at the end of this appendix.

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 cfm.

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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 distilled 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 the washings collected from the nozzle and probe. All distilled water and acetone washings were stored in separate sealed polyethylene sample bottles for transfer to the laboratory. The silica gel used in the fourth impinger was removed and stored in a sealed sample bottle. The contents of the first, second, and third impingers were combined, measured volumetrically, and stored in a sealed sample bottle. A distilled water wash of the impingers was added to this same bottle. A final acetone rinse of impingers was conducted, and the washings were stored in a separate sealed sample bottle.

Blanks of the distilled water and acetone were taken to be analyzed for residue at BCM's laboratory.

1.6 Molecular Weight Determinations

A Fyrite gas analyzer was used to determine the molecular weight of the exhaust gas. 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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TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

PLANT: Bethlehem Steel
DATE: [illegible]
SAMPLING LOCATION: [illegible]
*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	.032	96"	3.07		
2	.105	96"	10.08		
3	.194	96"	18.62		
4	.323	96"	31.00		

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VELOCITY DETERMINATIONS

Client: Bethlehem Steel

Location: Bethlehem Pa.

Date: 8-26-87

Stack Pressure:

Barometric Pressure: 29.68

Pitot Factor: .84

Engineer:

Sample Port Location:

Pitot/Temperature Readings

Point No.	Distance (Inches)	Port 1		Port 2		Port 3		Port 4		Port __	
		ΔP	T	ΔP	T	ΔP	T	ΔP	T	ΔP	T
1		.17	116°	.45	116°	.54	116°	.56	116°		
2		.2		.52		.69		.73			
3		.22		.54		.77		.78			
4		.21		.56		.66		.66			
TOTAL											
AVG.											

Betz • Converse • Murdoch • Inc. BCM

NOMOGRAPH DATA

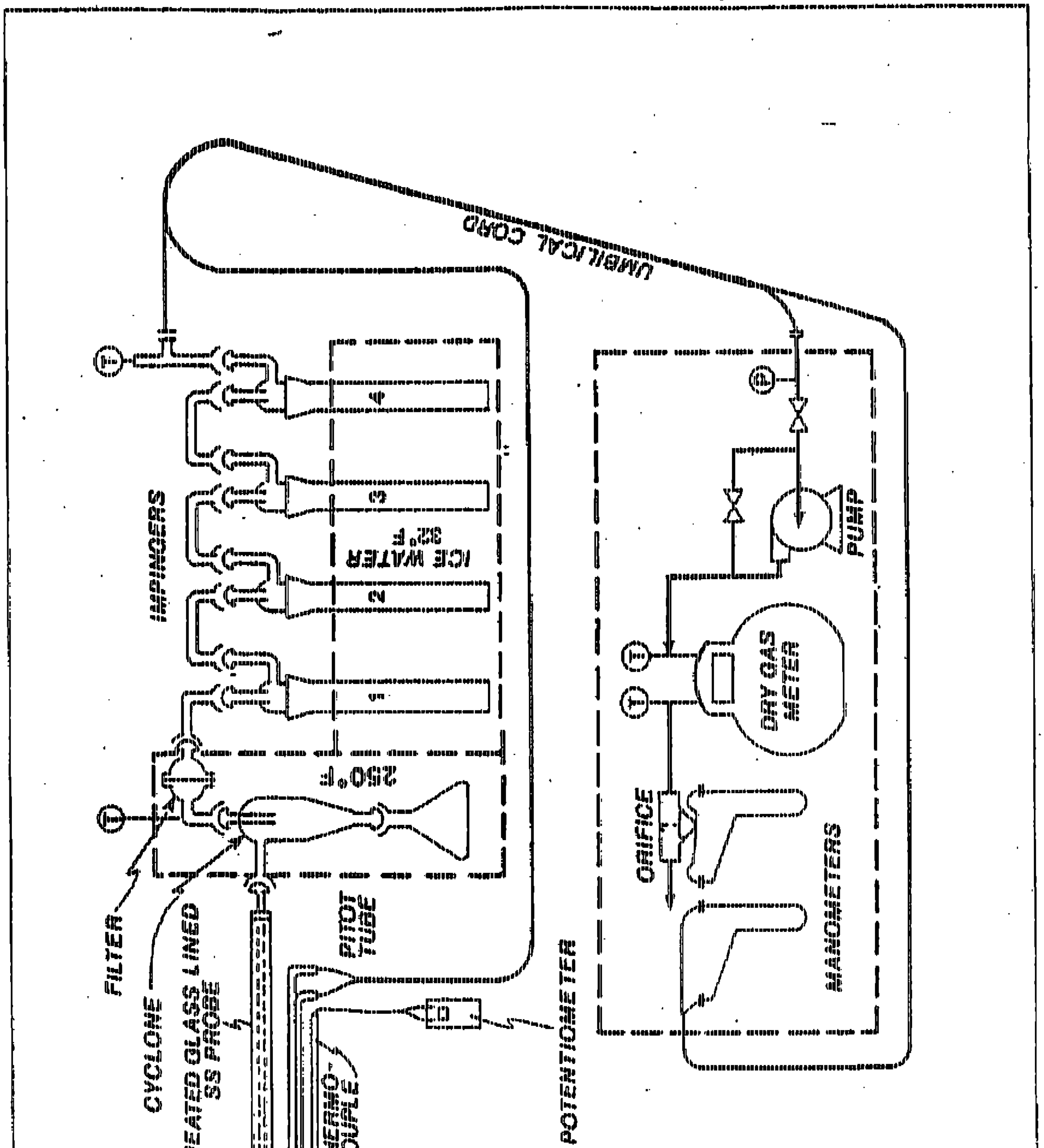
PLANT Bethlehem Steel

DATE 8-27-87

SAMPLING LOCATION "A" [illegible]

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	1.70
AVERAGE METER TEMPERATURE (AMBIENT + 20 °F), °F	$T_{m\,avg.}$	95°
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B_{wo}	3
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	
STATIC PRESSURE IN STACK, in. Hg (P_m ± 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	$T_{s\,avg.}$	116°
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	.52
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	.78
C FACTOR	1.0	
CALCULATED NOZZLE DIAMETER, in.	.245	
ACTUAL NOZZLE DIAMETER, in.	.20	
REFERENCE Δp, in. H_2O	1.2	

Cp = .84


UMBILICAL CORD
IMPINGERS
ICE WATER 32°F
1
2
3
4
250°F
FILTER
CYCLONE
HEATED GLASS LINED SS PROBE
PITOT TUBE
THERMO-COUPLE
POTENTIOMETER
NOZZLE
GAS FLOW
DRY GAS METER
ORIFICE
MANOMETERS
PUMP
T
P

EPA METHOD 5

APPENDIX 2

LABORATORY ANALYSIS AND DATA REDUCTION

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APPENDIX 2

LABORATORY ANALYSIS AND DATA REDUCTION

1.0 ANALYTICAL METHODS

All samples generated during the test program were analyzed at BCM's laboratory in Norristown, Pennsylvania. The following discussions describe the analytical methods employed.

1.1 Particulate Samples - Push Emission Scrubber

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

Nozzle, probe, and filter holder distilled water washings 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 were filtered through a 0.22-micron filter to determine the insoluble back-half particulate.

The filtrate and acetone wash of the impingers were dried separately to determine the soluble back-half particulate.

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 2-1 and 2-2.

2.0 COMPUTER INPUT SHEET

The reduced data calculated from the field data sheets were combined with the laboratory results on the computer input data sheet to facilitate programming. The computer input data sheet follows page 2-3.

3.0 CALCULATIONS

The equations used to calculate the results of the particulate test program follow the computer input data sheet.

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TABLE 2-2

PARTICULATE LABORATORY RESULTS
BACK HALF PARTICULATE CATCH (mg)

Run Number	Insoluble Back Half	Impingers and Water Wash*	Impinger Acetone Wash*	Total Catch
1	1.2	5.9	1.8	8.9

* Blank-corrected results

4.0 TEST RESULTS

The complete results of the computer analysis, and data reduction of the input generated from the particulate sampling program, follow the equations for particulate, moisture, and flow calculations.

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
$\overline{\sqrt{\Delta P}}$	=	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.

1 Heading	BETHLEHEM STEEL								
2 Number of tests	1								
3 Test type ("EPA","PA","F",or "H2S")	"EPA"								
4 Test identification (ID's in qoutes)	"1"								
5 Stack area, in^2	9238								
6 Stack temperature, °F	115								
7 Sample volume, ft^3	16.317								
8 Meter temperature, °F	64								
9 Orifice (ΔH), in. H_2O	1.46								
10 Nozzle diameter, in	.26								
11 Duration of test, min.	233								
12 Volume of CO_2, %	0								
13 Volume of CO, %	0								
14 Volume of O_2, %	21								
15 Static pressure, in. H_2O	+.27								
16 Barometric pressure, in. Hg	27.65								
17 Pitot correction factor	.84								
18 Traverse (Avg.$\sqrt{\Delta p}$), in. H_2O	.96								
19 Volume H_2O collected, ml	10								
20 Weight collected, mg	47.3								
21 Volume titrant, SO_3, ml	0								
22 Volume titrant, SO_2, ml	0								
23 Normality titrant, SO_3	0								
24 Normality titrant, SO_2	0								
25 Meter calibration factor	1.0								
26 Avg. Cosine of angle	1.0								
27 Post leak check rate, CFM	0								
28 Leak check rate no. 1, CFM	0								
29 Leak check time no. 1, min.	0								

Job Number 40-4021-12

File Name BETH VAN

BCM

TABLE 2-1

PARTICULATE LABORATORY RESULTS
FRONT-HALF PARTICULATE CATCH (mg)

Run Number	Filter	P&C Water Wash*	P&C Acetone Wash*	Total Catch
1	13.9	22.5	9.7	46.1

* Blank-corrected results

B. Alloshmo Steel
8-27-87

ING LOCATION

E TYPE

UMBER / OPERATOR DL. T.B.

ETRIC PRESSURE 29.68 STATIC PRESSURE

R NUMBER(S)

UMBER(S)

LE NUMBER PLATE NUMBER

ICKUP (ml)

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FIELD DATA SHEET

ORSAT:

CO_2 0

O_2 21

CO 0

PYROMETER NUMBER

THERMOCOUPLE NUMBER

PROBE NUMBER TYPE

NOZZLE NUMBER I.D.

METER BOX NUMBER $\Delta H_@$

PITOT NUMBER C_p

SAMPLE BOX NUMBER(S)

ASSUMED MOISTURE (%)

ASSUMED METER TEMPERATURE

C FACTOR REFERENCE Δp

READ AND RECORD ALL DATA EVERY ____ MINUTES

VERSE INT MBER	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	DRYGAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
	00	1134	302.836									
1	1'30"		303.5	.86 / .9274	1.4	1.4	124	64	64	2	250	55
3	1'30"	1146	304.4	.95 / .9747	1.5	1.5	123	66	66	5	255	48
L	1'25"	1209	305.4	.85 / .922	1.3	1.3	109	64	66	5	250	48
1	1'10"	1218	306.2	.90 / .9487	1.4	1.4	112	64	66	5	250	48
1	1'25"	1234	307.1	.97 / .9849	1.5	1.5	123	64	66	5	252	50
3	1'25"	1248	308.139	1.0 / 1	1.6	1.6	119	64	66	5	240	52
2	1'25"	1514	309.1	1.1 / 1.049	1.7	1.7	111	64	64	5	255	54
1	1'25"	1522	310.3	.92 / .959	1.45	1.45	109	64	64	5	250	50

DATE RUN 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
	1544	3103									
1'25"		311.3	1.0	1.55	1.55	105	64	64	5	250	54
	1604		/								
1'25"		312.3	1.0	1.56	1.55	104	64	64	5	250	54
	1712		/								
1'25"		313.6	1.0	1.55	1.55	124	64	64	5	255	54
	1724		/								
1'55"		315.1	.9	1.4	1.4	122	64	64	5	245	52
			.9487								
	1738										
1'25"		316.1	.85	1.3	1.3	126	64	64	5	255	56
	1750		.922								
1'25"		317.1	.9	1.4	1.4	123	64	64	5	255	56
	1801		.9487								
1'30"		318.1	.88	1.35	1.35	126	64	64	5	255	56
	1836		.9381								
1'30"		319.183	.81	1.3	1.3	126	64	64	5	245	56
			.9								

Lk check rate = .018

BCM

4.0 SUMMARY OF RESULTS

The parameters evaluated by the PADER method are contained in Appendix 2. Pertinent test results are listed below.

Run Number	Emission Concentration (gr/dscf)	Emission Rate (lb/hr)
1	0.0445	57.76

BETHLEHEM STEEL

PARAMETERS: 1

AREA OF BREECHING	(SQ FT)	50.26
SAMPLE VOLUME	(DSCF)	16.392
MOISTURE	(%)	2.8
MOLECULAR WEIGHT	(LB/LB-MOLE)	28.54
GAS TEMPERATURE	(F)	118.0
GAS VELOCITY	(FT/MIN)	3415.7
GAS VOLUME	(DRY SCFM)	151284.1
GAS VOLUME	(ACFM)	171688.8

PARTICULATE EMISSIONS:

CONCENTRATION	(GRAINS/DSCF)	.0445
CONC. @ STK COND.	(GRAINS/CF)	.0392
EMISSION RATE	(LB/HR)	57.7608

ORSAT ANALYSIS:

CARBON DIOXIDE	(VOL %)	.0
CARBON MONOXIDE	(VOL %)	.0
OXYGEN	(VOL %)	21.0
NITROGEN	(VOL %)	79.0

EXCESS AIR	(%)	-14583.2
ISOKINETICS	(%)	107.3

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APPENDIX 3

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 $68^{\circ}F$ 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, $^{\circ}F$

t_w = Average temperature of wet test meter, $^{\circ}F$

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.

APPENDIX 4

PERTINENT REGULATIONS

quirements of § 129.15(c) of this Title (relating to coke pushing operation) have been satisfied. Upon such demonstration, the Department will issue a determination, in writing, either as an operating permit condition, for those sources subject to permit requirements under the act, or as an order containing appropriate conditions and limitations.

(c) Any person responsible for any source specified in items (1) through (7) or (9) of subsection (a) of this section shall take all reasonable actions to prevent particulate matter from becoming airborne. Such actions shall include, but not be limited to, the following:

(1) Use, where possible, of water or chemicals for control of dust in the demolition of buildings or structures, construction operations, the grading of roads, or the clearing of land.

(2) Application of asphalt, oil, water or suitable chemicals on dirt roads, material stockpiles, and other surfaces which may give rise to airborne dusts.

(3) Paving and maintenance of roadways.

(4) Prompt removal of earth or other material from paved streets onto which earth or other material has been transported by trucking or earth moving equipment, erosion by water, or other means.

(d) The requirements contained in subsection (a) of this section and § 123.2 of this Title (relating to fugitive particulate matter) shall not apply to fugitive emissions arising from the production of agricultural commodities in their unmanufactured state on the premises of the farm operation.

§123.2. Fugitive particulate matter.

No person shall cause, suffer, or permit fugitive particulate matter to be emitted into the outdoor atmosphere from any source or sources specified in items (1) through (9) of §123.1(a) of this Title (relating to prohibition of certain emissions) if such emissions are:

(1) either visible, at any time, at the point such emissions pass outside the person's property, irrespective of the concentration of particulate matter in such emissions; or

(2) not visible at the point such emissions pass outside the person's property and the average concentration, above background, of three samples, of such emissions at any point outside the person's property, exceeds 150 particles per cubic centimeter.

PARTICULATE MATTER EMISSIONS

§123.11. Combustion units.

(a) No person shall cause, suffer, or permit the emission into the outdoor atmosphere of particulate matter, at any time, from any combustion unit in excess of:

(1) The rate of 0.4 lbs. per million B.t.u. of heat input, when the heat input to the combustion unit in millions of B.t.u's per hour is greater than 2.5 but less than 50.

(2) The rate determined by the formula:

$A = 3.6E^{-0.56}$

where:

A = Allowable emissions in pounds per million B.t.u. of heat input, and

E = Heat input to the combustion unit in millions of B.t.u.'s per hour,

when E is equal to or greater than 50 but less than 600.

(3) The rate of 0.1 pounds per million B.t.u. of heat input when the heat input to the combustion unit in millions of B.t.u.'s per hour is equal to or greater than 600.

(b) Allowable emissions under subsection (a) of this section are graphically indicated in Appendix A to this Chapter.

§123.12. Incinerators.

No person shall cause, suffer, or permit the emission to the outdoor atmosphere of particulate matter from any incinerator, at any time, in such a manner that the particulate matter concentration in the effluent gas exceeds 0.1 grain per dry standard cubic foot, corrected to 12% carbon dioxide.

§123.13. Processes.

(a) The provisions of subsections (b) and (c) of this section shall apply to all processes except combustion units and incinerators.

(b) No person shall cause, suffer, or permit the emission into the outdoor atmosphere of particulate matter from any process listed in the following table, at any time, either in excess of the rate calculated by the formula set forth in paragraph (2) of this subsection or in such a manner that the concentration of particulate matter in the effluent gas exceeds 0.02 grains per dry standard cubic foot, whichever is greater:

(1) *Table*

TABLE 1

Process	*Process Factor, F*
1. Carbon black mfg.	800 lbs./ton of product
2. Charcoal mfg.	400 lbs./ton of product
3. Crushers or grinders or screens	20 lbs./ton of feed
4. Paint mfg.	0.05 lbs./ton of pigment handled
5. Phosphoric acid mfg.	6 lbs./ton of phosphorous burned
6. Detergent drying	30 lbs./ton of product
7. Alfalfa dehydration	30 lbs./ton of product
8. Grain elevators. Loading or unloading	90 lbs./ton of grain
9. Grain screening and cleaning	300 lbs./ton of grain
10. Grain drying	20C lbs./ton of product
11. Meat smoking	0.01 lbs./ton of meat
12. Ammonium Nitrate mfg. Granulator	0.2 lbs./ton of product
13. Ferroalloy production furnace	0.3 lbs./ton of product
14. Primary iron and/or steel making:	
Iron production	100 lbs./ton of product
Sintering: windbox	20 lbs./ton of dry solids feed
Steel production	40 lbs./ton of product
Scarfing	20 lbs./ton of product
15. Primary lead production:	
Roasting	0.004 lbs./ton of ore feed
Sintering: windbox	0.2 lbs./ton of sinter
Lead reduction	0.5 lbs./ton of product

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16. Primary zinc production:	
Roasting	3 lbs./ton of ore feed
Sintering: windbox	2 lbs./ton of product
Zinc reduction	10 lbs./ton of product
17. Secondary aluminum production:	
Sweating	50 lbs./ton of aluminum product
Melting and refining	10 lbs./ton of aluminum feed
18. Brass and bronze production	
Melting and refining	20 lbs./ton of product
19. Iron foundry:	
Melting.	
5T./hr. and less	150 lbs./ton of iron
More than 5T./hr.	50 lbs./ton of iron
Sand handling	20 lbs./ton of sand
Shake-out	20 lbs./ton of sand
20. Secondary lead smelting	0.5 lbs./ton of product
21. Secondary magnesium smelting	0.2 lbs./ton of product
22. Secondary zinc smelting:	
Sweating	0.01 lbs./ton of product
Refining	0.3 lbs./ton of product
23. Asphaltic concrete production	6 lbs./ton of aggregate feed
24. Asphalt roofing mfg:	
Felt saturation	0.6 lbs./ton of asphalt used
25. Portland cement mfg:	
Clinker production	150 lbs./ton of dry solids feed
Clinker cooling	50 lbs./ton of product
26. Coal dry-cleaning	2 lbs./ton of product
27. Lime calcining	200 lbs./ton of product
28. Petroleum refining.	
Catalytic cracking	40 lbs./ton of liquid feed
29. Pressed, blown and spun glass; glass production melting furnaces.	50 lbs./ton of fill
30. By product coke production: pushing operation.	1 (lb./ton coke pushed)

(2) *Formula*

$A = 0.76E^{0.42}$ where:

A = Allowable emissions in lbs./hr

E = Emission index = F x W lbs./hr.

F = Process factor in lbs./unit, and

W = Production or charging rate in units/hr.

The factor F shall be obtained from the table in paragraph (1) of this subsection. The units for F and W shall be compatible.

(3) *Allowable emissions.* Allowable emissions under this subsection are graphically indicated in Appendix B to this chapter.

(c) For processes not listed in subsection (b)(1) of this section including but not limited to coke oven battery waste heat stacks and autogeneous zinc coker waste heat stacks, the following shall apply:

(1) *Prohibited emissions.* No person shall cause, suffer, or permit the emission into the outdoor atmosphere of particulate matter from any process not listed in subsection (b)(1) of this section in such a manner that the concentration of particulate matter in the effluent gas, at any time, exceeds any of the following:

(i) 0.04 grains per dry standard cubic foot, when the effluent gas volume is less than 150,000 dry standard cubic feet per minute.

(ii) The rate determined by the formula:

$A = 6000E^{-1}$, where:

A = Allowable emissions in grains per dry standard cubic foot, and

E = Effluent gas volume in dry standard cubic feet per minute.

when E is equal to or greater than 150,000 but less than 300,000.

(iii) 0.02 grains per dry standard cubic foot, when the effluent gas volume is greater than 300,000 dry standard cubic feet per minute.

(2) *Allowable emissions.* Allowable emissions under this subsection are graphically indicated in Appendix C to this Chapter.

SULFUR COMPOUND EMISSIONS

§123.21. General.

(a) This section shall apply to all sources except those subject to other provisions of this Article, with respect to the control of sulfur compound emissions.

(b) No person shall cause, suffer, or permit the emission into the outdoor atmosphere of sulfur oxides, from any source, in such a manner that the concentration, at any time, of the sulfur oxides, expressed as SO_2, in the effluent gas exceeds 500 parts per million, by volume (dry basis).

§123.22. Combustion units.

(a) *Non-air basin areas.*

(1) *General provision.* No person shall cause, suffer, or permit the emission into the outdoor atmosphere of sulfur oxides, expressed as SO^2, from any combustion unit, at any time, in excess of the rate of four pounds per million B.t.u. of heat input over any one-hour period except as provided for in paragraph (4) of this subsection.

(2) *Commercial fuel oil.* No person shall, at any time, offer for sale, deliver for use, exchange in trade, cause the use of, suffer the use of, or permit the use of commercial fuel oil in non-air basin areas which contains sulfur in excess of the applicable percentage by weight set forth in the following table:

Grades Commercial Fuel Oil	*% Sulfur*
No. 2 and Lighter (viscosity less than or equal to 5.820cSt)	0.5
No. 4, No. 5, No. 6, and heavier (viscosity greater than 5.82cSt)	2.8

(3) *Equivalency provision.* Paragraph (2) of this subsection shall not apply to those persons or installations where equipment or processes are used to reduce the emissions from the burning of fuels with a higher sulfur content than that specified in paragraph (2) of this subsection. Such emissions shall not exceed those which would result from the use of the fuels specified in paragraph (2) of this subsection.

12/15/83

	Value								
1 Heading	Bethlehem Steel, Coke Battery A Scrubber Stack								
2 Number of tests	1								
3 Test type ("EPA","PA","F",or "H2S")	"EPA"								
4 Test identification (ID's in qoutes)	"1"								
5 Stack area, in^2	7238								
6 Stack temperature, °F	90								
7 Sample volume, ft^3	12.224								
8 Meter temperature, °F	70.1								
9 Orifice (ΔH), in. H_2O	2.079								
10 Nozzle diameter, in	.239								
11 Duration of test, min.	15.42								
12 Volume of CO_2, %	0								
13 Volume of CO, %	0								
14 Volume of O_2, %	21								
15 Static pressure, in. H_2O	+.25								
16 Barometric pressure, in. Hg	29.63								
17 Pitot correction factor	.84								
18 Traverse (Avg.$\sqrt{\Delta P}$), in. H_2O	0.780								
19 Volume H_2O collected, ml	7								
20 Weight collected, mg	17.7								
21 Volume titrant, SO_3, ml	–								
22 Volume titrant, SO_2, ml	–								
23 Normality titrant, SO_3	–								
24 Normality titrant, SO_2	–								
25 Meter calibration factor	1.00								
26 Avg. Cosine of angle	1								
27 Post leak check rate, CFM	0								
28 Leak check rate no. 1, CFM	0								
29 Leak check time no. 1, min.	0								

Job Number 4021-20

File Name CBACOMP.WIN