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Commonwealth of Pennsylvania
Environmental Resources
January 17, 1992

Subject: Source Test Review

To: Data File
Bethlehem Steel Corporation
Bethlehem, Northampton County

From: William Schneider *WS*
Source Testing Unit
Division of Technical Services and Monitoring
Bureau of Air Quality Control

Through: Chief, Source Testing and Monitoring Section *LB*

The Bethlehem Steel Corporation operates a coke oven battery at its Bethlehem plant. The "A" battery consists of 80 ovens, six meters high. The coke is pushed from the ovens into a conventional moving quench car. A hood mounted on the door machine captures the emissions generated during the pushing process. This effluent passes through a venturi scrubber and cyclonic separator system located at the west end of the battery. The effluent is exhausted through the induced draft fan to the stack.

BCM Engineers, Inc. conducted a particulate test of the coke "A" battery scrubber outlet stack on September 13, 1991. On the day of the test, the average net coking time was 24 hours and the average tons of coke pushed during the day was 22.5 tons per oven. The test was conducted in accordance with standard procedures for the isokinetic collection of a particulate sample. The test results are acceptable to the Department. The following results were extracted from the test report:

Effluent Moisture Content (percent)	1.7
Effluent Temperature (°F)	119.1
Volumetric Flowrate (DSCFM)	129,528
Particulate Concentration (GR/DSCF)	0.015
Actual Particulate Emission Rate (lb/hr)	1.09
Allowable Particulate Emission Rate (lb/hr)	4.66
Percent Isokinetic	109.5

cc: Thomas DiLazaro, Bethlehem District Office
AP File through Krishnan Ramamurthy
EPA/RSL
Reading File - Source Testing

WS:mlz

October 30, 1991

SUBJECT: BETHLEHEM STEEL CORP.
"A" Battery Scrubber
Bethlehem
Northampton County

TO: L. Blaine DeHaven, Chief
Source Testing & Monitoring Section

THRU: ^{T.A.} Thomas A. DiLazaro
District Engineer

FROM: Ronald D. Mordosky *RDM*
Air Quality Specialist

Attached is a copy of the stack test which was performed on the "A" Battery scrubber stack at Bethlehem Steel's Bethlehem Coke Works.

Please review the test report to determine if the test was conducted in accordance with the Department's regulations.

RDM/bas

Attachment

1/15

PARTICULATE EVALUATION

OF

COKE BATTERY "A" SCRUBBER STACK

AT

BETHLEHEM STEEL CORPORATION
BETHLEHEM, PENNSYLVANIA

BCM NO. 00-4021-33

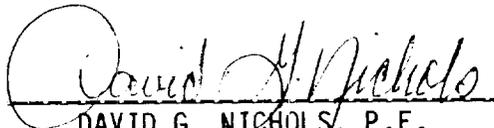
SEPTEMBER 13, 1991

PREPARED BY



PAUL JADLOWIEC
SECTION MANAGER

APPROVED BY



DAVID G. NICHOLS, P.E.
VICE PRESIDENT

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CONTENTS

1.0	EXECUTIVE SUMMARY	1
2.0	SCOPE AND OBJECTIVES	1
3.0	CONTROL SYSTEM OPERATION	1
4.0	PROCEDURES	2
4.1	Field Work	2
4.1.1	Test Station and Traverse Location	2
4.1.2	Gas Flow and Gas Temperature Measurements	2
4.1.3	Molecular Weight Determination	2
4.1.4	Moisture Content Sampling	3
4.1.5	Particulate Sampling	3
4.1.6	Field Data Sheets	4
4.1.7	Sample Recovery Procedure	4
4.2	Analysis	4
4.3	Calculations	5
4.4	Calibrations	5
4.5	Process Data	5
5.0	TEST RESULTS	5
Table 1 Summary of Results--Coke Battery "A" Scrubber Outlet		6

APPENDICES

Appendix A	Field Data Sheets	
Appendix B	Analytical Data Sheets	
Appendix C	BCM Computation Sheets	
Appendix D	Field Equipment Calibrations	
Appendix E	Process Data	



1.0 EXECUTIVE SUMMARY

Bethlehem Steel Corporation (Bethlehem Steel) retained BCM Engineers Inc. (BCM) to conduct a compliance particulate emission determination at its facility in Bethlehem, Pennsylvania. A single test run was performed at the Coke Battery "A" Scrubber Outlet Stack to determine the compliance status of the coke battery with respect to Pennsylvania Department of Environmental Resources (PADER) particulate emission standards. Testing and analysis were conducted according to EPA Method 5 and appropriate PADER test methodology.

Results indicate the actual emission rate of 1.09 pounds per hour (lb/hr) was below the allowable emission rate of 4.66 lb/hr. Complete results of the testing program can be found in Table 1 of Section 5.0.

2.0 SCOPE AND OBJECTIVES

The scope of this project was to determine particulate emissions from Coke Battery "A" Scrubber Outlet Stack. The test results will be used to determine compliance with PADER particulate emission standards. The following parameters were determined for the one test run:

Gas Flow	acfm and dscfm
Gas Temperature	°F
Gas Moisture	% by Volume
Particulate Emission	gr/dscf and lb/hr

3.0 CONTROL SYSTEM OPERATION

The control system operates in a manner such that particulate emissions from the coke pushing operation are contained by a hood and routed to the scrubber for removal. Air dampers in the system remain closed and are opened only during the coke pushing operations. Air flow through the scrubber, therefore, only occurs during coke pushing.

4.0 PROCEDURES

The field sampling program was performed on August 20, 1991. The BCM test personnel consisted of Messrs. Paul Jadowiec, Daniel Petrovay, and Karl Brenton. Mr. Lawrence Kriegler served as plant coordinator.

4.1 FIELD WORK

4.1.1 Test Station and Traverse Location

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 is 96 inches. Two test ports, located 90 degrees apart, were used for particulate sampling. Sixteen traverse points were selected (eight per port) to account for each of the sixteen coke oven pushes.

4.1.2 Gas Flow and Gas Temperature Measurements

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

4.1.3 Molecular Weight Determination

A Bacharach Fyrite analyzer was used to determine the molecular weight of the flue gas. Fyrite gas analyzers give accurate readings within +/- 0.5% Carbon Dioxide or Oxygen up to 530°C. Readings are unaffected by most other gases. The average of three samples was used for each test run. The following parameters were measured in order to calculate molecular weight: volume percentage carbon dioxide and volume percentage oxygen; the volume percentage of carbon monoxide and nitrogen was determined by difference. These parameters were measured using the principle of gas absorption in specific absorbing solutions.

4.1.4 Moisture Content Sampling

Moisture sampling was conducted employing the principles presented in EPA Method Four and concurrently with particulate sampling. Parameters evaluated in order to determine the gas stream moisture content were: sample gas volume, sample gas temperature, sample gas pressure, impinger moisture gain, and silica gel moisture gain. Some minor modifications were made to the Method Four train to allow concurrent particulate and moisture content sampling; these modifications involve no deviations 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.

4.1.5 Particulate Sampling

The sampling procedures and sampling equipment used are those outlined in Method 5 of Appendix 1, 40 CFR 60. This methodology also complies with PADER testing regulations.

A total of 16 traverse points (8 per port) were sampled during the test run. Each point was sampled during an individual oven push. Sampling at a particular traverse point corresponded to the pushing time and commenced when coke began falling into the car and continued for 30 seconds after all coke was pushed or until the dampers were closed, whichever came first. For this test, the dampers closed before the end of the 30-second time period. The total sampling time, therefore, equals the amount of time required for 16 pushes and was used to determine the average duration of a single pushing operation.

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, which was heated 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. 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 $225 \pm 25^{\circ}\text{F}$. 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 were 500-ml impingers of the Greenburg-Smith design, modified by replacing the tip with a 1/2-inch inside diameter (ID) glass tube. Note: The impinger train was immersed in an ice bath for the entire test period so that the existing gas temperature would not exceed 68°F .

From the impinger train, the gas was conducted through an umbilical cord to the control console 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 air-tight vacuum pump, a dry gas meter, and a calibrated orifice. The orifice was equipped with pressure taps which were connected across the inclined manometer and were used to ensure that isokinetic conditions were maintained.

The sampling train was subjected to a leak check prior to 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 feet 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 DI water, then acetone, and the washings obtained were added to those collected from the nozzle and the probe. All water and acetone washings were stored in separate sealed polyethylene sample bottles.

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 sealed sample bottles. The first, second, and third impingers were finally rinsed with acetone and the washings placed in a separate bottle.

4.1.6 Field Data Sheets

The following data were recorded during the sampling program: 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. The field data sheets generated during the program are contained in Appendix A.

4.1.7 Sample Recovery Procedure

Sample recovery was conducted in the BCM air van.

4.2 ANALYSIS

All analytical data sheets and calculations are contained in Appendix B. All sample analyses were conducted by BCM at their Pittsburgh, Pennsylvania, office.



4.3 CALCULATIONS

The BCM Computation Sheets contained in Appendix C show the coke production rate and allowable and actual emission rate calculations. The coke production rate of 75.00 tons per hour was calculated using the historical values of 1802 tons of coke per day and 80 ovens pushed in 24 hours. The allowable emission rate was calculated according to 123.13(b)(2) of the Pennsylvania Air Pollution Control Act. The actual particulate emission rate was calculated from the particulate concentration (gr/dscf), the stack gas flow rate (dscf/min), and the coke pushing time (min/hr). The coke push time was calculated from the average duration of a single push determined during the test run and the historical number of ovens pushed in 24 hours.

4.4 CALIBRATIONS

Field equipment calibrations are contained in Appendix D.

4.5 PROCESS DATA

All process data are contained in Appendix E.

5.0 TEST RESULTS

All gas flow rate and particulate emission data determined during the testing are contained in Table 1. All data were collected during the 16 separate oven pushes. Values as presented in Table 1, therefore, represent stack conditions during pushing operations. The particulate emission rate, however, was calculated to represent the actual pounds of particulate emitted in an hour period, based on the minutes per hour of pushing time.

The actual emission rate measured was 1.09 lb/hr. The allowable emission rate was 4.66 lb/hr.

TABLE 1
 SUMMARY OF RESULTS
 COKE BATTERY "A" SCRUBBER OUTLET

Parameter	Results
Gas Flow (acfm)	146,648
Gas Flow (dscfm)	129,528
Gas Temperature (°F)	119.1
Gas Moisture (%)	1.7
Isokinetic (%)	109.5
Actual Particulate Emissions:	
gr/dscf	0.015
lb/hr	1.09
Allowable Particulate Emissions:	
lb/hr	4.66
Backhalf Soluble Emissions:	
gr/dscf	0.014

APPENDIX A
FIELD DATA SHEETS

PLANT Bethlehem Steel DATE 8-20-91 RUN NUMBER 1 PA PARTICULATE

TRAVERSE POINT NUMBER	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V _m , ft ³)	VELOCITY HEAD (V _g , in. H ₂ O)	ORIFICE DIFFERENTIAL (ΔH, in. H ₂ O)		STACK TEMPERATURE (T _s , °F)	DRY GAS METER TEMPERATURE (T _m , °F)		PUMP VACUUM in Hg	SAMPLE BOX TEMPERATURE °F	IMPINGER TEMPERATURE °F
				DESIRED	ACTUAL		INLET (1" in.), °F	OUTLET (1" in. out.), °F			
B	12:05	119,403									
2	1:12	120,372	0.68	2.90	2.90	120	81	73	4	258	54
1	1:15	121,602	0.63	2.70	2.70	119	81	73	4	255	54
C	1:20	122,792	0.72	3.20	3.20	125	82	73	4	220	54
4	1:05	124,202	0.80	3.50	3.50	117	108	77	4	240	52
3	1:10	125,409	0.80	3.50	3.50	116	94	78	4	245	54
2	1:15	125,409	0.80	3.50	3.50	116	94	78	4	245	54
*	1:20	126,808	0.65	2.80	2.80	117	80	72	3	242	55
1	1:20	127,717	0.65	2.80	2.80	117	80	72	3	242	55
Leak CHK = Ø CFM @ 14" H ₂ O											
		Total =	Sample Volume =	Time Weighted Avg =		Time Weighted Avg =		Time Weighted Avg =		Time Weighted Avg =	
		18.87	17.986	2.92		119.1		26.6		54	
		18.67	19.305								
		17.986	TAP = 0.820								

APPENDIX B
ANALYTICAL DATA SHEETS

ANALYTICAL PARTICULATE DATA

PADER METHODOLOGY

Client BETHLEHEM STEEL-BETHLEHEM Project No. 00-4021-33

Date AUGUST 20, 1991 Run No. 1

FRONT HALF CATCH

Acetone rinse container No. 14Q
 Acetone rinse volume (Vaw) 87
 Acetone blank residue concentration (Ca) .04 mg/g
 $W_a = C_a V_{aw} p_a = (.04)(87)(1.7850) = \underline{2.73}$ mg
 Gross wt 110005.60 mg
 Tare wt 109988.25 mg
 Less acetone blank wt (W_a) 2.73 mg
 Weight of particulate in acetone rinse 14.62 mg

Water rinse container No. 14J
 Water rinse volume (V_{ww}) 108
 Water blank residue concentration (C_w) 0.00 mg/g
 $W_w = C_w V_{ww} p_w = (0)(108)(1.9982) = \underline{0.00}$ mg
 Gross wt 108686.60 mg
 Tare wt 108684.40 mg
 Less water blank wt (W_w) 0.00 mg
 Weight of particulate in water rinse 2.20 mg

Filter No. 371
 Gross wt 396.05 mg
 Tare wt 395.25 mg
 Weight of particulate on filter .80 mg
 Weight of particulate in acetone rinse 14.62 mg
 Weight of particulate in water rinse 0.00 mg
 Total weight of particulate 15.42 mg

BACK HALF CATCH

Filter No. .8 .45 .22
389 346 384
 Gross wt 229.80 mg
 Tare wt 229.80 mg
 Weight of particulate on filter 0.00 mg

TOTAL PARTICULATE CATCH

Front half 17.62 mg
 Back half 0.00 mg
 Total 17.62 mg

ANALYTICAL PARTICULATE DATA
PADER METHODOLOGY

Client BETHLEHEM STEEL - BETHLEHEM Project No. 00-4021-33
Date AUGUST 20, 1991 Run No. 1
Sample location # 1 BATTERY STACK SCRUBBER

SOLUBLE BACKHALF

Acetone rinse container No. 14R
Acetone rinse volume (Vaw) 94
Acetone blank residue concentration (Ca) .04 mg/g
 $W_a = C_a V_{aw} p_a = (.04) (94) (.17850) =$ 2.95 mg
Gross wt 114378.45 mg
Tare wt 114374.20 mg
Less acetone blank wt (W_a) 2.95 mg
Weight of particulate in acetone rinse 1.30 mg

Water filtrate container No. 14X
Water filtrate volume (V_w) 385
Water blank residue concentration (C_w) 0 mg/g
 $W_w = C_w V_w p_w = (0) (385) (.9982) =$ 0 mg
Gross wt 108495.80 mg
Tare wt 108481.25 mg
Less water blank wt (W_w) 0.00 mg
Weight of particulate in water filtrate 14.55 mg
Weight of particulate in acetone rinse 1.30 mg
Total weight of particulate 15.85 mg

BLANK ANALYTICAL DATA

Plant BETHLEHEM STEEL - BETHLEHEM

Sample location # 1 BATTERY STACK SCRUBBER

Type of blank ACETONE

Container number ISP

Density of blank (ρ_a) .7850 g/ml

Blank volume (V_a) 200 ml

Gross wt. 111272.80 mg

Tare wt. 111266.75 mg

Weight of blank (m_a) 6.05 mg

$$Ca = \frac{m_a}{V_a \rho_a} = \frac{(6.05)}{(200)(.7850)} = \underline{.04} \text{ mg/g}$$

BLANK ANALYTICAL DATA

Plant BETHLEHEM STEEL - BETHLEHEM

Sample location #1 BATTERY STACK SCRUBBER

Type of blank DISTILLED WATER

Container number ISM

Density of blank (ρ_a) .9982 g/ml

Blank volume (V_a) 200 ml

Gross wt. 108191.65 mg

Tare wt. 108191.65 mg

Weight of blank (m_a) 0.00 mg

$$Ca = \frac{m_a}{V_a \rho_a} = \frac{(0.00)}{(200)(.9982)} = \underline{0.00} \text{ mg/g}$$

APPENDIX C
BCM COMPUTATION SHEETS



COMPUTATION SHEET

Sheet Number	<u>1</u>	Of	<u>2</u>
Date	<u>9-9-91</u>		
Job Number	<u>00-4021-33</u>		
Computed by	<u>PJ</u>	Checked by	<u>JS</u>

Name of Client Bethlehem Steel Corporation

Project Coke Battery "A" scrubber outlet

Description Emission Rate Calculation

Coke Production Rate

1802 Tons/Day and 80 ovens pushed / Day

$$\therefore \frac{1802 \text{ Tons/Day}}{80 \text{ ovens/Day}} = 22.5 \text{ Tons/oven}$$

$$22.5 \text{ Tons/oven} \times 80 \text{ ovens/24 hours} = \underline{75.00 \text{ Tons/hr}}$$

Allowable Emission Rate, as per 123.13(b)(2) of PA Air Pollution Control Act

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

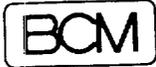
where: A = allowable emission rate, lb/hr

E = F x W, lb/hr

F = Process Factor (table 1), 1 lb/ton

W = Production Rate, 75.00 ton/hr

$$A = 0.76 (1 \text{ lb/ton} \times 75.00 \text{ ton/hr})^{0.42} = \underline{4.66 \text{ lb/hr}}$$



COMPUTATION SHEET

Sheet Number	2	of	2
Date	9-9-91		
Job Number	00-4021-33		
Computed by	PJ	Checked by	JB

Name of Client Bethlehem Steel Corporation
Project Coke Buttery "A" Scrubber Outlet
Description Emission Rate Calculation

$$\text{Actual Emission Rate (lb/hr)} = \frac{\left(\begin{array}{l} \text{Particulate} \\ \text{Concentration} \\ \text{(gr/dscf)} \end{array} \right) \left(\begin{array}{l} \text{Flow Rate} \\ \text{(dscf/min)} \end{array} \right) \left(\begin{array}{l} \text{Push Time} \\ \text{(min/hr)} \end{array} \right)}{7000 \text{ grains/lb}}$$

where:

$$\text{Particulate Concentration} = 0.015 \text{ gr/dscf}$$

$$\text{Flow rate} = 129,528 \text{ dscf/min}$$

$$\begin{aligned} \text{Push Time} &= \left(\frac{18.87 \text{ min total push time}}{16 \text{ Total ovens pushed}} \right) \left(\frac{80 \text{ ovens pushed}}{24 \text{ hours}} \right) \\ &= 3.93 \text{ min/hr} \end{aligned}$$

$$\begin{aligned} \text{Actual Emission Rate (lb/hr)} &= \frac{(0.015 \text{ gr/dscf})(129,528 \text{ dscf/min})(3.93 \text{ min/hr})}{7000 \text{ grains/lb}} \\ &= \underline{\underline{1.09 \text{ lb/hr}}} \end{aligned}$$

BETHLEHEM STEEL CORPORATION
 COKE BATTERY "A" SCRUBBER OUTLET

8-20-91
 RUN 1

PARTICULATE EMISSIONS

SYMBOL	DESCRIPTION	VALUE
Theta	= Duration of test, min.	= 18.87
Vm	= Dry sample volume (meter conditions), dcf	= 17.986
SQRT(dP)	= Average of square roots of pitot pressure differential, in. H2O	= 0.820
dH	= Orifice pressure drop, in. water	= 2.920
Ts	= Average stack temperature, deg. F	= 119.1
Tm	= Average dry gas meter temperature, deg. F	= 76.6
CO2	= CO2 in stack gas, %	= 0.00
O2	= O2 in stack gas, %	= 21.00
CO	= CO in stack gas, %	= 0.00
N2	= N2 in stack gas, %	= 79.00
Pbar	= Barometric pressure, in. Hg	= 29.46
Ps	= Stack pressure (absolute), in. Hg.	= 29.48
Cp	= Pitot correction factor, dimensionless	= 0.838
Y	= Dry gas meter correction factor	= 1.020
Dn	= Diameter of nozzle, in.	= 0.248
Ds	= Diameter of stack, ft.	= 8.000
Vlc	= Volume of liquid collected in impingers and silica gel, ml	= 6.6
Mn	= Front half particulate catch, mg	= 17.62
Mn	= Back half insoluble part. catch, mg	= 0.00
Mn	= Back half soluble part. catch, mg	= 15.85
Mn	= Total particulate catch, mg	= 17.62
An	= Area of the nozzle, sq. ft.	= 0.00034
As	= Area of the stack, sq. ft.	= 50.27
Md	= Dry molecular weight of stack gas, dry basis, lb/lb-mole	= 28.84
Vw(std)	= Volume of liquid collected, cu .ft.	= 0.311
Ms	= Molecular weight of stack gas, wet basis, lb/lb-mole	= 28.66
Vm(std)	= Dry sample volume (standard conditions), dscf	= 17.897
Vs	= Stack velocity, ft/sec	= 48.63

BETHLEHEM STEEL CORPORATION
 COKE BATTERY "A" SCRUBBER OUTLET

8-20-91
 RUN 1

PARTICULATE EMISSIONS

SYMBOL	DESCRIPTION	VALUE
Qs	= Stack gas flow, acfm	= 146678
Qsd	= Stack gas flow, dscfm	= 129528
Bws	= Moisture content of the gas stream, %	= 1.7
CO2	= CO2 in stack gas, %	= 0.00
O2	= O2 in stack gas, %	= 21.00
CO	= CO in stack gas, %	= 0.00
N2	= N2 in stack gas, %	= 79.00
I	= Isokinetic ratio, percent	= 109.8
C's	= Particulate concentration, gr/dscf	= 0.015

PADER INFORMATION

C's	= Part. conc. (front half), gr/dscf	= 0.015
C's	= Part. conc. (back half), gr/dscf	= 0.000
C's	= Part. conc. soluble, (back half), gr/dscf	= 0.014

APPENDIX D
FIELD EQUIPMENT CALIBRATIONS

PITOT CALIBRATION

Pitot No. 4-6

Date 12-3-89

Engineer KB

Range	Run No.	ΔP_{std}	A SIDE			B SIDE			DIF.
			ΔP	C_p	DEV.	ΔP	C_p	DEV.	
1	1	.025	.035	.836	Ø	.035	.836	Ø	Ø
	2	.025	.035	.836	Ø	.035	.836	Ø	
	3	.025	.035	.836	Ø	.035	.836	Ø	
AVG.			.836			.836			Ø

2	1	.20	.275	.844	.006	.28	.836	.003	Ø
	2	.20	.28	.836	.002	.285	.829	.004	
	3	.20	.28	.836	.002	.28	.836	.003	
AVG.			.838			.833			.005

3	1	.48	.68	.831	Ø	.68	.831	Ø	Ø
	2	.48	.68	.831	Ø	.68	.831	Ø	
	3	.48	.68	.831	Ø	.68	.831	Ø	
AVG.			.831			.831			Ø

4	1	.66	.90	.847	.002	.91	.843	.002	Ø
	2	.66	.91	.843	.002	.90	.847	.002	
	3	.66	.90	.847	.002	.90	.847	.002	
AVG.			.845			.845			Ø

5	1	.88	1.20	.847	Ø	1.20	.847	Ø	Ø
	2	.88	1.20	.847	Ø	1.20	.847	Ø	
	3	.88	1.20	.847	Ø	1.20	.847	Ø	
AVG.			.847			.847			Ø

6	1	1.20	1.70	.840	Ø	1.70	.840	Ø	Ø
	2	1.20	1.70	.840	Ø	1.70	.840	Ø	
	3	1.20	1.70	.840	Ø	1.70	.840	Ø	
AVG.			.840			.840			Ø

7	1	1.40	2.0	.828	Ø	2.0	.828	Ø	Ø
	2	1.40	2.0	.828	Ø	2.0	.828	Ø	
	3	1.40	2.0	.828	Ø	2.0	.828	Ø	
AVG.			.828			.828			Ø

$C_p = .838$

$$C_p = 0.99 \sqrt{\frac{\Delta P_{std}}{\Delta P_{s^*}}}$$

$$DEV. = C_p - \bar{C}_p$$

$$DEV. \leq 0.01$$

$$DIF. = \bar{C}_{p(A)} - \bar{C}_{p(B)}$$

$$DIF. \leq 0.01$$



COMPUTATION SHEET

Sheet Number _____ of _____
Date _____
J. O. Number _ - _ - _
Computed by _____
Checked by _____

Name of Client _____
Project Thermocouple Calibration
Description Date 3-8-90

K-4-5

<u>Range</u>	<u>STD</u>	<u>Actual</u>
<u>Ambient</u>	66°	65°
<u>High</u>	177°	178°
<u>Low</u>	44°	46°



METER BOX CALIBRATION SHEET

Date 6-4-91 Box No. A2 Inspector Joel S.
 Pump NEW Oil Wick CLEANED Pump Serial No. _____
 Manometers _____ Knobs OK Oil OK Tubing OK
 Quick Connects _____ Vacuum Gage Valves
 Dry Gas Meter: Volume 956.7 ft.³ Serial No. _____
 Thermometers 72 In 72 Op Out 72 Of Ambient 72 Of _____
 Amperes: Lights Switches Variac
 Leak Check - Max. Vacuum 28 in. Hg Leak Rate 0 CFM
 Remarks 29.29 Barom. DISASSEMBLED BOX - CLEANED OUT ALL LINES ETC.
 FINE TUNED DGM STROKE RATIO _____

Man. Orifice	CF _w	CF _d	T _w	IT _d	OT _d	T _d	Time θ
0.5	5.000	5.067	75	104.2	83.4	93.8	13:13 / 13:22
1.0	5.000	5.035	75	104.4	80.8	92.6	9:32 / 9:53
2.0	10.000	10.281	75	116.3	86.4	101.4	15:11 / 15:15

Tolerances: 1.6 ≤ ΔH_θ ≤ 2.1

~~0.99~~ 1.01

ΔH _θ =	$\frac{(0.0317)(\Delta H)}{(P_b)(OT_d + 460)} \left[\frac{(T_w + 460)(\theta)}{CF_w} \right]^2$	γ =	$\frac{(CF_w)(P_b)(T_d + 460)}{(CF_d)(P_b + \Delta H/13.6)(T_w + 460)}$
1.99	$\frac{0.0317(0.5)}{(29.29)(83.4 + 460)} \left[\frac{535}{(75 + 460)(13.22)} \right]^2$	1.020	$\frac{(5)(29.29)(93.8 + 460)}{(5.067)(29.29 + 0.0368)(75 + 460)}$ 535
2.08	$\frac{0.0317(1.0)}{(29.29)(80.8 + 460)} \left[\frac{535}{(75 + 460)(9.53)} \right]^2$	1.023	$\frac{(5)(29.29)(92.6 + 460)}{(5.035)(29.29 + 0.0737)(75 + 460)}$ 535
1.96	$\frac{0.0317(2.0)}{(29.29)(86.4 + 460)} \left[\frac{535}{(75 + 460)(13.35)} \right]^2$	1.016	$\frac{(10)(29.29)(101.4 + 460)}{(10.281)(29.29 + 0.147)(75 + 460)}$ 535

1.02 AVE ± .02 (2%) 1.00 ± γ ± 1.04

APPENDIX E
PROCESS DATA

NOZZLE CALIBRATION

Date 8-20-91

Calibrated by PJ

Nozzle identification number	D ₁ , in.	D ₂ , in.	D ₃ , in.	ΔD, in.	D _{avg}
For Bethlehem Steel, Coke Battery "A" Scrubber Outlet Test	0.248	0.247	0.249	0.002	0.248 0.248

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 D₁, D₂, and D₃.

Nozzle calibration data.

"A" Battery

PUWER SIDE

33	7:10
43	SP. DISTR. 22
53	47
63	59
73	8:12
83	25

COKE SIDE

5	SP. DISTR. 37
15	9:02
25	14
35	25
45	39
55	SP. ONLY 52
65	10:17
75	29
85	41

PUWER SIDE

7	53
17	CUT 4 CTS SP. DISTR. 11:06
27	31
37	43
47	55
57	12:08
67	SP. DISTR. 21
77	46
87	59

24 - OVENS
n-2 SHIFT