REPORT

TO

BETHLEHEM STEEL CORPORATION
BETHLEHEM, PENNSYLVANIA

FOR

PARTICULATE EMISSION DETERMINATIONS OF THE COKE BATTERY "A" SCRUBBER STACK

BCM PROJECT NO. 00-4021-20

JANUARY 1989

PREPARED BY

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BCM
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Commonwealth of Pennsylvania
Environmental Resources
March 6, 1989

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

Coke Oven Battery "A" at Bethlehem Steel is an 80-oven battery of 6 meter high ovens with double gas collector mains. Emissions generated during the coke pushing operation are controlled by a venturi scrubber and a cyclonic separater located at the west end of the battery.

On December 15, 1988, particulate emission testing was conducted by BCM, Inc. at the exhaust stack servicing the battery. 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 data was extracted from the test report:

Number of Ovens Pushed During Test	16
Coke Pushed During Test (tons/oven)	23.5
Volumetric Flowrate (dscfm)	126048
Emission Rate (lb/hr)	1.300
Allowable Emission Rate (lb/hr)	4.745
Percent Isokinetic	100.5

cc: William E. Nuver, Bethlehem District Office
M. Rao Kona, Norristown Regional Office
Permit File No. 48-305-001
EPA/RSL
Reading File
Douglas Lesher

JP:dlg

P7175 STR Bethlehem

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TABLE 1

TEST RESULTS

Parameter	Test Result
Gas Moisture Content (%)	2.6
Gas Temperature (°F)	90
Gas Velocity (ft/min)	2,709
Gas Volume (dry scfm)	126,048
Gas Volume (acfm)	136,161
Particulate Emission Concentration (gr/dscf)	0.0225
Actual Particulate Emission Rate (lb/hr)	1.300
Allowable Particulate Emission Rate (lb/hr)	4.745

Bethlehem
STRUCTURAL PRODUCTS DIVISION

BETHLEHEM STEEL CORPORATION
BETHLEHEM, PA 18016

January 27, 1989

Mr. N. Rao Kona
PA Department of Environmental Resources
Bureau of Air Quality Control
1875 New Hope Street
Norristown, PA 19401

Dear Mr. Kona:

Pursuant to the requirements of DER Regulations Chapter 139, attached is a report of the particulate emissions testing conducted on the Bethlehem Plant's "A" Coke Oven Battery pushing emission control system stack for the year 1988. The results show that the particulate emissions are within the allowable limit as stipulated in Section 123.13(b) of PA title 25.

Very truly yours,

BETHLEHEM STEEL CORPORATION

T. E. Kreichelt

T. E. Kreichelt
Superintendent
Environment, Safety and Health

[redacted]

sc: A. E. Moffitt (w/o Attachments)
S. A. Coppola (w/o Attachments)
D. M. Anderson

25010126.AGO

BETHLEHEM STEEL CORPORATION
BETHLEHEM PLANT

"A" Battery Pushing Emission Control System
Particulate Emissions Evaluation

Pursuant to the requirement of DER Regulations Chapter 139, particulate emission tests were conducted on the "A" Coke Oven Battery pushing emission control system stack on December 15, 1989. 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 draftfans to the stack.

On the day of the test the average net coking time was approximately 25.7 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 23.5 tons per oven.

Venturi pressure drops during the test were approximately 35 inches of water on the north and south scrubber. During the test, water flow rates averaged 750 GPM to each of the 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.

Sampling Results

Test results are summarized in BCM's test report, Attachment 2. The total particulate loading (front half plus back half insolubles) for the test was calculated at 1.30 lb./hr. The calculated allowable limit is 4.74 lb./hr.

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Attachment 1

'A' Battery Scrubber Test 12/15/88
Ovens Pushed

Oven No.	Time
64	8:45
84	9:11
6	9:25
36	13:43
46	13:54
56	14:04
66	14:19
76	14:29
86	15:34
28	16:20
38	16:33
48	16:47
58	16:58
68	17:09
78	17:23
1	17:52

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CONTENTS

TABLES

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1.0 EXECUTIVE SUMMARY

Bethlehem Steel Corporation (Bethlehem Steel) retained BCM Eastern Inc. (BCM) to conduct a compliance 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.

Results show that the actual emission rate of 1.300 pounds per hour (lb/hr) was below the allowable emission rate of 4.745 lb/hr. Complete results of the testing program can be found in Table 1 of Section 5.0.

TABLE B-1

LABORATORY RESULTS
PENNSYLVANIA PARTICULATE CATCH

Sample Fraction	Particulate Weight (mg)
Filter	0.6
Front-Half Water Wash	5.4
Front-Half Acetone Wash	7.7
Insoluble Back-Half (0.22 u filter)	4.0
TOTAL	17.7

TABLE B-2

LABORATORY RESULTS
SOLUBLE PARTICULATE CATCH

Sample Fraction	Particulate Weight (mg)
Impinger Acetone Wash	6.7
Soluble Back-Half (Impinger Filtrate)	3.6
TOTAL	10.3

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2.0 SCOPE AND OBJECTIVES

The scope of the project included a single particulate emission test at the scrubber outlet stack to determine the compliance status of the coke battery. The objectives of the sampling were to determine the following parameters:

- Gas flow - acfm and scfm
- Gas temperature - °F
- Gas moisture content - percent by volume
- Gas velocity - fpm
- Particulate emissions - grains/dscf and lb/hr

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3.0 PROCEDURES

3.1 FIELD WORK

Field testing was conducted on December 15, 1988. The sampling team consisted of the following BCM personnel:

Phillp C. Burg, Project Manager
Karl Brenton, Technician

Mr. George Ossman 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 procedure as outlined in U.S. Environmental Protection Agency (EPA) Reference Methods 1 through 5 of the Federal Register, Volume 42, Number 160. Descriptions of these methodologies can be found in Appendix A of this report.

3.2 ANALYTICAL METHODS

All samples generated during the sampling program were analyzed at the BCM Laboratory in Norristown, Pennsylvania. An outline of the analytical methodologies is contained in Appendix B. Laboratory data are also presented in Appendix B.

3.3 CALCULATIONS

BCM's HP 3000 computer, programmed to accept input data in accordance with EPA calculation procedures, was used to perform most calculations. The reduced data appear on the computer input sheet, which is presented in Appendix B. Appendix B also contains the equations used to determine the test results and also the BCM computation sheets which show the allowable and actual particulate emission rate calculations.

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 prior to the test program. Appendix C provides calibration data.

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4.0 CONTROL SYSTEM OPERATION AND TESTING PROCEDURE

4.1 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.

4.2 TESTING PROCEDURE

A total of 16 traverse points (eight 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. 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.

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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.

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6.0 DISCUSSION OF RESULTS

6.1 GENERAL

Sampling went well and no problems were experienced. Isokinetic deviations were within the allowable range and pre- and post-leak checks were below the maximum allowable leakage rate.

6.2 CALCULATIONS

The BCM Computation Sheets contained in Appendix B show the coke production rate and allowable and actual emission rate calculations. The coke production rate of 78.33 tons per hour was calculated using the historical values of 23.5 tons of coke per oven 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.

APPENDIX A

FIELD SAMPLING PROGRAM

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APPENDIX A

FIELD SAMPLING PROGRAM

1.0 SAMPLING PROCEDURES

1.1 Test Station and Traverse Location

The 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 16 coke oven pushes.

1.2 Gas Flow and Temperature Determinations

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

1.3 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 concurrent sampling of particulate and moisture content. These modifications did not deviate from sampling principles.

The modifications made included the substitution of a glass fiber for Pyrex wool as a filtering medium and the substitution of a calibrated orifice for a rotameter as a flow metering device.

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1.4 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 the Pennsylvania Department of Environmental Resources (PADER) testing regulations.

The size of the nozzle required to maintain isokinetic sampling was calculated from the results of a previously completed velocity and temperature traverse. The sampling train used a glass-lined stainless steel probe, 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 ± 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 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 exiting 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 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 is depicted following the data sheets.

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 for transfer to the BCM 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 sealed sample bottles for transfer to the BCM Laboratory. The first, second, and third impingers were finally rinsed with acetone and the washings placed in separate bottles.

1.5 Molecular Weight Determinations

A Fyrite gas analyzer was used to determine the molecular weight of the exhaust gas at each source. The following parameters were measured in order to calculate molecular weight: volume percent carbon dioxide (CO_2), volume percent oxygen (O_2), and volume percent nitrogen (N_2), determined by difference.

2.0 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 appear at the end of this appendix.

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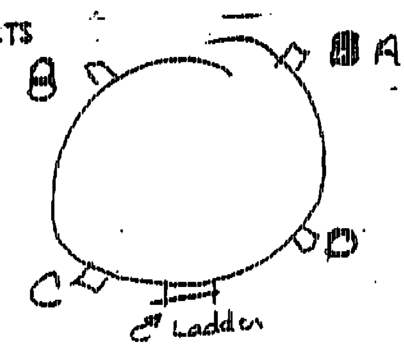
TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

PLANT Bethlehem Steel
DATE 10/21/88
SAMPLING LOCATION Coke Battery Scrubber Stack
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 1/4 INCH)	DISTANCE B	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5)
1	.032	96"	3.1 ✓	5"	8.1
2	.105	↓	10.1 ✓	↓	15.1
3	.194		18.6 ✓		23.6
4	.323		31.0 ✓		36.0
5	.677		65.0 ✓		70.0
6	.806		77.9 ✓		82.9
7	.895		85.9 ✓		90.9
8	.968		92.9 ✓		97.9

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VELOCITY DETERMINATIONS

Client: Bethlehem Steel Sample Port Location:

Location: Coke Batteries A Scrubber Stack

Date: 12/14/82

Stack Pressure: _____

Barometric Pressure: _____

Pitot Factor: _____

Engineer: _____

Pitot/Temperature Readings

Point No.	Distance (Inches)	Port A		Port A		Port A		Port__		Port__	
		ΔP	T	ΔP	T	ΔP	T	ΔP	T	ΔP	T
1		.40		.40	93	.38					
2		.50	92	.56		.47					
3		.60		.64		.62	94				
4		.64		.65	93	.65					
5		.68		.70		.66					
6		.65		.71	92	.62	95				
7		.68		.71		.65					
8		.70		.70	92	.					
TOTAL											
AVG.				ΔP =	.62						

$\sqrt{\Delta P} = .778$

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NOMOGRAPH DATA

PLANT Bethlehem Steel

DATE 12/15/88

SAMPLING LOCATION _____

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	1.79 BCM 1.25
AVERAGE METER TEMPERATURE (AMBIENT + 20°F), °F	$T_{m\,avg.}$	90
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B_{wo}	3
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	
STATIC PRESSURE IN STACK, in. Hg ($P_m \pm 0.073$ x STACK GAUGE PRESSURE in in. H_2O)	P_s	
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	
AVERAGE STACK TEMPERATURE, °F	$T_{s\,avg.}$	95
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	
C FACTOR		
CALCULATED NOZZLE DIAMETER, in.		
ACTUAL NOZZLE DIAMETER, in.		
REFERENCE Δp, in. H_2O		

Bethlehem Steel

12/15/88

LOCATION Coke Battery Scrubber Stack Outlet

...PE PM-Part

...R CMB OPERATOR PCB

...IC PRESSURE 29.63 STATIC PRESSURE

...NUMBER(S)

...ER(S) + Impinger

...NUMBER PLATE NUMBER

...P (ml) +0 ml

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ORSAT:

CO_2 ____

O_2 ____

CO ____

PYROMETER NUMBER

THERMOCOUPLE NUMBER

PROBE NUMBER TYPE

NOZZLE NUMBER I.D. .239

METER BOX NUMBER 125 $\Delta H_@$ 1.79

PITOT NUMBER #9-7 C_p

SAMPLE BOX NUMBER(S)

ASSUMED MOISTURE (%) 3

ASSUMED METER TEMPERATURE 80°

C FACTOR 1.0 REFERENCE Δp .55

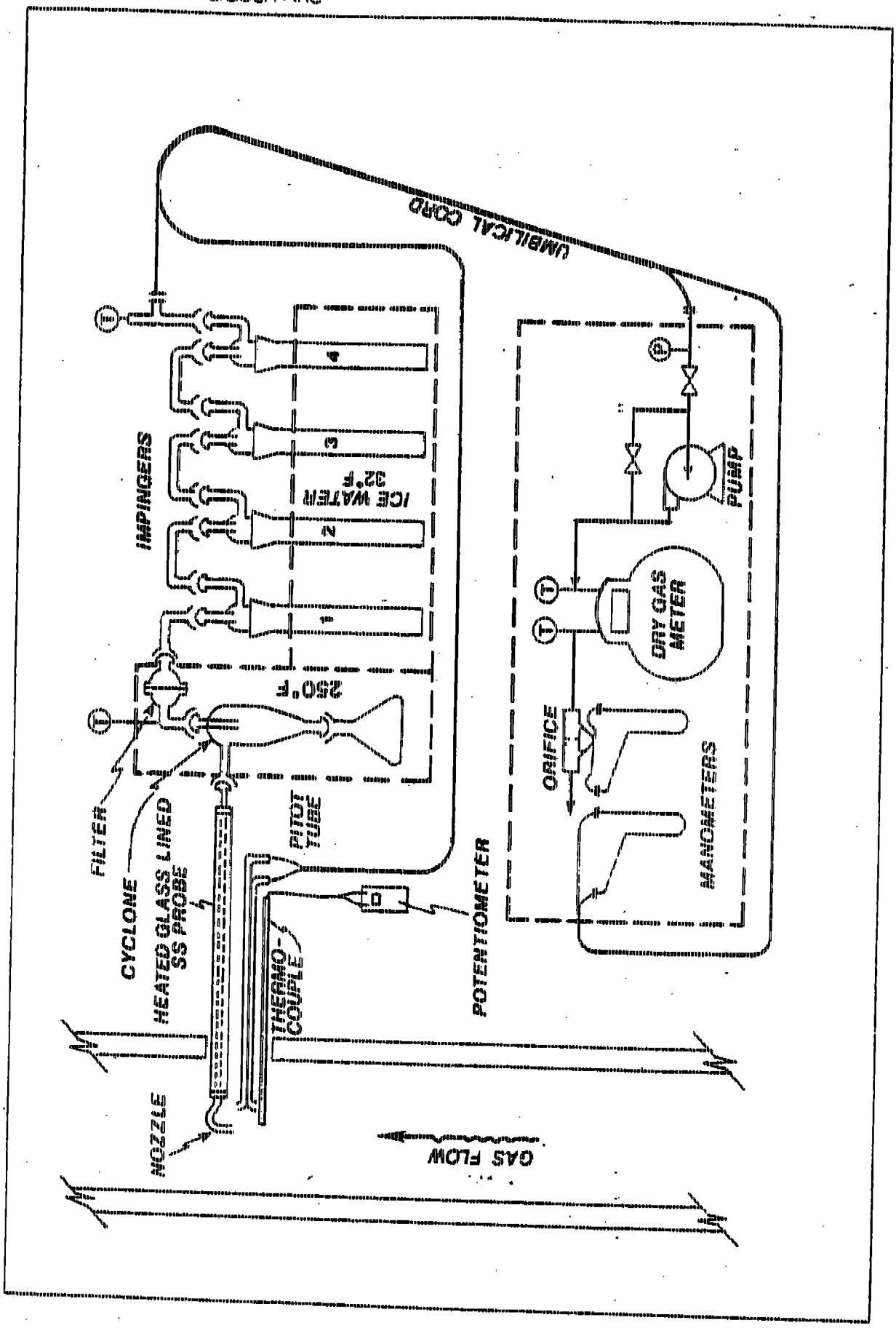
READ AND RECORD ALL DATA EVERY ____ MINUTES

...E	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
		0845	238.188									
3	1'05"	0846	239.965	.63	2.10	2.10	93	79	63	12	220	44
		0911		.7937								
7	0'55"	0912	239.764	.66	2.30	23	96	67	57	14	200	42
		0925		.8124								
5	0'55"	0926	240.510	.68	2.30	2.30	95	67	57	15	225	44
		1343		.8246								
5	1'00"	1344	241.350	.67	2.10	2.10	92	57	55	3	235	40
		1354		.7474								
4	0'55"	1355	242.152	.64	2.20	2.40	92	77	57	3	236	40
		1403		.8								
3	0'55"	1404	242.845	.62	2.10	2.10	91	77	61	3	242	40
		1418		.7874								
2	0'55"	1419	243.575	.54	1.80	1.80	90	90	65	3	288	40
		1429		.7348								
1	0'50"	1430	244.160	.40	1.35	1.35	90	78	69	2	207	40
				.6324								
					1.37643							
						1.00486 ✓						

Bethlehem Steel

DATE 12/15/88 RUN NUMBER one

SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
				DESIRED	ACTUAL		INLET (T_{m_i}), °F	OUTLET (T_{m_o}), °F			
	1534	244.768									
1'10"	1535	245.417	.34	1.15	1.15	76	72	59	2	244	40
	1619		.583								
1'05"	1620	246.190	.55	1.85	1.85	87	61	59	2	245	38
	1632		.7416								
0'55"	1633	246.887	.63	2.10	2.10	87	81	60	2	245	36
	1646		.7937								
0'50"	1647	247.676	.64	2.10	2.10	87	78	63	3	248	36
	1657		.8								
0'50"	1658	248.306	.64	2.10	2.10	88	92	68	2	239	34
	1709		.8								
1'05"	1710	249.200	.78	2.60	2.60	93	95	74	2	234	34
	1723		.883								
0'55"	1724	250.138	.80	2.70	2.70	94	86	76	3	233	34
	1737		.8944								
1'05"	1753	259.020	.70	2.30	2.30	87	72	70	2	231	34
			.8367								
926 sec											
15.42 min		V_m = 12.224 ✓	$\sqrt{\Delta p}$ = .780 ✓ (time weighted)		ΔH = 2.079 ✓		T_m = 70.1 ✓				
						T_s = 90.0 ✓					


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

EPA METHOD 5

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APPENDIX B

LABORATORY ANALYSIS AND DATA REDUCTION

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APPENDIX B

LABORATORY ANALYSIS AND DATA REDUCTION

1.0 ANALYTICAL METHODS

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

1.1 Particulate Samples

Prior to their use in the field, all glass fiber filters used in the sampling program had been tare-weighted following 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 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 these locations in the sampling train.

A 100 ml aliquot of the impinger solutions was filtered through tared 0.22 micron filters. The filters were desiccated and reweighed and any weight gain represented the insoluable particulate matter contained in the back-half portion of the particulate catch. The 100 ml filtrates and impinger acetone washes were evaporated in tared beakers, desiccated and reweighed. Any residue was considered the soluble back-half portion of the particulate catch.

Water and acetone 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.

Table B-1 contains the portions of the particulate catch which were used as per PADER regulations to determine particulate emissions. These portions include the particulate contained on the filter, the front half water and acetone washes, and the insoluable back-half particulate catch. Table B-2 contains the soluble back-half particulate catch which was reported (as per PADER regulations) but not included in the emission calculations.

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1.2 Moisture Content

The silica gel had been tare-weighed prior to its use in the field. After its use, the silica gel was reweighed. The entire weight gain was due to water vapor. The total volume of the impinger solutions, minus the original volume of water in the impingers, plus the volume of moisture and/or vapor collected by the silica gel, equaled the total moisture gain of the sampling train. This volume was used as the basis for percent moisture by volume calculations.

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 sheets to facilitate programming. The computer input data sheets are included in this appendix.

3.0 EQUATIONS FOR THE CALCULATIONS OF TEST RESULTS

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

4.0 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.

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COMPUTATION SHEET

Sheet Number 1 of 2
Date 1/12/89
J. O. Number
Computed by F. Berg
Checked by

Name of Client: Bethlehem Steel
Project: Compliance determination, Coke battery A
Description: Allowable emission rate calculation

A. Coke Production Rate

historically: 23½ tons coke/oven and 80 ovens pushed in 24 hours

therefore:

$$\left(\frac{80 \text{ ovens}}{24 \text{ hrs.}}\right)\left(23.5 \text{ tons/hr}\right) = 78.33 \text{ tons/hr}$$

B. 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, 78.33 tons/hr

$$A = (0.76)(1 \text{ lb/ton} \times 78.33 \text{ tons/hr})^{0.42}$$

$$A = 4.745 \text{ lb/hr}$$

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COMPUTATION SHEET

Sheet Number 2 of 2
Date 1/2/92
J. O. Number -
Computed by E.B.Lacy
Checked by

Name of Client Bethlehem Steel
Project Emissions determination - Coke Battery A
Description Actual Emission Rate calculations

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

where:

gr/dscf = 0.0225

Flow rate = 126,048 dscf/min

$$\text{push time} = \left(\frac{15.42 \text{ min total push time}}{16 \text{ total ovens pushed}}\right)\left(\frac{20 \text{ ovens pushed}}{24 \text{ hrs}}\right)$$

$$= 3.21 \text{ min/hr}$$

$$\text{Actual Emission Rate (lb/hr)} = \frac{(0.0225 \text{ gr/dscf})(126,048 \text{ dscf/hr})(3.21 \text{ min/hr})}{7000 \text{ gr/lb}}$$

$$= 1.300 \text{ lb/hr}$$

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

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

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

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

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

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

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

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

LEGEND

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

V_s = Stack velocity, ft/min

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

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

W_t = Total weight of particulates collected, mg

Θ = Duration of test, min.

BETHLEHEM STEEL, COKE BATTERY A SCRUBBER STACK OUTLET 12/15/88

PARAMETERS:		1
AREA OF BREECHING	(SQ FT)	50.26
SAMPLE VOLUME	(DSCF)	12.115
MOISTURE	(%)	2.6
MOLECULAR WEIGHT	(LB/LB-MOLE)	28.55
GAS TEMPERATURE	(F)	90.0
GAS VELOCITY	(FT/MIN)	2708.9
GAS VOLUME	(DRY SCFM)	126047.6
GAS VOLUME	(ACFM)	136160.7
PARTICULATE EMISSIONS:		
CONCENTRATION	(GRAINS/DSCF)	.0225
CONC. @ STK COND.	(GRAINS/CF)	.0209
EMISSION RATE	(LB/HR)	24.3665
ORSAT ANALYSIS:		
CARBON DIOXIDE	(VOL %)	.0
CARBON MONOXIDE	(VOL %)	.0
OXYGEN	(VOL %)	21.0
NITROGEN	(VOL %)	79.0
EXCESS AIR	(%)	-14583.2
ISOKINETICS	(%)	100.5

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APPENDIX C

EQUIPMENT CALIBRATION

1.0 PITOT CALIBRATION

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

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

Where:

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

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

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

ΔP_{std} = Velocity head measured by standard pitot

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

2.0 DRY GAS METER AND ORIFICE METER

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

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

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

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

Where:

ΔH = Orifice pressure differential, in H_2O

P_b = Barometric pressure, in Hg

t_d = Average temperature of dry gas meter, °F.

t_w = Average temperature of wet test meter, °F

θ = Duration of test, min.

V_d = Dry gas meter volume, ft^3

V_w = Wet test meter volume, ft^3

3.0 POTENTIOMETER CALIBRATION

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

4.0 PROBE CALIBRATION

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

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METER BOX CALIBRATION SHEET

Date 10/26/05 Box No. 125 Inspector AK

Pump ✓ Oil ✓ Wick ✓ Pump Serial No. _____

Manometers ✓ Ends ✓ Oil ✓ Tubing ✓

Quick Connects _____ Vacuum Gage _____ Valves NO

Dry Gas Meter ✓ Volume _____ ft³ Serial No. _____

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

Amphenol _____ Lights _____ Switches _____ Variac _____

Leak Check - Max. Vacuum 27 in. Hg Leak Rate 0 CFM

Remarks _____

CBP

Man. Orifice	CF_w	CF_d	T_w	IT_d	OT_d	T_d	Time θ
0.5	5.005	5.100	63	84.2	65.7	75.0	11.98
1.0	5.005	5.083	66	89.2	68.8	79	8.56
2.0	10.007	10.440	62	101.8	73.6	87.7	12.82

29.66

29.50

29.66

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

$$\Delta H_@ = \frac{(0.0317)(\Delta H)}{(P_b)(OT_d+460)}\left[\frac{(T_w+460)(\theta)}{(CF_w)}\right]^2$$

$$Y = \frac{(CF_w)(P_b)(T_d+460)}{(CF_d)(P_b+\Delta H/13.6)(T_w+460)}$$

$\Delta H_@$ = $\frac{(0.0317)(0.5)}{(29.60)(\frac{65}{65.7}+460)(525)}\left[\frac{(65^{523}+460)(11.98)}{(5.005)}\right]^2$ = 1.67

Y = $\frac{(5.005)(29.66)(75^{539}+460)}{(5.100)(29.66+0.0368)(\frac{63}{523}+460)}$ = 1.003

$\Delta H_@$ = $\frac{(0.0317)(1.0)}{(29.50)(68.8+460)}\left[\frac{(66^{526}+460)(8.56)}{(5.005)}\right]^2$ = 1.64

Y = $\frac{(5.005)(29.50)(79^{539}+460)}{(5.083)(29.50+0.0737)(\frac{66}{526}+460)}$ = 1.007

$\Delta H_@$ = $\frac{(0.0317)(2.0)}{(29.66)(73.6+460)}\left[\frac{(62^{522}+460)(12.82)}{(10.007)}\right]^2$ = 1.79

Y = $\frac{(10.007)(29.66)(87.7^{547.7}+460)}{(10.440)(29.66+0.147)(\frac{62}{522}+460)}$ = 1.00

BCM METER BOX CALIBRATION SHEET

Date 12-19-97 Box No. 125 Inspector KA

Pump ✓ Oil ✓ Vac ✓ Pump Serial No. —

Manometers ✓ Knobs ✓ Oil ✓ Tubing ✓

Quick Connects ✓ Vacuum Gage ✓ Valves ✓

Dry Gas Meter ✓ Volume — ft³ Serial No. —

Thermometers — In — °F Out — °F Ambient 66 °F

Amphenol ✓ Lights ✓ Switches ✓ Varias —

Leak Check - Max. Vacuum ____ in. Hg Leak Rate ____ CFM

Remarks ____

Man. Orifice	CF_w	CF_d	T_w	T_d	OT_d	T_d	Time θ
0.5	3.76	3.845	65	85	65	75	10
1.0	5.692	5.942	65	97	70	84	10
2.0	7.871	8.265	65	102	78	90	10

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

$\Delta H_@ =$	$\frac{(0.0317)(\Delta H)}{(P_b)(OT_d+460)}\left[\frac{(T_w+460)(\theta)}{(CF_w)}\right]^2$	$Y =$	$\frac{(CF_w)(P_b)(T_d+460)}{(CF_d)(P_b+\Delta H/13.6)(T_w+460)}$
1.98	$\frac{(0.0317)(0.5)}{(29.92)(65+460)}\left[\frac{(65+460)(10)}{(3.76)}\right]^2$	1.00	$\frac{(3.76)(29.92)(75+460)}{(3.826)(29.92+0.0368)(65+460)}$
1.70	$\frac{(0.0317)(1.0)}{(29.92)(76+460)}\left[\frac{(65+460)(10)}{(5.692)}\right]^2$	.99	$\frac{(5.692)(29.92)(84+460)}{(5.942)(29.92+0.0737)(65+460)}$
1.85	$\frac{(0.0317)(2.0)}{(29.92)(78+460)}\left[\frac{(65+460)(10)}{(7.871)}\right]^2$	.99	$\frac{(7.871)(29.92)(90+460)}{(8.265)(29.92+0.147)(65+460)}$

NOZZLE DIAMETER CALIBRATION SHEET

PRE-TEST

Set No. _____ Date 12/14/88 Inspector R Quay

Nominal Size	Micrometer Readings 1	2	3	Ave.	Comments
0.125					
0.1875					
0.250	.238	.241	.239	.239	
0.3125					
0.375					
0.500					

POST-TEST

Set No. _____ Date 12/20/88 Inspector R Quay

Nominal Size	Micrometer Readings 1	2	3	Ave.	Comments
0.125					
0.1875					
0.250	.238	.240	.239	.239	
0.3125					
0.375					
0.500					