

# THE ALMEGA CORPORATION

JACA-64

Note: This is a reference cited in AP 42, *Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources*. AP42 is located on the EPA web site at [www.epa.gov/ttn/chief/ap42/](http://www.epa.gov/ttn/chief/ap42/)

The file name refers to the reference number, the AP42 chapter and section. The file name "ref02\_c01s02.pdf" would mean the reference is from AP42 chapter 1 section 2. The reference may be from a previous version of the section and no longer cited. The primary source should always be checked.

AP-42 Section 12.2  
Reference  
Report Sect. 4  
Reference 12B

NO. 2 COKE SIDE EMISSIONS CONTROL  
GAS CLEANING CAR  
SCRUBBER STACK EXHAUST  
PARTICULATE EMISSIONS TESTING  
INLAND STEEL COMPANY

## REPORT PREPARED FOR:

INLAND STEEL COMPANY  
3210 WATLING STREET  
EAST CHICAGO, INDIANA 46312

## REPORT PREPARED BY:

THE ALMEGA CORPORATION  
607-C COUNTRY CLUB DRIVE  
BENSENVILLE, ILLINOIS 60106

INLAND P.O. NO. N-47176

THE ALMEGA CORPORATION  
PROJECT I-5438

AUGUST, 1980

Inland Steel Company  
Indiana Harbor Works  
3210 Watling Street  
East Chicago, Indiana 46312

219 392 3261

Donald C. Lang  
Director  
Air & Water Control



**Inland Steel**

September 2, 1980

Ms. Sandra Gardebring  
Director, Enforcement Division  
Region V  
U. S. Environmental Protection Agency  
230 South Dearborn  
Chicago, Illinois 60604

SUBJECT: EPA Consent Order H79-75  
Inland Steel Company

Dear Ms. Gardebring:

In our letter to you dated July 31, 1980, we had indicated that a compliance test on the second pushing emission control car for Coke Oven Batteries Nos. 6, 7, 8, 9 and 10 was scheduled for August 4, 1980. That test has been completed, and a copy of the test results are hereby submitted.

If you have any questions, please call me at 219/392-3261.

Very truly yours,

JDF:mb  
Attachment

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## EMISSION TESTING OF THE NO. 2 COKE SIDE GAS CLEANING CAR: INLAND STEEL COMPANY

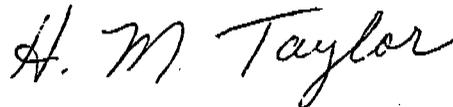
Testing was performed August 4-8, 1980, by The Almega Corporation to determine the particulate emission rate from the No. 2 Coke Side Emission Control Gas Cleaning Car in Plant 2 at Inland Steel Company in East Chicago, Indiana.

This report details the test procedures and results of this emission test. Attached as appendices is a complete documentation of all test methodologies, field test data and calculation summary data sheets, and sampling equipment calibration data.

The emission test was performed by Mr. H. M. Taylor and Mr. J. Lewis of The Almega Corporation. Mr. H. M. Taylor was team leader and certifies to the accuracy of the report.

Respectfully submitted,

THE ALMEGA CORPORATION



H. M. Taylor

HMT: nw

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## EMISSION TESTING OF THE NO. 2 COKE SIDE GAS CLEANING CAR: INLAND STEEL COMPANY

### INTRODUCTION

Particulate emissions testing was performed August 4-8, 1980 on the No. 2 Coke Side Emission Control Gas Cleaning Car at Inland Steel Company in East Chicago, Indiana.

The purpose of this test series was to determine degree of compliance of this quench car scrubber exhaust stack with applicable State of Indiana and USEPA emission regulations.

Mr. Mike Turner of Inland Steel coordinated the test and monitored quench car and coke battery operations during the testing. Also present during the test series were representatives of National Steel Corporation who monitored scrubber operations throughout the test.

Mr. Stephen Gronberg and Mr. Peter Spawn of GCA Technology Division (contracted by the Federal EPA) witnessed the test procedures during testing.

### SUMMARY OF TEST METHODS

The stack emission test, comprising three repetitions, followed the protocol requested by Inland Steel and included in Appendix B.

Testing was performed using the four sampling ports located on the short side of this 32 1/2 x 57 inch rectangular tapered stack. At this location testing was conducted at three points along each of four stack traverses making a total of 12 sampling points for each test repetition. Each stack sampling point corresponded to one coke oven push. Sampling at each test point was conducted from the time each coke push was commenced and terminated when the coke car arrived at the quench tower, the fan dampers closed and the quench sprays were switched on. Each test repetition consisted of 12 sampling points and 12 coke pushes with a total of 36 coke pushes and 3 test repetitions representing the entire emission test.

Emission testing was conducted using a Western Precipitation Method 5 EPA sampling train generally following the procedural requirements as detailed in Methods 1 through 5 in the Code of Federal Regulations, (CFR) (Ref. 1).

The location of the 12 sampling points for this test followed the CFR Title 40, Method 1 (Ref. 1) included in Appendix C.

The stack gas velocity was determined using an S type pitot tube and followed the CFR Title 40 Method 2 (Ref. 1) included in Appendix D.

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Stack gas Orsat samples were taken following the CFR Title 40 Method 3 (Ref. 1) included in Appendix E for determination of CO<sub>2</sub>, O<sub>2</sub> and molecular weight.

The stack gas moisture was determined following the CFR Title 40 Method 4 (Ref. 1) included in Appendix F.

Particulate concentration and emission rate was determined generally following Method 5 of the CFR Title 40 (Ref. 1) included in Appendix G. The gas velocity and moisture determinations were conducted simultaneously with the particulate emission testing.

The particulate catch included nozzle, probe, cyclone and prefilter washings and filter particulates.

A stainless steel lined 72 inch long sampling probe and 0.1875 inch I.D. stainless steel sampling nozzle were used for the three test repetitions.

## SUMMARY OF TEST RESULTS

Results of this test series are summarized in Table 1.

A diagram of the one spot quench car showing the stack and sampling port location is shown in Figure 1.

The field test and laboratory analysis data, calculation summaries and equipment calibration data are included in Appendix A.

## DISCUSSION OF TEST RESULTS

1) Scrubber stack particulate emissions in lbs per ton of coke pushed are calculated below:

Test Repetition#	1	2	3
Particulate emission lbs/hr	8.437	8.822	10.813
Test time mins.	23.08	28.38	25.37
Coke production tons/test run	119.6	123.8	120.9
Particulate emissions* lbs/ton of coke	0.0271	0.0337	0.0378

\*For test repetition #1, this is calculated from:

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$$\frac{8.437 \times \frac{23.08}{60}}{119.6} = 0.0271 \text{ lbs/ton of coke pushed}$$

2) Since the stack gas velocity, temperature and moisture was variable between the time the coke was pushed into the car to the commencement of the water sprays at the quench tower, 100% isokinetic sampling during each test repetition was difficult to maintain. However, using the stack gas temperatures and velocity head readings obtained at the beginning and end of each sampling point and calculating the average for each test repetition, isokinetic sampling rates were 93.4, 97.8 and 95.1% for test runs #1, #2, and #3, respectively. Based upon the nature of the process itself, fluctuations in the stack gas parameters and motion of the car, these isokinetic sampling rates are, in our opinion, extremely good.

3) The average stack gas velocity and temperature determined for the beginning and end of each test repetition and the average used in the calculation for the stack gas volume flow rate are shown in the summary calculation data sheets included in Appendix A.

Typically, the average stack gas temperatures ranged from 108 to 1390F and the average velocities from 70 to 83 ft/sec. Stack gas moistures ranged from 14.9 to 16.1% on a vol/vol basis.

4) The sampling time for each point ranged typically between 1 3/4 and 2 1/2 minutes. Consequently, the total sampling time for each 12 point run ranged from 23 to 28 minutes for each of the three repetitions. This follows the sampling protocol of Appendix A, but is less than the 1 hour minimum test repetition time required by CFR Title 40 (Ref. 1).

5) Due to the shorter test times for each repetition as detailed in (4) above, the total sample volumes are less than 30 scf db prescribed by CFR Title 40 (Ref. 1). However, due to the extremely high stack gas velocities encountered during the test, using a larger nozzle in order to sample a larger volume of stack gas was not possible and at the same time maintain isokinetic sampling rates.

Velocity pressure head readings of the stack gas across the stack ranged from 0.50 to 3.60 inches of water.

## CONCLUSION

Particulate emissions testing was performed August 4-8, 1980 on the No. 2 Coke Side Emission Control One Spot Quench Car in Plant 2 at Inland Steel in East Chicago, Indiana.

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Emission testing was conducted by H. M. Taylor and J. Lewis of The Almega Corporation generally following the Code of Federal Regulations, Title 40, Methods 1 through 5 (Ref. 1) and following the protocol as required by Inland Steel and detailed in Appendix B.

Results of this test series indicate No. 2 quench car stack particulate emissions as follows:

Test Repetition No.	Coke Production (tons/test run)	Stack Particulate Concentration (grains/scf db)	Stack Particulate Emission Rate (lbs/ton of coke)
1	119.6	0.0238	0.0271
2	123.8	0.0253	0.0337
3	120.9	0.0266	0.0378

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## SUMMARY OF EMISSION TEST DATA

TABLE: 1

PLANT: Inland Steel Company, East Chicago, Indiana

LOCATION: No. 2 Coke Side Emission Control One Spot Gas  
Cleaning Car: Scrubber Exhaust Stack

OPERATOR: H. M. Taylor and J. Lewis

TEST DATE: 8/4/80 8/5/80 8/8/80

REPETITION #: 1 2 3

### STACK GAS

	8/4/80	8/5/80	8/8/80
Average temperature, °F	122.8	122.1	126.9
Velocity average fps	70.89	70.38	82.72
Volume flow x 10 <sup>6</sup> scfh db	2.48	2.44	2.85
Volume flow x 10 <sup>3</sup> acfm	54.72	54.32	63.85
Moisture %	14.87	15.68	16.07
Carbon Dioxide %	0.63	0.60	0.87
Oxygen %	19.33	19.67	19.33

### PARTICULATE SAMPLE

	8/4/80	8/5/80	8/8/80
Time, mins.	23.08	28.38	25.37
Volume scf db	13.297	16.827	17.085
Particulates collected, grams	0.0205	0.0276	0.0294
Isokinetic Ratio, I%			
90 ≤ I ≤ 110	93.4	97.8	95.1

### COKE PRODUCTION RATE

	8/4/80	8/5/80	8/8/80
Tons/Test run (12 pushes)	119.6	123.8	120.9

### PARTICULATE

	8/4/80	8/5/80	8/8/80
Concentration grains/scf db	0.0238	0.0253	0.0266
x 10 <sup>-6</sup> lbs/scf db	3.40	3.62	3.79
Emissions lbs/hr	8.437	8.822	10.813
lbs/ton of coke	0.027	0.034	0.038

FIGURE 1

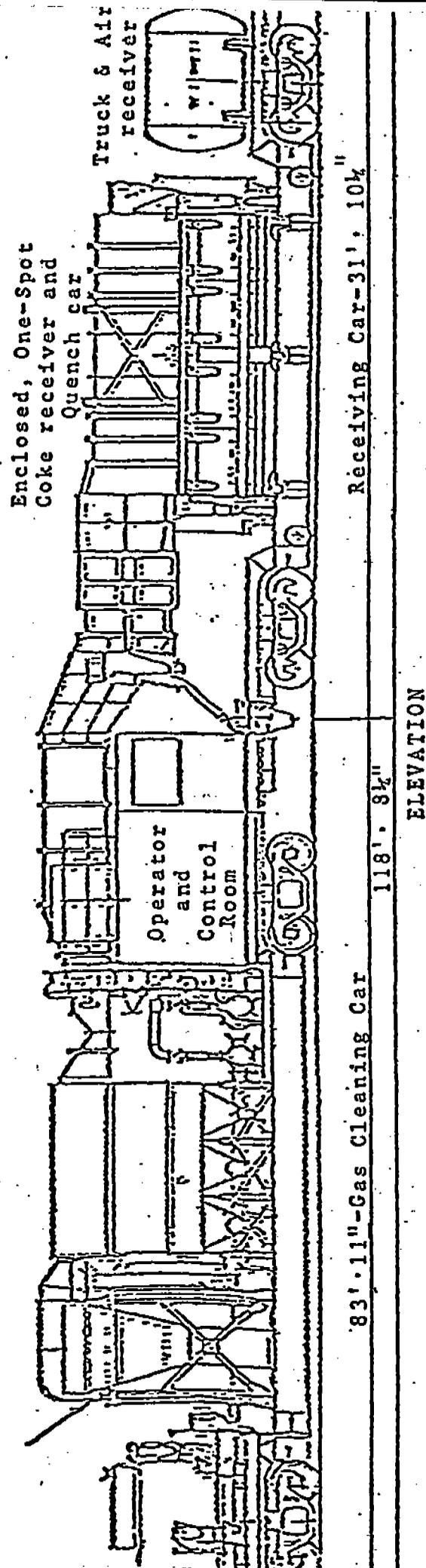
INLAND STEEL COMPANY  
EAST CHICAGO, INDIANA  
COKE BATTERY

Enclosed One-Spot Coke Pushing Emission Control System

The System is a one-spot pushing control system composed of four major units:

1. Enclosed coke guide
2. Enclosed coke receiver
3. Self-propelled evacuation and gas cleaning car
4. Conventional coke quench tower with modified water piping

The System is designed to capture emissions evolved during pushing of coke from coke ovens and transfer of hot coke to the quench tower. The emissions so captured are cleaned in a high energy venturi wet scrubber followed by a solids/water separator prior to exhausting to atmosphere.



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## REFERENCES

- 1 Code of Federal Regulations, Title 40,  
Parts 60 to 80, July 1, 1979.

## APPENDICES

- A Field Test and Analysis Data, Calculation  
Summaries and Equipment Calibration Data
- B Test Protocol: Coke Side Emission Control  
System: Scrubber Exhaust
- C Method 1 -- Sample and Velocity Traverses for  
Stationary Sources
- D Method 2 -- Determination of Stack Gas Velocity  
and Volumetric Flow Rate (Type S Pitot Tube)
- E Method 3 -- Gas Analysis for Carbon Dioxide,  
Excess Air and Dry Molecular Weight
- F Method 4 -- Determination of Moisture in  
Stack Gases
- G Method 5 -- Determination of Particulate  
Emissions from Stationary Sources
- H Nomenclature

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## **APPENDIX A**

**FIELD TEST AND ANALYSIS DATA, CALCULATION  
SUMMARIES AND EQUIPMENT CALIBRATION DATA**

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PARTICULATE: CALCULATION SUMMARY

SOURCE: INLAND STEEL: #2 NS. CONC. SIDE QUENCH CAR SEPARATOR STACK

REPETITION: Run 1 8-4-80

ENGLISH UNITS (29.92in. $\frac{760}{760}$ °F)	CONVERSION FACTOR	METRIC UNITS (760mm 20°C)
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Volume of sample at standard conditions,  
dry basis

$$V_{mstd} = \left[ 17.71 \frac{^{\circ}R}{64 \text{ in.Hg}} \right] V_m \left[ \frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m} \right] = \underline{13.297} \text{ cu.ft.} \times 0.02821 \text{ M}^3$$

Volume water vapor in sample at standard  
conditions

$$V_{wstd} = \left[ 0.0474 \frac{\text{cu.ft.}}{\text{ml}} \right] V_{lc} = \underline{2.3226} \text{ cu.ft.} \times 0.02821 \text{ M}^3$$

Moisture content in stack gas

$$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{0.1487}$$

Particle concentration in stack gas on  
dry basis

$$c's = \left[ 0.01543 \frac{\text{gr}}{\text{mg}} \right] \left[ \frac{M_n}{V_{mstd}} \right]^{20.5} = \underline{0.0238} \text{ grains/scf} \times 2297 \text{ mg/M}^3$$

$$= 2.205 \cdot 10^{-6} \frac{M_n}{V_{mstd}} = \underline{3.3995} \cdot 10^{-6} \text{ lbs/scf}$$

Stack gas volume flow rate on dry basis

$$Q_s = 3600 (1 - B_{wo}) V_s A \left[ \frac{T_{std} P_s}{(T_s)_{avg} P_{std}} \right] = \underline{2.481999} \cdot 10^6 \text{ scfh} \times 0.02821 \text{ M}^3/\text{hr}$$

(A = 12.8646 sq. ft.  $V_s = 70.89$  fps)

Process rate or BTU rating

$P_w$

= \_\_\_\_\_

Emission Rate

$Q_s c's$

= 8.437 lbs/hr.  $\times 0.4536$  kg/hr

$\frac{Q_s c's}{P_w}$

= \_\_\_\_\_ lbs/  $\times 0.4536$  kg/

$I = (1.667 \frac{\text{min}}{\text{sec}}) T_s$

$$\left[ \frac{(0.00267 \text{ in.Hg.cu.ft.}) V_{lc} + \frac{V_m}{T_m} (P_{bar} + \frac{\Delta H}{13.6})}{\frac{\text{ml } ^{\circ}R}{6V_s P_s A_n}} \right]$$

( $A_n = 0.0001917$  sq.ft.)

= 93.43 %

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## STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: INLAND STEEL  
 LOCATION: #2 N.S. QUENCH CAR  
 OPERATOR: HMT & TL  
 TEST DATE: 8-4-80 Run 1

Dry molecular weight of stack gas

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

0.63
19.33
80.04

$$= \underline{28.874} \text{ lb/lb-mole}$$

Molecular weight of stack gas, wet basis

$$M_s = M_d (1 - B_{wO}) + 18 B_{wO} = \underline{27.257} \text{ lb/lb-mole}$$

Pitot tube coefficient

$$C_p \text{ (from calibration curve)} = \underline{0.840}$$

Average velocity head of stack gas, inches H<sub>2</sub>O

( $\sqrt{\Delta p}$ ) avg.	<u>START PUSH</u>	<u>START QUENCH</u>	<u>AVERAGE</u>
	<u>1.1459</u>	<u>1.1664</u>	<u>1.1562</u>

Average absolute stack gas temperature

( $T_s$ ) avg. = <u>110.3/135.3</u> °F + 460	<u>570.3</u>	<u>595.3</u> °R	<u>AVERAGE</u> <u>582.8</u>
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Absolute stack gas pressure

$$P_s = P_b + (\text{Static Pressure}/13.6) = \underline{29.328} \text{ in. Hg}$$

Stack gas velocity

$$(V_s) \text{ avg.} = (85.48) C_p (\sqrt{\Delta p}) \text{ avg.} \sqrt{\frac{(T_s) \text{ avg.}}{P_s M_s}}$$

$$= \underline{6250} \quad \underline{72.27} \text{ ft/sec.} \quad \frac{\underline{AVERAGE}}{70.89}$$

Stack gas volume flow rate, dry basis

$$Q_s = 3,600 (1 - B_{wO}) V_s A \left[ \frac{T_{std} \cdot P_s}{(T_s) \text{ avg.} \cdot P_{std}} \right]$$

$$= \underline{2,481,999} \text{ scfh AVERAGE}$$

54,715 ACFM AVERAGE

SAMPLE ANALYTICAL DATA FORM

Plant INLAND STEEL Run number 1 8-4-80  
 Sample location #2 CORE SIDE ONE SPOT CAR  
 Relative humidity 65%  
 Density of acetone ( $\rho_a$ ) 0.7856 g/ml

Sample type	Sample identifiable	Liquid level marked and/or container sealed
Acetone rinse filter(s)	✓ ✓	✓

Acetone rinse container number 1  
 Acetone rinse volume ( $V_{aw}$ ) 224 ml  
 Acetone blank residue concentration ( $C_a$ ) 0.0038 mg/g  
 $W_a = C_a V_{aw} \rho_a = (0.0038) (224) (0.7856) = \underline{0.7}$  mg

Date and time of wt 8-11-80 Gross wt 135309.0 mg  
 Date and time of wt 8-11-80 Gross wt 135309.0 mg  
 Average gross wt 135309.0 mg  
 Tare wt 135289.1 mg  
 Less acetone blank wt ( $W_a$ ) 0.7 mg  
 Weight of particulate in acetone rinse 19.2 mg

Filter(s) container number 1  
 Date and time of wt 8-11-80 Gross wt 791.4 mg  
 Date and time of wt 8-11-80 Gross wt 791.4 mg  
 Average gross wt 791.4 mg  
 Tare wt 790.1 mg  
 Weight of particulate on filter(s) 1.3 mg  
 Weight of particulate in acetone rinse 19.2 mg  
 Total weight of particulate 20.5 mg

Note: In no case should a blank residue >0.01 mg/g or 0.001% of the weight of acetone used be subtracted from the sample weight.

Remarks \_\_\_\_\_

Signature of analyst David W. Johnson  
 Signature of reviewer [Signature]

# PARTICULATE FIELD DATA

PLANT Island Steel

AMBIENT TEMPERATURE 73°F

METER Δ Hg 1.13

DATE 8-4-80

BAROMETRIC PRESSURE 29.21

C FACTOR 0.840

LOCATION East Chicago, Ind

ASSUMED MOISTURE, % 18

PROCESS WEIGHT RATE

OPERATOR AMT

PROBE LENGTH, in. 72

WEIGHT OF PARTICULATE COLLECTED, mg

STACK NO. #2 ONE SPOT CAR

NOZZLE DIAMETER, in. 0.1875 in.

FINAL WEIGHT

RUN NO. 1

STACK DIAMETER, in. 57 x 32 1/2

TARE WEIGHT 0.7901

SAMPLE BOX NO. Toy #2

PROBE HEATER SETTING 320°F

TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER of

METER BOX NO. Toy #4

HEATER BOX SETTING 320°F

VELOCITY in. Hg gauge

TOTAL

WEIGHT GAIN

TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER of

VELOCITY in. Hg gauge

WEIGHT GAIN

TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER of

VELOCITY in. Hg gauge

WEIGHT GAIN

TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER of

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VELOCITY in. Hg gauge

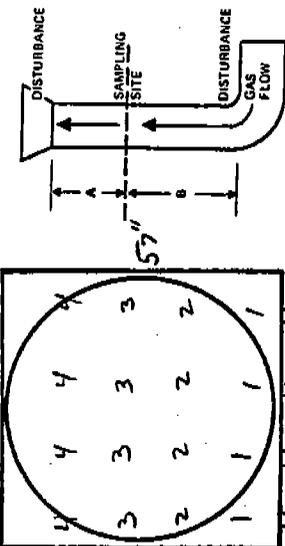
WEIGHT GAIN

TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER of

VELOCITY in. Hg gauge

WEIGHT GAIN

TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER of



TRAVERSE POINT NUMBER	MIN. SAMPLING TIME (g), min.	STATIC PRESSURE (in. H <sub>2</sub> O)	STACK TEMPERATURE (T <sub>s</sub> ), °F	VELOCITY HEAD (ΔP <sub>s</sub> ) (in. H <sub>2</sub> O)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in. H <sub>2</sub> O	GAS SAMPLE VOLUME (V <sub>m</sub> ), ft <sup>3</sup>	GAS SAMPLE TEMPERATURE AT DRY GAS METER		TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER of	PUMP VACUUM in. Hg gauge	VELOCITY in. Hg gauge
							INLET (T <sub>m, in</sub> ), °F	OUTLET (T <sub>m, out</sub> ), °F			
A1	1:50	+1.6	103/135	1.40	0.80	6.572.970	77	77	80	5	
2	2:00		112/140	0.75	0.48	14.10	82	80	75	3	
3	2:02		108/138	0.75	0.48	15.00	82	80	75	3	
B1	1:45		108/143	3.00	1.80	15.91	83	80	76	7	
2	1:58		118/140	1.50	0.85	17.49	86	83	75	5	
3	1:47		105/127	0.50	0.37	18.75	88	85	70	2	
C1	1:45	+1.6	110/135	3.10	1.86	19.43	88	85	70	7	
2	2:00		115/138	0.70	0.45	21.06	89	85	70	3	
3	1:58		115/122	0.60	0.41	21.95	89	85	72	3	
D1	1:58		108/142	3.20	1.91	22.75	90	87	72	9	
2	2:02		120/143	1.70	0.94	24.62	91	87	70	5	
3	2:00		101/120	0.50	0.36	26.00	91	88	73	2	
ADJUST 8.09 and Air						252.7.000					
TOTAL											
AVERAGE	23.08 min	4.0	110.3/135.3	1.45	0.873	14.030	86.3	83.5			

COMMENTS: LEAK CHECK START ±0.01 cfm 15" H<sub>2</sub>O  
LEAK CHECK END ±0.01 cfm 15" H<sub>2</sub>O

POINTS OK AT 3" H<sub>2</sub>O START  
POINTS OK AT 3" H<sub>2</sub>O END

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VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml				SILICA BELT WEIGHT, g	ORSAT MEASUREMENT	TIME	CO <sub>2</sub>	O <sub>2</sub>	CO	N <sub>2</sub>
	1	2	3	4							
FINAL	125	122	2	2	210						
INITIAL	100	100	0	0	200						
LIQUID COLLECTED	25	12	2	2	10						
TOTAL VOLUME COLLECTED	39	49			10						

Av. (0.63) (19.33)

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PARTICULATE: CALCULATION SUMMARY

SOURCE: *INLAND STEEL: #2 N.S. COKE SIDE QUENCH CAR SCRUBBER STACK*  
 REPETITION: *RUN 2 8-5-80*

ENGLISH UNITS (29.92in. <sup>480</sup> F)      CONVERSION FACTOR      METRIC UNITS (760mm 20°C)

Volume of sample at standard conditions, dry basis

$$V_{mstd} = \left[ 17.71 \frac{^{\circ}R}{64 \text{ in.Hg}} \right] V_m \left[ \frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m} \right] = \underline{16.827} \text{ cu.ft.} \times 0.02821 \text{ M}^3$$

Volume water vapor in sample at standard conditions

$$V_{wstd} = \left[ 0.0474 \frac{\text{cu.ft.}}{\text{ml}} \right] V_{lc} = \underline{3.1284} \text{ cu.ft.} \times 0.02821 \text{ M}^3$$

Moisture content in stack gas

$$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{0.1568}$$

Particle concentration in stack gas on dry basis

$$c's = \left[ 0.01543 \frac{\text{gr}}{\text{mg}} \right] \left[ \frac{M_n}{V_{mstd}} \right] 27.6 = \underline{0.0253} \text{ grains/scf} \times 2297 \text{ mg/M}^3$$

$$= 2.205 \cdot 10^{-6} \frac{M_n}{V_{mstd}} = \underline{3.6167} \cdot 10^{-6} \text{ lbs/scf}$$

Stack gas volume flow rate on dry basis

$$Q_s = 3600 (1 - B_{wo}) V_s A \left[ \frac{T_{std} P_s}{(T_s)_{avg} P_{std}} \right] = \underline{2.439216} \cdot 10^6 \text{ scfh} \times 0.02821 \text{ M}^3/\text{hr}$$

(A = 12.8446 sq. ft. V<sub>s</sub> = 70.38 fps)

Process rate or BTU rating

$$P_w = \underline{\hspace{2cm}}$$

Emission Rate

$$\frac{Q_s c's}{P_w} = \underline{8.822} \text{ lbs/hr.} \times 0.4536 \text{ kg/hr}$$

$$= \underline{\hspace{2cm}} \text{ lbs/} \times 0.4536 \text{ kg/}$$

$$I = \left( 1.667 \frac{\text{min}}{\text{sec}} \right) T_s \left[ \frac{(0.00267 \text{ in.Hg.cu.ft.}) V_{lc} + \frac{V_m}{T_m} (P_{bar} + \frac{\Delta H}{13.6})}{\frac{\text{ml } ^{\circ}R}{\theta V P A}} \right]$$

(A<sub>n</sub> = 0.0001917 sq.ft.) = 97.83 %

# The ALMEGA CORPORATION

## STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: Inland Steel  
 LOCATION: #2 NS Oxygen Car  
 OPERATOR: Mont + JZ  
 TEST DATE: 8-5-80 Run 2

Dry molecular weight of stack gas

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

0.60
19.67
79.73
= 28.883 lb/lb-mole

Molecular weight of stack gas, wet basis

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

= 27.177 lb/lb-mole

Pitot tube coefficient

$$C_p \text{ (from calibration curve)}$$

= 0.840

Average velocity head of stack gas, inches H<sub>2</sub>O

$$(\sqrt{\Delta p}) \text{ avg.}$$

	<u>START PUSH</u>	<u>START PUSH</u>	<u>AVERAGE</u>
	<u>1.1319</u>	<u>1.1598</u>	<u>1.1459</u>

Average absolute stack gas temperature

$$(T_s) \text{ avg.} = \frac{108.4}{135.9} \text{ } ^\circ\text{F} + 460$$

	<u>START PUSH</u>	<u>START PUSH</u>	<u>AVERAGE</u>
	<u>568.4</u>	<u>595.9</u>	<u>582.1</u>

Absolute stack gas pressure

$$P_s = P_b + (\text{Static Pressure}/13.6)$$

= 29.275 in. Hg

Stack gas velocity

$$(V_s) \text{ avg.} = (85.48) C_p (\sqrt{\Delta p}) \text{ avg.} \sqrt{\frac{(T_s) \text{ avg.}}{P_s M_s}}$$

	<u>START PUSH</u>	<u>START PUSH</u>	<u>AVERAGE</u>
	<u>68.70</u>	<u>72.06</u>	<u>70.38</u>

Stack gas volume flow rate, dry basis

$$Q_s = 3,600 (1 - B_{wo}) V_s A \left[ \frac{T_{std} \cdot P_s}{(T_s) \text{ avg.} \cdot P_{std}} \right]$$

= 2,439,216 scfh AVERAGE  
54,323 ACFM AVERAGE

SAMPLE ANALYTICAL DATA FORM

Plant INLAND STEEL Run number 2 8-5-80  
 Sample location #2 COKE SIDE ONE SPOT CAR  
 Relative humidity 65%  
 Density of acetone ( $\rho_a$ ) 0.7856 g/ml

Sample type	Sample identifiable	Liquid level marked and/or container sealed
Acetone rinse filter(s)	✓ ✓	✓

Acetone rinse container number 2  
 Acetone rinse volume ( $V_{aw}$ ) 229 ml  
 Acetone blank residue concentration ( $C_a$ ) \_\_\_\_\_ mg/g

$W_a = C_a V_{aw} \rho_a = (0.0038) (229) (0.7856) = \underline{0.7}$  mg

Date and time of wt 8-11-80 Gross wt 135458.8 mg

Date and time of wt 8-11-80 Gross wt 135458.8 mg

Average gross wt 135458.8 mg

Tare wt 135434.7 mg

Less acetone blank wt ( $W_a$ ) 0.7 mg

Weight of particulate in acetone rinse 23.4 mg

Filter(s) container number 2

Date and time of wt 8-11-80 Gross wt 791.7 mg

Date and time of wt 8-11-80 Gross wt 791.7 mg

Average gross wt 791.7 mg

Tare wt 787.5 mg

Weight of particulate on filter(s) 4.2 mg

Weight of particulate in acetone rinse 23.4 mg

Total weight of particulate 27.6 mg

Note: In no case should a blank residue >0.01 mg/g or 0.001% of the weight of acetone used be subtracted from the sample weight.

Remarks \_\_\_\_\_

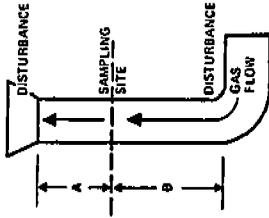
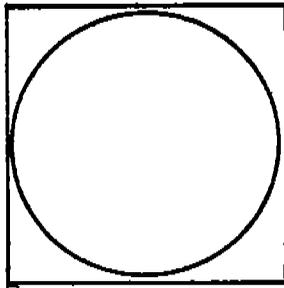
Signature of analyst David N. Johnson

Signature of reviewer [Signature]

# PARTICULATE FIELD DATA

PLANT Island Steel AMBIENT TEMPERATURE 78°F  
 DATE 8-5-80 BAROMETRIC PRESSURE 29.15  
 LOCATION East Chicago, Ind. ASSUMED MOISTURE, % 16  
 OPERATOR H.M. Jr. PROBE LENGTH, in. 72  
 STACK NO. #2 One Spout Stack NOZZLE DIAMETER, in. 0.1875 in.  
 RUN NO. 2 STACK DIAMETER, in. 57 x 32 1/2  
 SAMPLE BOX NO. Top #1 PROBE HEATER SETTING 320°F  
 METER BOX NO. Top #4 HEATER BOX SETTING 320°F

SCHEMATIC OF STACK



CROSS SECTION

WEIGHT OF PARTICULATE COLLECTED, mg	
SAMPLE	FILTER
FINAL WEIGHT	
TARE WEIGHT	0.7875
WEIGHT GAIN	
TOTAL	

PROCESS WEIGHT RATE

TRAVERSE POINT NUMBER	MIN. SEC	STATIC PRESSURE (in. H <sub>2</sub> O)	START / PUSH / PULL / STACK TEMPERATURE (T <sub>s</sub> ), °F	VELOCITY HEAD (ΔP), (in. H <sub>2</sub> O)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in. H <sub>2</sub> O	GAS SAMPLE VOLUME (V <sub>m</sub> ), ft <sup>3</sup>	GAS SAMPLE TEMPERATURE AT DRY GAS METER		TEMPERATURE OF GAS LEAVING OR CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
							INLET (T <sub>m in</sub> ), °F	OUTLET (T <sub>m out</sub> ), °F			
A1	2:23	71.70	95/125	2.00	1.14	652.350	83	83	80	5	
2	2:33		115/130	1.00	0.60	29.140	83	80	70	3	
3	2:51		113/143	0.50	0.35	30.47	85	81	70	2	
B1	2:35		102/138	3.50	2.10	31.52	89	85	70	9	
2	1:58		100/140	1.25	0.76	34.10	90	85	70	3.5	
3	1:55		130/146	0.40	0.30	35.28	90	87	71	2	
C1	2:21	71.70	95/131	2.00	1.17	35.91	91	87	71	5	
2	2:32		105/140	1.70	1.00	37.70	91	88	70	4	
3	2:12		116/143	0.50	0.37	39.47	92	90	70	2.5	
D1	2:40		105/140	3.50	2.30	40.31	94	90	72	9.5	
2	2:14		120/131	0.70	0.47	43.01	95	92	70	3	
3	2:09		105/121	0.50	0.39	44.24	98	92	73	2	
Average	2:38	71.70	108.4/135.7	1.13	0.913	17.905	90.1	86.7			

COMMENTS:

Leak Check Start 1001 CFM 20"  
 Leak Check End 1001 CFM 23"  
 Pairs OK at 5" H<sub>2</sub>O Start  
 Pairs OK at 5" H<sub>2</sub>O End

ORSAT MEASUREMENT	TIME	CO <sub>2</sub>	O <sub>2</sub>	CO	N <sub>2</sub>
1	2	0.50	19.5		
2	6	0.80	18.5		
3	10	0.50	20.0		
4	Ave.	0.60	19.67		

VOLUME OF LIQUID WATER COLLECTED	1	2	3	4	5	6
FINAL	145	110	5			206
INITIAL	100	100	0			200
LIQUID COLLECTED	45	10	5			6
TOTAL VOLUME COLLECTED	60	66	66			66

THE ALMEGA CORPORATION

PARTICULATE: CALCULATION SUMMARY

SOURCE: *INLAND STEEL: #2 N.S. COKE SIDE QUENCH GAS SCRUBBER STACK*

REPETITION: *Run 3 8-8-80*

ENGLISH UNITS (29.92in. <sup>680</sup> / <sub>70</sub> F)	CONVERSION FACTOR	METRIC UNITS (760mm 20°C)
--	----------------------	------------------------------

Volume of sample at standard conditions,  
dry basis

$$V_{mstd} = \left[ 17.71 \frac{O_R}{64 \text{ in.Hg}} \right] V_m \left[ \frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m} \right] = \underline{17.085} \text{ cu.ft.} \times 0.02821 \text{ M}^3$$

Volume water vapor in sample at standard conditions

$$V_{wstd} = \left[ 0.0474 \frac{\text{cu.ft.}}{\text{ml}} \right] V_{lc} = \underline{3.2706} \text{ cu.ft.} \times 0.02821 \text{ M}^3$$

Moisture content in stack gas

$$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{0.1607}$$

Particle concentration in stack gas on dry basis

$$c's = \left[ 0.01543 \frac{\text{gr}}{\text{mg}} \right] \left[ \frac{M_n}{V_{mstd}} \right]^{29.4} = \underline{0.0266} \text{ grains/scf} \times 2297 \text{ mg/M}^3$$

$$= 2.205 \cdot 10^{-6} \frac{M_n}{V_{mstd}} = \underline{3.7944} \cdot 10^{-6} \text{ lbs/scf}$$

Stack gas volume flow rate on dry basis

$$Q_s = 3600 (1 - B_{wo}) V_s A \left[ \frac{T_{std} P_s}{(T_s)_{avg} P_{std}} \right] = \underline{2.84963} \cdot 10^6 \text{ scfh} \times 0.02821 \text{ M}^3/\text{hr}$$

(A = 12.8646 sq. ft. V<sub>s</sub> = 82.72 fps)

Process rate or BTU rating P<sub>w</sub> = \_\_\_\_\_

Emission Rate

$$\frac{Q_s c's}{P_w} = \underline{10.813} \text{ lbs/hr.} \times 0.4536 \text{ kg/hr}$$

$$= \underline{\hspace{2cm}} \text{ lbs/} \times 0.4536 \text{ kg/}$$

$$I = \left( 1.667 \frac{\text{min}}{\text{sec}} \right) T_s \left[ \frac{(0.00267 \text{ in.Hg.cu.ft.}) V_{lc} + \frac{V_m}{T_m} (P_{bar} + \frac{\Delta H}{13.6})}{\frac{\text{ml } O_R}{64 V_s P_s A_n}} \right]$$

(A<sub>n</sub> = 0.0001917 sq.ft.) = 95.11 %

# The ALMEGA CORPORATION

## STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: INLAND STEEL  
 LOCATION: #2 N.S. QUENCH CAR  
 OPERATOR: HMT-WL  
 TEST DATE: 8-8-80 Run 3

Dry molecular weight of stack gas

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

0.87
19.33
79.8
= 28.912 lb/lb-mole

Molecular weight of stack gas, wet basis

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

= 27.158 lb/lb-mole

Pitot tube coefficient

$$C_p \text{ (from calibration curve)}$$

= 0.840

Average velocity head of stack gas, inches H<sub>2</sub>O

(√Δp) avg.	START PUSH	START QUENCH	AVERAGE
	<u>1.3313</u>	<u>1.3597</u>	<u>1.3455</u>

Average absolute stack gas temperature

(T <sub>s</sub> ) avg. = <u>114.5/139.2</u> F + 460	START PUSH	START QUENCH	AVERAGE
	<u>574.5</u>	<u>599.2</u> R	<u>586.9</u>

Absolute stack gas pressure

$$P_s = P_b + (\text{Static Pressure}/13.6)$$

= 29.475 in. Hg

Stack gas velocity

$$(V_s) \text{ avg.} = (85.48) C_p (\sqrt{\Delta p}) \text{ avg.} \sqrt{\frac{(T_s) \text{ avg.}}{P_s M_s}}$$

= 80.98 84.47 ft/sec. 82.76

Stack gas volume flow rate, dry basis

$$Q_s = 3,600 (1 - B_{wo}) V_s A \left[ \frac{T_{std} \cdot P_s}{(T_s) \text{ avg.} \cdot P_{std}} \right]$$

= 2,849,631 scfh AVERAGE  
 63850 ACFM AVERAGE

SAMPLE ANALYTICAL DATA FORM

Plant Inland Steel Run number 3 8-8-80  
 Sample location #2 Core Side One Spot Car  
 Relative humidity 65%  
 Density of acetone ( $\rho_a$ ) 0.7856 g/ml

Sample type	Sample identifiable	Liquid level marked and/or container sealed
Acetone rinse filter(s)	✓ ✓	✓

Acetone rinse container number 3

Acetone rinse volume ( $V_{aw}$ ) 260 ml

Acetone blank residue concentration ( $C_a$ ) \_\_\_\_\_ mg/g

$W_a = C_a V_{aw} \rho_a = (0.0038) (260) (0.7856) = \underline{0.8}$  mg

Date and time of wt 8-11-80 Gross wt 134622.5 mg

Date and time of wt 8-11-80 Gross wt 134622.5 mg

Average gross wt 134622.5 mg

Tare wt 134595.1 mg

Less acetone blank wt ( $W_a$ ) 0.8 mg

Weight of particulate in acetone rinse 26.6 mg

Filter(s) container number \_\_\_\_\_

Date and time of wt 8-11-80 Gross wt 738.2 mg

Date and time of wt 8-11-80 Gross wt 738.2 mg

Average gross wt 738.2 mg

Tare wt 735.4 mg

Weight of particulate on filter(s) 2.8 mg

Weight of particulate in acetone rinse 26.6 mg

Total weight of particulate 29.4 mg

Note: In no case should a blank residue >0.01 mg/g or 0.001% of the weight of acetone used be subtracted from the sample weight.

Remarks \_\_\_\_\_

Signature of analyst David N. Johnson

Signature of reviewer [Signature]

BLANK ANALYTICAL DATA FORM

Plant INLAND STEEL  
 Sample location #2 CONE SIDE ONE SPOT CAR  
 Relative humidity 65%  
 Liquid level marked and container sealed Yes  
 Density of acetone ( $\rho_a$ ) 0.7856 g/ml  
 Blank volume ( $V_a$ ) 200 ml  
 Date and time of wt 8-11-80 Gross wt 134594.6 mg  
 Date and time of wt 8-11-80 Gross wt 134594.6 mg  
 Average gross wt 134594.6 mg  
 Tare wt 134594.0 mg  
 Weight of blank ( $m_a$ ) 0.6 mg

$$C_a = \frac{m_a}{V_a \rho_a} = \frac{(0.6)}{(200)(0.7856)} = 0.0038 \text{ mg/g}$$

Note: In no case should a blank residue greater than 0.01 mg/g) or 0.001% of the blank weight be subtracted from the sample weight.

Filters Filter number \_\_\_\_\_  
 Date and time of wt \_\_\_\_\_ Gross wt \_\_\_\_\_ mg  
 Date and time of wt \_\_\_\_\_ Gross wt \_\_\_\_\_ mg  
 Average gross wt \_\_\_\_\_ mg  
 Tare wt \_\_\_\_\_ mg  
 Difference wt \_\_\_\_\_ mg

Note: Average difference must be less than 15 mg or 2% of total sample weight whichever is greater.

Remarks \_\_\_\_\_

Signature of analyst David N. Lehning

Signature of reviewer [Signature]

# PARTICULATE FIELD DATA

PLANT Island Steel

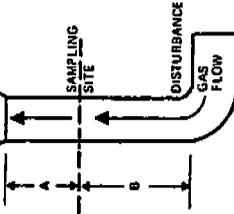
AMBIENT TEMPERATURE 79°F

METER ΔHg 1.13

DATE 8-8-80

BAROMETRIC PRESSURE 29.35

C FACTOR 0.840



LOCATION East Chicago, Ind.

ASSUMED MOISTURE, % 18

OPERATOR AMT #72

PROBE LENGTH, in. 72

STACK NO. #2 On 5 Spot Car

NOZZLE DIAMETER, in. 0.1875 in.

RUN NO. 3

STACK DIAMETER, in. 57 x 32 1/2

SAMPLE BOX NO. Toy #4

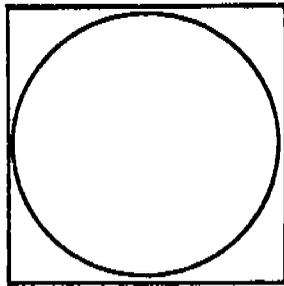
PROBE HEATER SETTING 320°F

METER BOX NO. Toy #4

HEATER BOX SETTING 320°F

PROCESS WEIGHT RATE

WEIGHT OF PARTICULATE COLLECTED, mg	
SAMPLE	FILTER
FINAL WEIGHT	PROBE WASH
TARE WEIGHT	
WEIGHT GAIN	<u>0.7354</u>
TOTAL	



CROSS SECTION

TRAVERSE POINT NUMBER	MIN: SEC	STATIC PRESSURE (in. H <sub>2</sub> O)	START / PUSH / STACK TEMPERATURE (T <sub>s</sub> ), °F	START / PUSH / VELOCITY HEAD (ΔP <sub>s</sub> ) (ΔP <sub>s</sub> )	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in. H <sub>2</sub> O	GAS SAMPLE VOLUME (V <sub>m</sub> ), ft <sup>3</sup>	GAS SAMPLE TEMPERATURE AT DRY GAS METER		TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
							INLET (T <sub>in</sub> ), °F	OUTLET (T <sub>out</sub> ), °F			
A	1:58	+1.70	99 / 139	2.00	1.14	66.31	82	82	80	4.5	
2	2:08		135 / 145	1.75	0.97	33.15	90	88	71	4	
3	1:59		118 / 140	1.00	0.62	34.62	92	88	71	3.5	
B	2:23		100 / 135	3.60	2.40	35.67	94	89	71	10	
2	2:24		119 / 135	1.50	0.88	38.15	96	90	72	4	
3	2:24		113 / 140	1.00	0.64	39.71	98	92	72	3.5	
C	2:02	+1.70	111 / 139	3.40	2.30	41.01	99	94	72	9.5	
2	2:08		115 / 140	2.00	1.17	43.04	99	95	70	4.5	
3	2:00		114 / 138	0.75	0.50	44.66	99	95	70	3	
D	1:48		110 / 136	3.50	2.34	45.60	100	95	70	10	
2	1:48		130 / 150	2.00	1.14	47.42	100	95	70	5	
3	2:05		110 / 133	0.50	0.37	48.77	101	97	71	2.5	
Approx 2:19 stop											
TOTAL											
AVERAGE						18.220	95.8	91.7			

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml				SILICA BEC WEIGHT, g
	1	2	3	4	
FINAL	140	119	3	207	1.3313
INITIAL	100	100	0	200	1.3597
LIQUID VOLUME COLLECTED	40	19	3	7	
TOTAL VOLUME COLLECTED	62	69			

COMMENTS:  
 LEAK CHECK START 0 c.c.m. at 15" H<sub>2</sub>O  
 LEAK CHECK END 0 c.c.m. at 15" H<sub>2</sub>O  
 START: PLOTS OK AT 5" H<sub>2</sub>O  
 END: PLOTS OK AT 5" H<sub>2</sub>O

# THE ALMEGA CORPORATION

## PITOT TUBE CORRECTION FACTOR AND CALIBRATION DATA

Probe Description: 72" Joy Probe with #5 nozzle

Pitot Tube Type: "S"

Identification No.: 1

Calibration Date: 7-30-80

Calibrated By: *[Signature]*

### WIND TUNNEL SPECIFICATIONS

Type: Plexiglass (Round)

Inside Diameter: 12 inches

Length: 10 feet

Port Locations: 8 feet downstream

Cp std = .99 70°

"A" SIDE CALIBRATION				
RUN NO.	$\Delta p_{std}$ (IN. H <sub>2</sub> O)	$\Delta p$ (s) (IN. H <sub>2</sub> O)	Cp (s)	DEV.
	0.100	0.139	0.840	
	0.750	1.045	0.839	
	1.250	1.738	0.840	
		AVERAGE	0.840	

"B" SIDE CALIBRATION				
RUN NO.	$\Delta p_{std}$ (IN. H <sub>2</sub> O)	$\Delta p$ (s) (IN. H <sub>2</sub> O)	Cp (s)	DEV.
	0.100	0.139	0.840	
	0.750	1.047	0.838	
	1.250	1.740	0.839	
		AVERAGE	0.839	

"A" Side Average Deviation =  
 "B" Side Average Deviation =

Must be < 0.01

# The ALMEGA CORPORATION

## NOZZLE CALIBRATION DATA FORM

Date 8-1-80 Calibrated by [Signature]

Nozzle identification number	Nozzle Diameter <sup>a</sup>			D <sub>4'</sub> mm (in.)	D <sub>avg</sub> <sup>c</sup>
	D <sub>1'</sub> mm (in.)	D <sub>2'</sub> mm (in.)	D <sub>3'</sub> mm (in.)		
Joy #5 NW	0.187	0.188	0.187	0.188	0.1875

where:

<sup>a</sup> D<sub>1,2,3,4</sub> = three different nozzles diameters, mm (in.); each diameter must be within (0.025 mm) .001 in.

<sup>b</sup> AD = maximum difference between any two diameters, mm (in.),  
AD ≤ (0.10 mm) 0.004 in.

<sup>c</sup> D<sub>avg</sub> = average of D<sub>1</sub>, D<sub>2</sub>, D<sub>3</sub> and D<sub>4</sub>.

# The ALMEGA CORPORATION

## STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 8-1-80 Thermocouple number 72" Toy Probe  
 Ambient temperature 70 °F Barometric pressure 29.98 in. Hg.  
 Calibrator TS Reference: mercury-in-glass   
 other \_\_\_\_\_

Reference point number a	Source <sup>b</sup> (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference, %
1	ICE BATH	33.5 °F	33 °F	0.10
2	BOILING WATER	211.0 °F	210 °F	0.15
3	HOT OIL	328.8 °F	326 °F	0.35

<sup>a</sup>Every 30°C (50°F) for each reference point.

<sup>b</sup>Type of calibration system used.

$$\left[ \frac{(\text{ref temp, } ^\circ\text{F} + \frac{460}{273}) - (\text{test thermom temp, } ^\circ\text{F} + \frac{460}{273})}{\text{ref temp, } ^\circ\text{F} + \frac{460}{273}} \right] 100 \leq 1.5\%$$

# THE ALMEGA CORPORATION

## DIFFERENTIAL PRESSURE GAUGE CALIBRATION DATA FORM

Gauge type Mechanical Serial or ID number #4 Meter Em #1

Scale 0 to 3" H<sub>2</sub>O

Gauge-oil manometer $\Delta P$	Differential pressure gauge $\Delta P$	Pressure difference %
1.00	1.00	0
2.00	2.00	0
3.00	3.00	0

Calibration: None initial  posttest

Date calibrated 8-1-80 by HTJ OK

# The ALMEGA CORPORATION

## DIFFERENTIAL PRESSURE GAUGE CALIBRATION DATA FORM

Gauge type MAGNETIC Serial or ID number 80921RF68

Scale 0 TO 5 inches H<sub>2</sub>O TL

Gauge-oil manometer $\Delta P$	Differential pressure gauge $\Delta P$	Pressure difference %
0.50	0.50	0
1.00	1.00	0
2.00	2.00	0
3.49	3.50	0.3%
4.98	5.00	0.4%

Calibration: TL initial  posttest

Date calibrated 8-1-80 by TL

# THE ALMEQ. CORPORATION

Calibrated by: Jerry W. Lewis Box No. 4  
 Date 7/24/80

Barometric pressure,  $P_b = 29.90$  in. Hg Dry gas meter No. CU-3-31107935

Orifice manometer setting $\Delta H$ , in. H <sub>2</sub> O	Gas volume Dry test meter $V_w$ , ft <sup>3</sup>	Gas volume Dry gas meter $V_d$ , ft <sup>3</sup>	Wet test Meter $t_w$ , OF	Temperature		Time $t$ , min	$Y$	$\Delta H$
				Inlet $t_{di}$ , OF	Outlet $t_{do}$ , OF			
0.5	9.554	9.988	71.79 (514)	105	108	17.303	1.01	
1.0	9.660	10.20	80.80 (510)	114	118	11.61*	0.993	
1.5	10.515	11.12	80.80 (510)	123	122	10.0	1.02	
2.0	12.557	13.274	80.80 (510)	129	122	10.0	1.02	
2.5	12.734	13.510	80.80 (510)	132	125	10.50	1.02	
3.0	13.334	14.40	80.80 (510)	135	128	13.0	1.01	
				Average			1.012	
						Average		0.996* (1.012) = Ave 1.009 (1.012)

**Calculations**

	$Y$	$\Delta H$	
$\frac{\Delta H}{13.6}$	$V_w P_b (t_d + 460)$	$0.0317 \Delta H$	$\left[ \frac{(t_w + 460) e}{V_w} \right]^2$
$\frac{\Delta H}{13.6}$	$V_d \left( P_b + \frac{\Delta H}{13.6} \right) (t_w + 460)$	$P_b (t_d + 460)$	

$Y =$  Ratio of accuracy of dry test meter to dry test meter. Tolerance = + 0.03  
 \*  $\Delta H$  with  $T_b = 50$ ; Sample to Above by  $\frac{1}{2}$  inch of calibrated Dry Test Meter (Std)

POSTTEST DRY GAS METER CALIBRATION DATA FORM (English units)

Test number Run #1-3, Inlet Date 8/11/80 Meter Box number 4 Plant Inland Steel  
 Barometric pressure,  $P_b = 29.235$  in. Hg. Dry gas meter number Cu-3-31109 Pretest  $Y = 1.01$

Orifice manometer setting, ( $\Delta H$ ), in. $H_2O$	Gas volume		Temperature		Time ( $\theta$ ) min	Vacuum setting in. Hg	$Y_1$	$V_w P_b (t_d + 460)$ $V_d (P_b + \frac{\Delta H}{13.6}) (t_w + 460)$
	Dry test meter ( $V_w$ ), ft <sup>3</sup>	Dry gas meter ( $V_d$ ), ft <sup>3</sup>	Dry test meter ( $t_w$ ), of	Dry gas meter Inlet ( $t_w$ ), of				
1.4	10	10.21	75 (535)	92 99 101	94 (554)	10.0	1.011	
1.4	10	10.25	76 (536)	100 109 110	107.7 (562)	10.0	1.019	
1.4	10	10.29	76 (536)	108 109 110	104.2 (564)	10.0	1.019	
								$Y = 1.016^*$

a. If there is only one thermometer on the dry gas meter, record the temperature under  $t_d$  where

$V_w$  = Gas volume passing through the dry test meter, ft<sup>3</sup>.

$V_d$  = Gas volume passing through the dry gas meter, ft<sup>3</sup>.

$t_w$  = Temperature of the gas in the dry test meter, OF.

$t_{d1}$  = Temperature of the inlet gas of the dry gas meter, OF.

$t_{d0}$  = Temperature of the outlet gas of the dry gas meter, OF.

$t_d$  = Average temperature of the gas in the dry gas meter, obtained by the average of  $t_{d1}$  and  $t_{d0}$ .

$\Delta H$  = Pressure differential across orifice, in.  $H_2O$ .

$Y_1$  = Ratio of accuracy of dry test meter to dry gas meter for each run.

$Y$  = Average ratio of accuracy of dry test meter to dry gas meter for all three runs; tolerance = pretest  $Y \pm 0.05Y$ .

$P_b$  = Barometric pressure, in. Hg.

$\theta$  = Time of calibration run, min.

\* within 5% of pretest no other calibration

# **THE ALMEGA CORPORATION**

## **APPENDIX B**

**TEST PROTOCOL: COKE SIDE EMISSION CONTROL  
SYSTEM: SCRUBBER EXHAUST**

PARTICULATE EMISSIONS SAMPLING PROCEDURE FOR THE  
ENCLOSED ONE-SPOT COKE PUSHING EMISSION CONTROL SYSTEM  
FOR CFEI STEEL CORPORATION  
SUPPLIED BY NATIONAL STEEL CORPORATION

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I. GENERAL

- a. Methods 1 through 5 as contained in the Federal Register, Vol. 42, No. 160, Thursday, August 18, 1977, "Standards of Performance for New Stationary Sources," are to be generally used as a primary guide in conducting this test. Modifications to these procedures due to the functional limitations of operation of a one-spot pushing control system are included. Corrections as noted in Federal Register, Vol. 43, No. 57, Thursday, March 23, 1978, pages 11984 to 11986 as apply to Methods 1 through 5 will be incorporated in this procedure.
- b. One-spot coke pushing emission control system is operated on a batch type process and will be tested as such under any applicable sections as contained in Methods 1 through 5, referenced above.
- c. Each sampling point will be sampled for one cycle which will include the time period to push the coke from the oven into the system and the travel of the system to the quench tower. This sampling period is defined with regard to the systems' operation as follows:

The sampling of each point will start with the opening of the fan louvers and stop when the fan louvers are closed upon the initiation of the quench in the quench tower.

- d. The objective of the sampling technique will be to measure the solid dry particulate collected on the "front portion" of a USEPA sampling train, such measurement to be representative of the emission from the stack tributary to the particulate scrubbing equipment used. The back half of the sampling train will also be analyzed for coal tar pitch volatiles (CTPV) according to the attached method entitled "Analytical Method for Coal Tar Products" (Appendix I). The results of the front half of the sampling train and the back half of the sampling train are to be reported separately.

## II. METHOD 1

- A. The sampling ports will be located on a straight section of the rectangular stack at one-half an equivalent diameter upstream from the opening and one and one-half equivalent diameters downstream from the transition into the fan. Assuming the cross-sectional dimensions of the stack to be thirty inches by seventy-two inches, four sampling ports will be located on the thirty inch side of the stack. This location is necessary due to clearance

restrictions encountered during the traveling of the system to the quench tower. Straightening vanes will be included at the base of the stack to help assure the proper directional flow of the gases. Stack configuration will be maintained to as close to a square as possible during design but is limited due to the previously mentioned restrictions.

### III. METHOD 2

- a. Method 2 will be used to obtain the necessary preliminary velocity and temperature measurements with administrator approval of the stack configuration and port location as previously described.

### IV. METHOD 3

- a. Integrated gas samples will be taken over three individual sampling periods as previously defined. The samples will be analyzed for CO, CO<sub>2</sub>, oxygen, and nitrogen by means of an Orsat analyzer. The sampling and analysis will be performed in accordance with Method 3. The average values from the three samples will be used in determining the dry molecular weight of the exhaust gas. If a complete test is not performed during the day, at least one sample will be taken.

- a. Based on design and previous test data, saturated moisture conditions are assumed. The moisture content will be calculated as per Method 4 based on the stack conditions obtained from the preliminary velocity and temperature traverses.

#### VI. METHOD 5

- a. The stack sampling equipment and procedure as described in the previously referenced Method 5 will be used in performing the particulate emissions test. The volume of gas sampled during the test period as described in II, Method 1, will be at least 30 dscf using the pump supplied with a standard USEPA sampling train. The following variations from the method as described are recommended for the purpose of this application.
  1. Due to the varying times required for the system to travel from the oven pushed to the quench tower, an integer sampling time increment cannot be guaranteed. Therefore, the sampling will be performed for the actual cycle time periods of the sampling period as previously described. These varying sampling times will then be used to time-weight the averages necessary in the final calculation.
  2. The use of a glass cyclone between the probe and filter holder will be optional based upon approval of the administrator.

3. A probe and filter temperature of 320° F will be maintained during the particulate emissions test run.
4. Acetone will be used as the rinsing agent in performing the washing procedure as described in the previously referenced Method 5. Cleanup will be done after each test.
5. The heating of the sampling probe nozzle and connector fitting at 320° F for the same duration as the total sample time prior to washing will be optional based upon approval of the administrator.

#### VII. ADDITIONAL REQUIREMENTS AND PROCEDURES

1. The following operating parameters will be recorded during each test and included in the final report:
  - a. Pressure differential (inches H<sub>2</sub>O) across venturi throat.
  - b. Feedwater rate (gpm) and temperature (°F) to scrubber.
  - c. Ram amperage.
  - d. Coal charged/push.
  - e. Proximate and ultimate coal analysis.
  - f. Coking time/push.
  - g. Standard calculation for amount of coke pushed/oven.

2. All source test and analytical instrumentation shall be calibrated against the appropriate primary standard within a six-month period prior to the actual test. All such calibration data must be certified by the responsible party and included in the final report.
3. All raw source test and operational data must be included in the final report and certified by the responsible party.
4. The final test report should be in a format similar to that presented in Appendix II (attached).
5. All standards utilized for the analysis of stack samples shall be primary standards made from either certified standard samples obtained from the National Bureau of Standards, a commercially available primary standard directly traceable to such, or where no certified NBS standard is available, an appropriate commercially available primary standard. ASTM Method E-200-67 should be consulted for the appropriate methodology for the preparation, standardization and storage of standard solutions.

## ANALYTICAL METHOD FOR COAL TAR PRODUCTS

Principle of the Method

The cyclohexane-soluble material in the particulates on the glass fiber filters is extracted ultrasonically. Blank filters are extracted along with, and in the same manner as, the samples. After extraction, the cyclohexane solution is filtered through a fritted glass funnel. The total material extracted is determined by weighing a dried aliquot of the extract.

Range and Sensitivity

When the electrobalance is set at 1 mg, this method can detect 75-2000 ug/sample.

Precision and Accuracy

When nine aliquots of a benzene solution from a sample of aluminum-reduction plant emissions containing 1,350 ug/sample were analyzed, the standard deviation was 25 ug (109). Experimental verification of this method using cyclohexane is not yet complete.

Advantages and Disadvantages of the Method

## (a) Advantages

This procedure is much faster and easier to run than the Soxhlet method.

(b) Disadvantages

If the whole sample is not used for cyclohexane-extraction analysis, small weighing errors make large errors in final results.

Apparatus

- (a) Ultrasonic bath, 90 Kc, 60 watts, partially filled with water.
- (b) Ultrasonic generator, Series 200, 90 Kc, 60 watts.
- (c) Electrobalance capable of weighing to 1 ug.
- (d) Stoppered glass test tube, 150- x 16-mm.
- (e) Teflon weighing cups, 2-ml, approximate tare weight 60 mg.
- (f) Dispensing bottle, 5-ml.
- (g) Pipets, with 0.5-ml graduations.
- (h) Glass fiber filters, 30-mm diameter, Gelman Type A or equivalent.
- (i) Silver membrane filters, 37-mm diameter, 0.8 micrometer pore size.
- (j) Vacuum oven.
- (k) Tweezers.
- (l) Beaker, 50-ml.
- (m) Glassine paper, 3.5- x 4.5-inches.
- (n) Wood application sticks for manipulating filters.
- (o) Funnels, glass fritted, 15-ml.
- (p) Graduated evaporative concentrator, 10-ml.

## Reagents

- (a) Cyclohexane, ACS nanograde reagent.
- (b) Dichromic acid cleaning solution.
- (c) Acetone, ACS reagent grade.

## Procedure

- (a) All extraction glassware is cleaned with dichromic acid cleaning solution, rinsed first with tap water, then with deionized water followed by acetone, and allowed to dry completely. The glassware is rinsed with nanograde cyclohexane before use. The Teflon cups are cleaned with cyclohexane, then with acetone.
- (b) Preweigh the Teflon cups to one hundredth of a milligram (0.01 mg).
- (c) Remove top of cassette and hole over glassine paper. Remove plug on bottom of cassette. Insert end of application stick through hole and gently raise filters around tweezers. Slide rolled filters into test tube and push them to bottom of tube with application stick. Add any particulates remaining in cassette and on glassine paper to test tube.
- (d) Pipet 5 ml of cyclohexane into test tube from dispensing bottle.
- (e) Put test tube into sonic bath so that water level in bath is above liquid level in test tube. Do not hold tube in hand while sonifying. A 50-ml beaker filled with water to level of cyclohexane in tube works well.
- (f) Sonify sample for 5 minutes.

- (g) Filter the extract in 15-ml medium glass fritted funnels.
- (h) Rinse test tube and filters with two 1.5-ml aliquots of cyclohexane and filter through the fritted-glass funnel.
- (i) Collect the extract and two rinses in the 10-ml graduated evaporative concentrator.
- (j) Evaporate down to 1 ml while rinsing the slides with cyclohexane.
- (k) Pipet 0.5 ml of the extract to preweighed Teflon weighing cup. These cups can be reused after washing with acetone.
- (l) Evaporate the dryness in a vacuum oven at 40 C for 3 hours.
- (m) Weigh the Teflon cup. Use counterweighing techniques on electrobalance with full scale range of 1 mg to determine weight of aliquot to nearest microgram. The weight gain is due to the cyclohexane-soluble residue.

#### Calculations

The amount of cyclohexane-extractable fraction present in the sample (in mg) may be determined according to the following equation:

$$\text{mg/sample} = 2 \times (\text{wt sample aliquot [mg]} - \text{wt blank aliquot [mg]})$$

The amount of cyclohexane-extractable fraction present in the air may then be determined according to the following equation:

$$\text{mg/cu m} = \frac{\text{mg/sample}}{\text{air volume collected (cu m)}}$$

## APPENDIX II

### COMPLIANCE TEST REPORT FORMAT

#### Cover

1. Plant name and location.
2. Source sampled.
3. Testing company or agency, name and address.

#### Certification

1. Certification by team leader.
2. Certification by reviewer \_\_\_\_\_

#### Introduction

1. Test purpose
2. Test location, type of process.
3. Test dates.
4. Pollutants tested.
5. Observers' names (industry and agency).
6. Any other important background information.

#### Summary of Results

1. Emission results.
2. Process data, as related to determination of compliance.
3. Allowable emissions.
4. Description of collected samples.
5. Visible emissions summary.
6. Discussion of errors, both real and apparent.

#### Source Operation

1. Description of process and control devices.
2. Process and control equipment flow diagram.
3. Process data and results, with example calculations.
4. Representatives of raw materials and products.
5. Any specially required operation demonstrated.

#### Sampling and analysis Procedures

1. Sampling port location and dimensioned cross-section.
2. Sampling point description, including labeling system.
3. Sampling train description.
4. Brief description of sampling procedures, with discussion of deviations from standard methods.
5. Brief description of analytical procedures, with discussion of deviations from standard methods.

#### Appendix

1. Complete results with example calculations.
2. Raw field data (original, not computer printouts).
3. Laboratory report, with chain of custody.
4. Raw production data, signed by plant official.
5. Test log.
6. Calibration procedures and results.
7. Project participants and titles.
8. Related correspondence.
9. Standard procedures.

# **The ALMEGA CORPORATION**

## **APPENDIX C**

**SAMPLE AND VELOCITY TRAVERSES FOR STATIONARY SOURCES**

## METHOD 1--SAMPLE AND VELOCITY TRAVERSES FOR STATIONARY SOURCES

1. *Principle and Applicability.*
  - 1.1 Principle. A sampling site and the number of traverse points are selected to aid in the extraction of a representative sample.
  - 1.2 Applicability. This method should be applied only when specified by the test procedures for determining compliance with the New Source Performance Standards. Unless otherwise specified, this method is not intended to apply to gas streams other than those emitted directly to the atmosphere without further processing.

2. *Procedure.*

- 2.1 Selection of a sampling site and minimum number of traverse points.
  - 2.1.1 Select a sampling site that is at least eight stack or duct diameters downstream and two diameters upstream from any flow disturbance such as a bend, expansion, contraction, or visible flame. For rectangular cross section, determine an equivalent diameter from the following equation:

$$\text{equivalent diameter} = 2 \left( \frac{(\text{length})(\text{width})}{\text{length} + \text{width}} \right)$$

equation 1-1

- 2.1.2 When the above sampling site criteria can be met, the minimum number of traverse points is twelve (12).
- 2.1.3 Some sampling situations render the above sampling site criteria impractical. When this is the case, choose a convenient sampling location and use Figure 1-1 to determine the minimum number of traverse points. Under no conditions should a sampling point be selected within 1 inch of the stack wall. To obtain the number of traverse points for stacks or ducts with a diameter less than 2 feet, multiply the number of points obtained from Figure 1-1 by 0.67.
- 2.1.4 To use Figure 1-1 first measure the distance from the chosen sampling location to the nearest upstream and downstream disturbances. Determine the corresponding number of traverse points for each distance from Figure 1-1. Select the higher of the two numbers of traverse points, or a greater value, such that for circular stacks the number is a multiple of 4, and for rectangular stacks the number follows the criteria of section 2.2.2.



NUMBER OF DUCT DIAMETERS UPSTREAM\*  
(DISTANCE A)

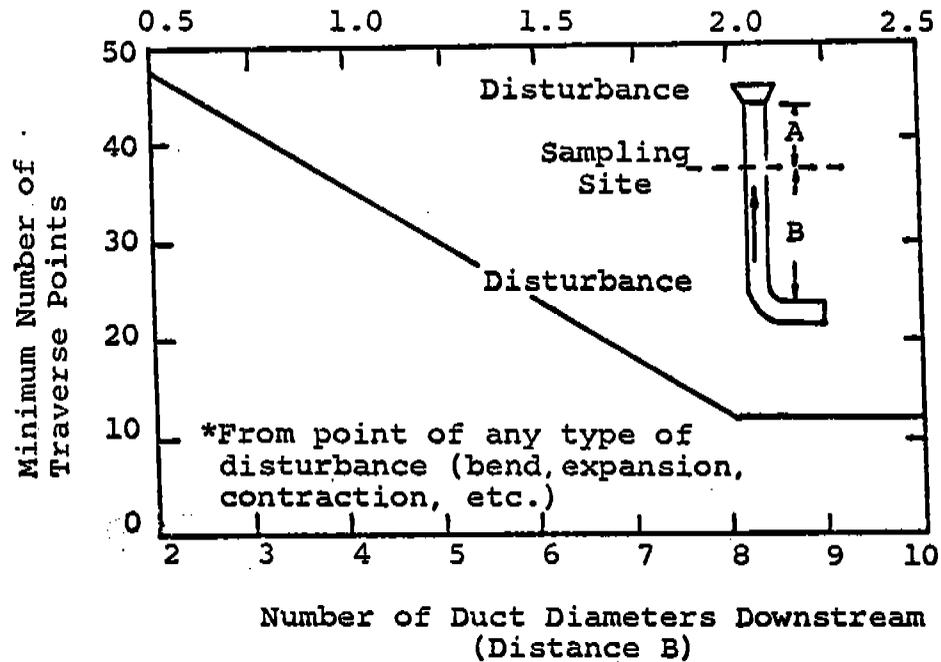


Figure 1-1. Minimum number of traverse points.

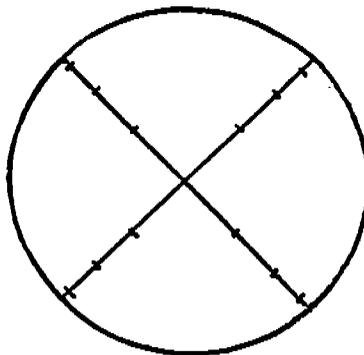


Figure 1-2. Cross section of circular stack divided into 12 equal areas, showing location of traverse points at centroid of each area.

- 2.2 Cross-sectional layout and location of traverse points.
- 2.2.1 For circular stacks locate the traverse points on at least two diameters according to Figure 1-2 and Table 1-1. The traverse axes shall divide the stack cross section into equal parts.
- 2.2.2 For rectangular stacks divide the cross section into as many equal rectangular areas as traverse points, such that the ratio of the length to the width of the elemental areas is between one and two. Locate the traverse points at the centroid of each equal area according to Figure 1-3.
3. References.

Determining Dust Concentration in a Gas Stream, ASME Performance Test Code #27, New York, N.Y., 1957.

Devorkin, Howard, et al., Air Pollution Source Testing Manual, Air Pollution Control District, Los Angeles, California, November, 1963.

Methods for Determination of Velocity, Volume, Dust and Mist Content of Gases, Western Precipitation Division of the Joy Manufacturing Co., Los Angeles, California, Bulletin WP-50, 1968.

Standard Method for Sampling Stacks for Particulate Matter, In: 1971 Book of ASTM Standards, Part 23, Philadelphia, Pa. 1971, ASTM Designation D-2928-71.

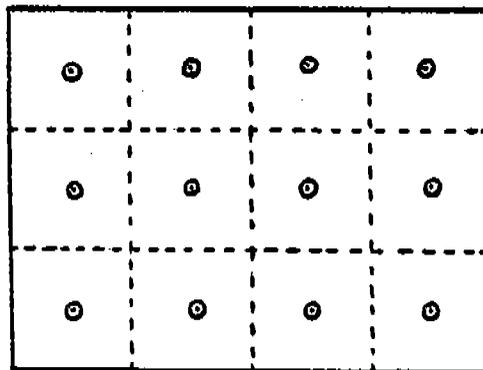


Figure 1-3. Cross section of rectangular stack divided into 12 equal areas, with traverse points at centroid of each area.

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## APPENDIX D

DETERMINATION OF STACK GAS VELOCITY AND VOLUMETRIC  
FLOW RATE (TYPE S PITOT TUBE)

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Method 2 - Page 1 of 6

METHOD 2--DETERMINATION OF STACK GAS VELOCITY AND VOLUMETRIC FLOW RATE (TYPE S PITOT TUBE)

1. *Principle and Applicability.*
  - 1.1 Principle. Stack gas velocity is determined from the gas density and from measurement of the velocity head using a Type S (Stauscheibe or reverse type) pitot tube.
  - 1.2 Applicability. This method should be applied only when specified by the test procedures for determining compliance with the New Source Performance Standards.
2. *Apparatus.*
  - 2.1 Pitot tube--Type S (Figure 2-1) or equivalent, with a coefficient within  $\pm 5\%$  over the working range.
  - 2.2 Differential pressure gauge--Inclined manometer, or equivalent, to measure velocity head to within 10% of the minimum value.
  - 2.3 Temperature gauge--Thermocouple or equivalent attached to the pitot tube to measure stack temperature to within 1.5% of the minimum absolute stack temperature.
  - 2.4 Pressure gauge--Mercury-filled U-tube manometer, or equivalent, to measure stack pressure to within 0.1 in.Hg.
  - 2.5 Barometer--To measure atmospheric pressure to within 0.1 in.Hg.
  - 2.6 Gas analyzer--To analyze gas composition for determining molecular weight.
  - 2.7 Pitot tube--Standard type, to calibrate Type S pitot tube.
3. *Procedure.*
  - 3.1 Set up the apparatus as shown in Figure 2-1. Make sure all connections are tight and leak free. Measure the velocity head and temperature at the traverse points specified by Method 1.
  - 3.2 Measure the static pressure in the stack.
  - 3.3 Determine the stack gas molecular weight by gas analysis and appropriate calculations as indicated in Method 3.

4. Calibration.

4.1 To calibrate the pitot tube, measure the velocity head at some point in a flowing gas stream with both a Type S pitot tube and a standard type pitot tube with known coefficient. Calibration should be done in the laboratory and the velocity of the flowing gas stream should be varied over the the normal working range. It is recommended that the calibration be repeated after use at each field site.

4.2 Calculate the pitot tube coefficient using equation 2-1.

$$C_{p\text{test}} = C_{p\text{std}} \sqrt{\frac{\Delta P_{\text{std}}}{\Delta P_{\text{test}}}} \quad \text{Equation 2-1}$$

where:

$C_{p\text{test}}$  = Pitot tube coefficient of Type S pitot tube.

$C_{p\text{std}}$  = Pitot tube coefficient of standard type pitot tube (if unknown, use 0.99).

$\Delta P_{\text{std}}$  = Velocity head measured by standard type pitot tube.

$\Delta P_{\text{test}}$  = Velocity head measured by Type S pitot tube.

4.3 Compare the coefficients of the Type S pitot tube determined first with one leg and then the other pointed downstream. Use the pitot tube only if the two coefficients differ by no more than 0.01.

5. Calculations.

Use Equation 2-2 to calculate the stack gas velocity.

$$(V_s)_{\text{avg.}} = K_p C_p (\sqrt{\Delta p})_{\text{avg.}} \sqrt{\frac{(T_s)_{\text{avg}}}{P_s M_s}}$$

Equation 2-2

where:

$(V_s)_{\text{avg.}}$  = Stack gas velocity, feet per second (f.p.s)

$K_p$  = 85.48  $\frac{\text{ft.}}{\text{sec.}}$   $\left(\frac{\text{lb.}}{\text{lb.mole-}^\circ\text{R}}\right)^{\frac{1}{2}}$  when these units are used

$C_p$  = Pitot tube coefficient, dimensionless.

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Method 2 - Page 3 of 6

- $(T_s)_{avg.}$  = Average absolute stack gas temperature,  $R^{\circ}$ .
- $(\sqrt{\Delta p})_{avg.}$  = Average velocity head of stack gas, inches  $H_2O$  (see Fig. 2-2).
- $P_s$  = Absolute stack gas pressure, inches Hg.
- $M_s$  = Molecular weight of stack gas (wet basis), lb/lb-mole.  
 $M_d(1-B_{wo})+18B_{wo}$
- $M_d$  = Dry molecular weight of stack gas (from Method 3).
- $B_{wo}$  = Proportion by volume of water vapor in the gas stream (from Method 4).

Figure 2-2 shows a sample recording sheet for velocity traverse data. Use the averages in the last two columns of Figure 2-2 to determine the average stack gas velocity from Equation 2-2.

Use Equation 2-3 to calculate the stack gas volumetric flow rate.

$$Q_s = 3600 (1-B_{wo}) V_s A \left( \frac{T_{std}}{(T_s)_{avg.}} \right) \left( \frac{P_s}{P_{std}} \right)$$

Equation 2-3

where:

- $Q_s$  = Volumetric flow rate, dry basis, standard conditions,  $ft^3/hr.$
- $A$  = Cross-sectional area of stack,  $ft.^2.$
- $T_{std}$  = Absolute temperature at standard condition,  $530^{\circ} R.$
- $P_{std}$  = Absolute pressure at standard conditions, 29.92 inches Hg.

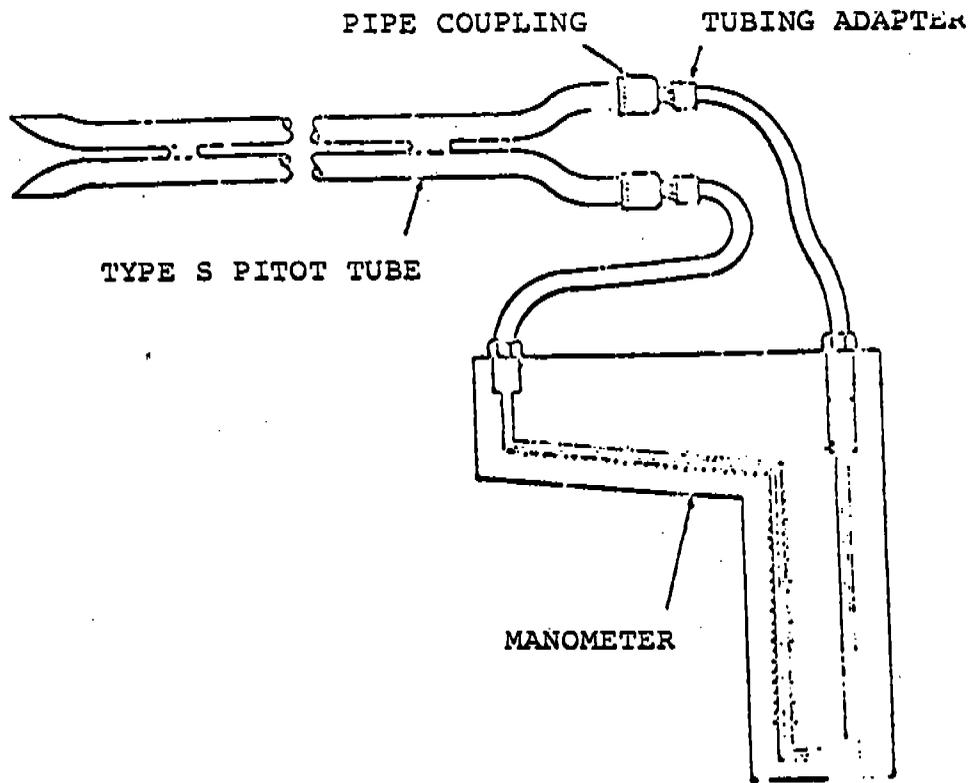


FIGURE 2-1: Pitot Tube  
Manometer Assembly



6. *References.*

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Perry, J. H. Chemical Engineers' Handbook, McGraw-Hill Book Co., Inc., New York, N.Y., 1960.

Shigehara, R. T., W. F. Todd, & W. S. Smith, Significance of Errors in Stack Sampling Measurements. Paper presented at the Annual Meeting of the Air Pollution Control Association, St. Louis. Mo., June 14-19, 1970.

Standard Method for Sampling Stacks for Particulate Matter, In: 1971 Book of ASTM Standards, Part 23, Philadelphia, Pa, 1971 ASTM Designation D-2928-71.

Vennard, J. K. Elementary Fluid Mechanics. John Wiley & Sons Inc., New York, N.Y., 1947.

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## APPENDIX E

GAS ANALYSIS FOR CARBON DIOXIDE, EXCESS AIR, AND  
DRY MOLECULAR WEIGHT

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Method 3 - Page 1 of 4

METHOD 3--GAS ANALYSIS FOR CARBON DIOXIDE, EXCESS AIR  
AND DRY MOLECULAR WEIGHT

1. *Principle and applicability.*
  - 1.1 Principle. An integrated or grab gas sample is extracted from a sampling point and analyzed for its components using an Orsat analyzer.
  - 1.2 Applicability. This method should be applied only when specified by the test procedures for determining compliance with the New Source Performance Standards. The test procedure will indicate whether a grab sample or an integrated sample is to be used.
2. *Apparatus.*
  - 2.1 Grab sample (Figure 3-1).
    - 2.1.1 Probe--Stainless steel or Pyrex<sup>1</sup> glass, equipped with a filter to remove particulate matter.
    - 2.1.2 Pump--One-way squeeze bulb, or equivalent, to transport gas sample to analyzer.
  - 2.2 *Integrated sample (Figure 3-2).*
    - 2.2.1 Probe--Stainless steel or Pyrex<sup>1</sup> glass, equipped with a filter to remove particulate matter.
    - 2.2.2 Air-cooled condenser or equivalent--To remove any excess moisture.
    - 2.2.3 Needle valve--To adjust flow rate.
    - 2.2.4 Pump--Leak-free, diaphragm type, or equivalent, to pull gas.
    - 2.2.5 Rate meter--To measure a flow range from 0 to 0.035 cfm.
    - 2.2.6 Flexible bag--Tedlar<sup>1</sup>, or equivalent, with a capacity of 2 to 3 cu. ft. Leak test the bag in the laboratory before using.
    - 2.2.7 Pitot tube--Type S, or equivalent, attached to the probe so that the sampling flow rate can be regulated proportional to the stack gas velocity when velocity is varying with time or a sample traverse is conducted.

---

<sup>1</sup> Trade name.

2.3 *Analysis.*

2.3.1 Orsat analyzer, or equivalent.

3. *Procedure.*

3.1 Grab sampling.

3.1.1 Set up the equipment as shown in Figure 3-1, making sure all connections are leak-free. Place the probe in the stack at a sampling point and purge the sampling line.

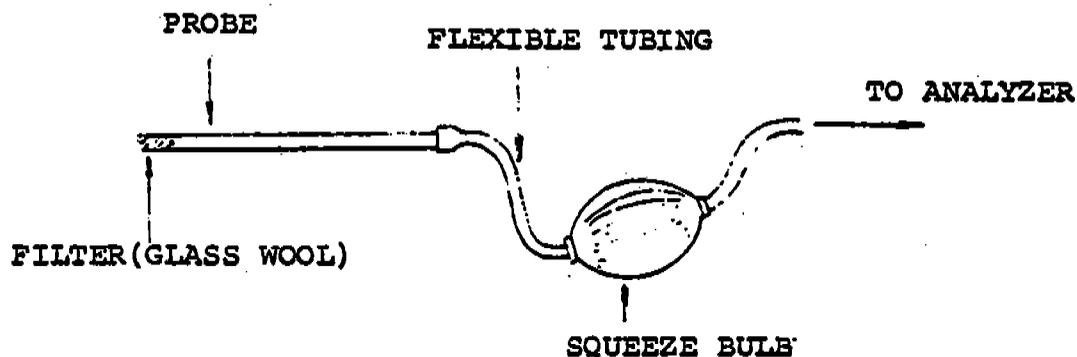


Figure 3-1. Grab-sampling train.

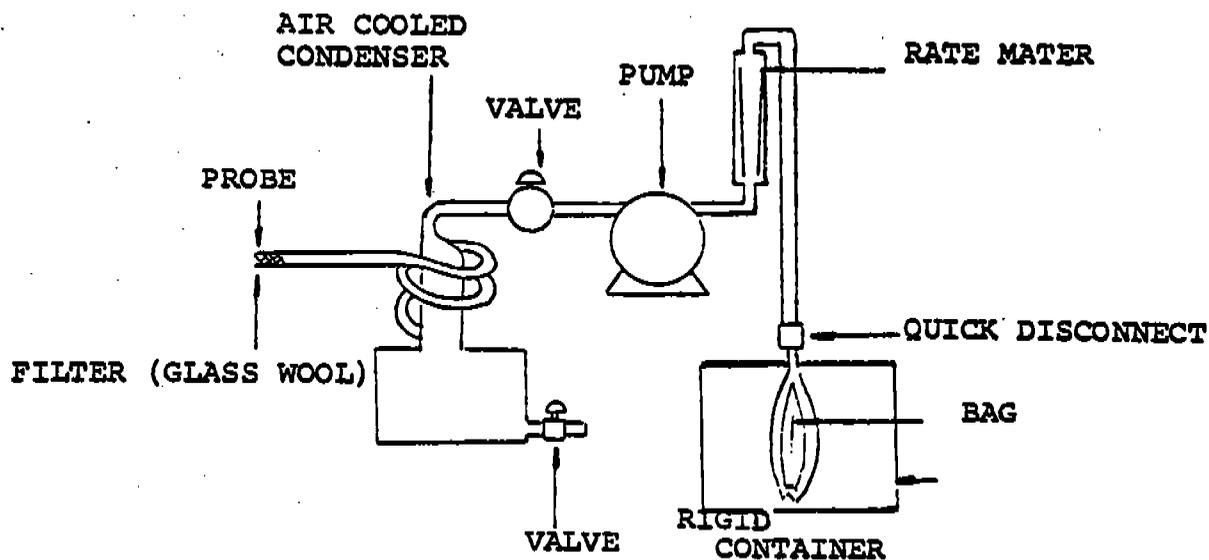


Figure 3-2. Integrated gas - sampling train.

- 3.1.2 Draw sample into the analyzer.
- 3.2 Integrated sampling.
- 3.2.1 Evacuate the flexible bag. Set up the equipment as shown in Figure 3-2 with the bag disconnected. Place the probe in the stack and purge the sampling line. Connect the bag, making sure that all connections are tight and that there are no leaks.
- 3.2.2 Sample at a rate proportional to the stack velocity.
- 3.3 Analysis.
- 3.3.1 Determine the CO<sub>2</sub>, O<sub>2</sub>, and CO concentrations as soon as possible. Make as many passes as are necessary to give constant readings. If more than ten passes are necessary, replace the absorbing solution.
- 3.3.2 For grab sampling, repeat the sampling and analysis until three consecutive samples vary no more than 0.5 percent by volume for each component being analyzed.
- 3.3.3 For integrated sampling, repeat the sampling and analysis of the sample until three consecutive analyses vary no more than 0.2 percent by volume for each component being analyzed.
4. Calculations.
- 4.1 Carbon dioxide. Average the three consecutive runs and report the result to the nearest 0.1% CO<sub>2</sub>.
- 4.2 Excess air. Use Equation 3-1 to calculate excess air, and average the runs. Report the result to the nearest 0.1% excess air.

$$\% \text{ EA} = \frac{(\% \text{O}_2) - 0.5(\% \text{CO})}{0.264(\% \text{N}_2) - (\% \text{O}_2) + 0.5(\% \text{CO})} \times 100$$

Equation 3-1

where:

- % EA = Percent excess air.
- % O<sub>2</sub> = Percent oxygen by volume, dry basis.
- % N<sub>2</sub> = Percent nitrogen by volume, dry basis.
- % CO = Percent carbon monoxide by volume, dry basis.
- 0.264 = Ratio of oxygen to nitrogen in air by volume.

- 4.3 Dry molecular weight. Use Equation 3-2 to calculate dry molecular weight and average the runs. Report the result to the nearest tenth.

$$\text{Md} = 0.44 (\% \text{CO}_2) + 0.32 (\% \text{O}_2) + 0.28 (\% \text{N}_2 + \% \text{CO})$$

Equation 3-2

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where:

Md = Dry Molecular weight, lb/lb-mole.

%CO<sub>2</sub> = Percent carbon dioxide by volume, dry basis.

%O<sub>2</sub> = Percent oxygen by volume, dry basis.

%N<sub>2</sub> = Percent nitrogen by volume, dry basis.

0.44 = Molecular weight of carbon dioxide divided by 100.

0.32 = Molecular weight of oxygen divided by 100.

0.28 = Molecular weight of nitrogen and CO divided by 100.

5. *References.*

Altshuller, A. P., et al., Storage of Gases and Vapors in Plastic Bags, *Int. J. Air & Water Pollution*, 6:75-81, 1963.

Conner, William D., and J. S. Nader, Air Sampling with Plastic Bags, *Journal of the American Industrial Hygiene Association*, 25:291-297, May-June, 1964.

Devorkin, Howard, et al., Air Pollution Source Testing Manual, Air Pollution Control District, Los Angeles, California, November, 1963.

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## APPENDIX F

### DETERMINATION OF MOISTURE IN STACK GASES

## METHOD 4--DETERMINATION OF MOISTURE IN STACK GASES

1. *Principle and Applicability.*
  - 1.1 Principle. Moisture is removed from the gas stream, condensed, and determined volumetrically.
  - 1.2 Applicability. This method is applicable for the determination of moisture in stack gas only when specified by test procedures for determining compliance with New Source Performance Standards. This method does not apply when liquid droplets are present in the gas stream<sup>1</sup> and the moisture is subsequently used in the determination of stack gas molecular weight.

Other methods such as drying tubes, wet bulb-dry bulb techniques, and volumetric condensation techniques may be used.

2. *Apparatus.*
  - 2.1. Probe--Stainless steel or Pyrex<sup>2</sup> glass sufficiently heated to prevent condensation and equipped with a filter to remove particulate matter.
  - 2.2 Impingers--Two midget impingers, each with 30 ml. capacity, or equivalent.
  - 2.3 Ice bath container--To condense moisture in impingers.
  - 2.4 Silica gel tube (optional)--To protect pump and dry gas meter.
  - 2.5 Needle valve--To regulate gas flow rate.
  - 2.6 Pump--Leak-free, diaphragm type, or equivalent, to pull gas through train.
  - 2.7 Dry gas meter--To measure to within 1% of the total sample volume.
  - 2.8 Rotameter--To measure a flow range from 0 to 0.1 c.f.m.
  - 2.9 Graduated cylinder--25 ml.
  - 2.10 Barometer--Sufficient to read to within 0.1 in.Hg.

<sup>1</sup>  
If liquid droplets are present in the gas stream, assume the stream to be saturated, determine the average stack gas temperature by traversing according to Method 1, and use a psychrometric chart to obtain an approximation of the moisture percentage.

<sup>2</sup>Trade name.

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- 2.11 Pitot tube--Type S, or equivalent, attached to probe so that the sampling flow rate can be regulated proportional to the stack gas velocity when velocity is varying with time or a sample traverse is conducted.
3. Procedure.
- 3.1 Place exactly 5 ml. distilled water in each impinger. Assemble the apparatus without the probe as shown in Figure 4-1. Leak check by plugging the inlet to the first impinger and drawing a vacuum. Insure that flow through the dry gas meter is less than 1% of the sampling rate.
- 3.2 Connect the probe and sample at a constant rate of 0.075 c.f.m. or at a rate proportional to the stack gas velocity. Continue sampling until the dry gas meter registers 1 cubic foot or until visible liquid droplets are carried over from the first impinger to the second. Record temperature, pressure and dry gas meter readings as required by Figure 4-2.
- 3.3 After collecting the sample, measure the volume increase to the nearest 0.5 ml.
4. Calculations.
- 4.1 Volume of water vapor collected.

$$V_{wc} = \frac{(V_f - V_i) \rho_{H_2O} RT_{std}}{P_{std} M_{H_2O}} = 0.0474 \frac{\text{ft.}^3}{\text{ml.}} (V_f - V_i)$$

Equation 4-1

where:

- $V_{wc}$  = Volume of water vapor collected (standard conditions) cu. ft.
- $V_f$  = Final volume of impinger contents, ml.
- $V_i$  = Initial volume of impinger contents, ml.
- $R$  = Ideal gas constant, 21.83 inches Hg - cu.ft/lb.mole-<sup>o</sup>R.
- $\rho_{H_2O}$  = Density of water, 1 g./ml.
- $T_{std}$  = Absolute temperature at standard conditions, 530<sup>o</sup>R.
- $P_{std}$  = Absolute pressure at standard conditions, 29.92 in.Hg.
- $M_{H_2O}$  = Molecular weight of water, 18 lb./lb.-mole.

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4.2 Gas volume.

$$V_{mc} = V_m \left( \frac{P_m}{P_{std}} \right) \left( \frac{T_{std}}{T_m} \right) = 17.71 \frac{^{\circ}R}{\text{in.Hg}} \left( \frac{V_{mP}}{T_m} \right)$$

Equation 4-2

where:

$V_{mc}$  = Dry gas volume through meter at standard conditions, cu.ft.

$V_m$  = Dry gas volume measured by meter, cu. ft.

$P_m$  = Barometric pressure at the dry gas meter, inches Hg.

$P_{std}$  = Pressure at standard conditions, 29.92 inches Hg.

$T_{std}$  = Absolute temperature at standard conditions, 530<sup>o</sup>R.

$T_m$  = Absolute temperature at meter (<sup>o</sup>F + 460) <sup>o</sup>R.

4.3 Moisture content.

$$B_{wo} = \frac{V_{wc}}{V_{wc} + V_{mc}} + B_{wm} = \frac{V_{wc}}{V_{wc} + V_{mc}} + (0.025)$$

Equation 4-3

where:

$B_{wo}$  = Proportion by volume of water vapor in the gas stream, dimensionless.

$V_{wc}$  = Volume of water vapor collected (standard conditions) cu.ft.

$V_{mc}$  = Dry gas volume through meter (standard conditions) cu.ft.

$B_{wm}$  = Approximate volumetric proportion of water vapor in the gas stream leaving the impingers, 0.025.

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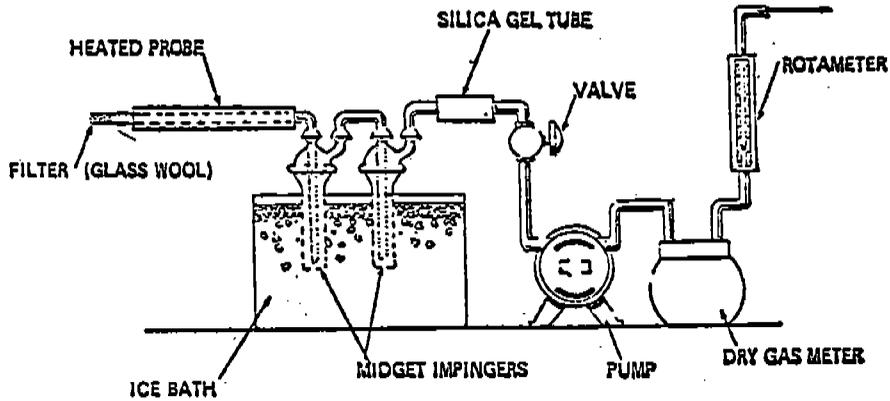


Figure 4-1. Moisture-sampling train.

LOCATION \_\_\_\_\_ COMMENTS \_\_\_\_\_  
 TEST \_\_\_\_\_  
 DATE \_\_\_\_\_  
 OPERATOR \_\_\_\_\_  
 BAROMETRIC PRESSURE \_\_\_\_\_

CLOCK TIME	GAS VOLUME THROUGH METER, (Vm), ft <sup>3</sup>	ROTAMETER SETTING ft <sup>3</sup> /min	METER TEMPERATURE, °F

Figure 4-2. Field moisture determination.

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5. *References.*

Air Pollution Engineering Manual, Danielson, J. A. (ed.), U. S. DHEW, PHS, National Center for Air Pollution Control, Cincinnati, Ohio, PHS Publication No. 999-AP-40, 1967.

Devorkin, Howard, et al., Air Pollution Source Testing Manual, Air Pollution Control District, Los Angeles, California, November, 1963.

Methods for Determination of Velocity, Volume, Dust and Mist Content of Gases, Western Precipitation Division of Joy Manufacturing Co., Los Angeles, California, Bulletin WP-50, 1968.

# **THE ALMEGA CORPORATION**

## **APPENDIX G;**

### **DETERMINATION OF PARTICULATE EMISSIONS FROM STATIONARY SOURCES**

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METHOD 5--DETERMINATION OF PARTICULATE EMISSIONS FROM  
STATIONARY SOURCES

1. *Principle and Applicability.*
  - 1.1 Principle. Particulate matter is withdrawn isokinetically from the source and its weight is determined gravimetrically after removal of uncombined water.
  - 1.2 Applicability. This method is applicable for the determination of particulate emissions from stationary sources only when specified by the test procedures for determining compliance with New Source Performance Standards.
2. *Apparatus.*
  - 2.1 Sampling train. The design specifications of the particulate sampling train used by EPA (Figure 5-1) are described in APTD-0581. Commercial models of this train are available.
    - 2.1.1 Nozzle--Stainless steel (316) with sharp, tapered leading edge.
    - 2.1.2 Probe--Pyrex<sup>1</sup> glass with a heating system capable of maintaining a minimum gas temperature of 250° F. at the exit end during sampling to prevent condensation from occurring. When length limitations (greater than about 8 ft.) are encountered at temperatures less than 600° F., Incoloy 825<sup>1</sup>, or equivalent, may be used. Probes for sampling gas streams at temperatures in excess of 600° F. must have been approved by the Administrator.
    - 2.1.3 Pitot tube--Type S, or equivalent, attached to probe to monitor stack gas velocity.
    - 2.1.4 Filter Holder--Pyrex<sup>1</sup> glass with heating system capable of maintaining minimum temperature of 225° F.
    - 2.1.5 Impingers/Condenser--Four impingers connected in series with glass ball joint fittings. The first, third, and fourth impingers are of the Greenburg-Smith design, modified by replacing the tip with a ½-inch ID glass tube extending to one-half inch from the bottom of the flask. The second impinger is the Greenburg-Smith design with the standard tip. A condenser may be used in place of the impingers provided that the moisture content of the stack gas can still be determined.

<sup>1</sup>Trade name.

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- 2.1.6 Metering system--Vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 5<sup>o</sup>F., dry gas meter with 2% accuracy, and related equipment, or equivalent, as required to maintain an isokinetic sampling rate and to determine sample volume.
- 2.1.7 Barometer--To measure atmospheric pressure to  $\pm$  0.1 inches Hg.
- 2.2 Sample recovery.
  - 2.2.1 Probe brush--At least as long as probe.
  - 2.2.2 Glass wash bottles--Two.
  - 2.2.3 Glass sample storage containers.
  - 2.2.4 Graduated cylinder--250 ml.
- 2.3 Analysis.
  - 2.3.1 Glass weighing dishes.
  - 2.3.2 Desiccator.
  - 2.3.3 Analytical balance--To measure to  $\pm$  0.1 mg.
  - 2.3.4 Trip balance--300 g. capacity, to measure to  $\pm$  0.05 g.
- 3. *Reagents.*
  - 3.1 Sampling.
    - 3.1.1 Filters--Glass fiber, MSA 1106 BH<sup>1</sup>, or equivalent, numbered for identification and preweighed.
    - 3.1.2 Silica gel--Indicating type, 6-16 mesh, dried at 175<sup>o</sup>C. (350<sup>o</sup> F.) for 2 hours.
    - 3.1.3 Water.
    - 3.1.4 Crushed ice.
  - 3.2 Sample recovery.
    - 3.2.1 Acetone--Reagent grade.
- 3.3 Analysis.

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<sup>1</sup> Trade name.

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- 3.3.1 Water.
- 3.3.2 Desiccant--Drierite<sup>1</sup>, indicating.
- 4. Procedure.
  - 4.1 Sampling.
    - 4.1.1 After selecting the sampling site and the minimum number of sampling points, determine the stack pressure, temperature, moisture and range of velocity head.
    - 4.1.2 Preparation of collection train. Weigh to the nearest gram approximately 200 g. of silica gel. Label a filter of proper diameter, desiccate<sup>2</sup> for at least 24 hours and weigh to the nearest 0.5 mg. in a room where the relative humidity is less than 50%. Place 100 ml. of water in each of the first two impingers, leave the third impinger empty, and place approximately 200 g. of preweighed silica gel in the fourth impinger. Set up the train without the probe as in Figure 5-1. Leak check the sampling train at the sampling site by plugging up the inlet to the filter holder and pulling a 15 in. Hg vacuum. A leakage rate not in excess of 0.02 c.f.m. at a vacuum of 15 in. Hg is acceptable. Attach the probe and adjust the heater to provide a gas temperature of about 250°F. at the probe outlet. Turn on the filter heating system. Place crushed ice around the impingers. Add more ice during the run to keep the temperature of the gases leaving the last impinger as low as possible and preferably at 70°F. or less. Temperatures above 70°F. may result in damage to the dry gas meter from either moisture condensation or excessive heat.
    - 4.1.3 Particulate train operation. For each run, record the data required on the example sheet shown in Figure 5-2. Take readings at each sampling point, at least every 5 minutes and when significant changes in stack conditions necessitate additional adjustments in flow rate. To begin sampling, position the nozzle at the first traverse point with the tip pointing directly into the gas stream. Immediately start the pump and adjust the flow to isokinetic conditions. Sample for at least 5 minutes at each traverse point; sampling time must be the same for each point. Maintain isokinetic sampling throughout the sampling period. Nomographs are available which aid in the rapid adjustment of the sampling rate without other computations.

<sup>1</sup> Trade name.

<sup>2</sup> Dry using Drierite<sup>1</sup> at 70°F. ± 10°F.

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APTD-0576 details the procedure for using these nomographs. Turn off the pump at the conclusion of each run and record the final readings. Remove the probe and nozzle from the stack and handle in accordance with the sample recovery process described in section 4.2.

4.2 Sample recovery. Exercise care in moving the collection train from the test site to the sample recovery area to minimize the loss of collected sample or the gain of extraneous particulate matter. Set aside a portion of the acetone used in the sample recovery as a blank for analysis. Measure the volume of water from the first three impingers, then discard. Place the samples in containers as follows:

Container No. 1 Remove the filter from its holder, place in this container and seal.

Container No. 2 Place loose particulate matter and acetone washings from all sample-exposed surfaces prior to the filter in this container and seal. Use a razor blade, brush or rubber policeman to lose adhering particles.

Container No. 3 Transfer the silica gel from the fourth impinger to the original container and seal. Use a rubber policeman as an aid in removing silica gel from the impinger.

4.3 Analysis. Record the data required on the example sheet shown in Figure 5-3. Handle each sample container as follows:

Container No. 1 Transfer the filter and any loose particulate matter from the sample container to a tared glass weighing dish, desiccate, and dry to a constant weight. Report results to the nearest 0.5 mg.

Container No. 2 Transfer the acetone washings to a tared beaker and evaporate to dryness at ambient temperature and pressure. Desiccate and dry to a constant weight. Report results to the nearest 0.5 mg.

Container No. 3 Weigh the spent silica gel and report to the nearest gram.

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5. *Calibration.* Use methods and equipment which have been approved by the Administrator to calibrate the orifice meter, pitot tube, dry gas meter, and probe heater. Recalibrate after each test series.
6. *Calculations.*
  - 6.1 Average dry gas meter temperature and average orifice pressure drop. See data sheet (Figure 5-2).
  - 6.2 Dry gas volume. Correct the sample volume measured by the dry gas meter to standard conditions (70°F. 29.92 inches Hg) by using Equation 5-1.

$$V_{m\text{std}} = V_m \left( \frac{T_{\text{std}}}{T_m} \right) \left( \frac{P_{\text{bar}} + \frac{\Delta H}{13.6}}{P_{\text{std}}} \right) =$$

$$\left( 17.71 \frac{^{\circ}\text{R}}{\text{in. Hg}} \right) V_m \left( \frac{P_{\text{bar}} + \frac{\Delta H}{13.6}}{T_m} \right)$$

Equation 5-1

where:

- $V_{m\text{std}}$  = Volume of gas sample through the dry gas meter (standard conditions) cu.ft.
- $V_m$  = Volume of gas sample through the dry gas meter (meter conditions) cu.ft.
- $T_{\text{std}}$  = Absolute temperature at standard conditions, 530°R.
- $T_m$  = Average dry gas meter temperature, °R.
- $P_{\text{bar}}$  = Barometric pressure at the orifice meter, inches Hg.
- $\Delta H$  = Average pressure drop across the orifice meter, inches H<sub>2</sub>O.
- 13.6 = Specific gravity of mercury.
- $P_{\text{std}}$  = Absolute pressure at standard conditions, 29.92 inches Hg.
- 6.3 = Volume of water vapor.



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$$V_{W\text{std}} = V_{1c} \frac{\rho_{H_2O}}{M_{H_2O}} \frac{RT_{\text{std}}}{P_{\text{std}}} \frac{\text{lb.}}{454 \text{ gm.}}$$

$$= 0.0474 \frac{\text{cu. ft.}}{\text{ml.}} V_{1c}$$

Equation 5-2

where:

- $V_{W\text{std}}$  = Volume of water vapor in the gas sample (standard conditions) cu.ft.
- $V_{1c}$  = Total volume of liquid collected in impingers and silica gel (see Figure 5-3) ml.
- $\rho_{H_2O}$  = Density of water, lg./ml.
- $M_{H_2O}$  = Molecular weight of water, 18 lb./lb.-mole.
- $R$  = Ideal gas constant, 21.83 inches Hg--cu.ft./lb.-mole-R.
- $T_{\text{std}}$  = Absolute temperature at standard conditions, 530°R.
- $P_{\text{std}}$  = Absolute pressure at standard conditions, 29.92 inches Hg.

6.4 Moisture content.

$$B_{wo} = \frac{V_{W\text{std}}}{V_{m\text{std}} + V_{W\text{std}}}$$

Equation 5-3

where:

- $B_{wo}$  = Proportion by volume of water vapor in the gas stream dimensionless.
- $V_{W\text{std}}$  = Volume of water in the gas sample (standard conditions) cu.ft.
- $V_{m\text{std}}$  = Volume of gas sample through the dry gas meter (standard conditions) cu.ft.

6.5 Total particulate weight. Determine the total particulate catch from the sum of the weights on the analysis data sheet (Figure 5-3).

6.6 Concentration.

6.6.1 Concentration in gr./s.c.f.

$$c'_s = \left( 0.0154 \frac{\text{gr.}}{\text{mg.}} \right) \left( \frac{M_n}{V_{m\text{std}}} \right)$$

Equation 5-4

where:

$c'_s$  = Concentration of particulate matter in stack gas, gr./s.c.f., dry basis.

$M_n$  = Total amount of particulate matter collected, mg.

$V_{m\text{std}}$  = Volume of gas sample through dry gas meter (standard conditions) cu. ft.

6.6.2 Concentration in lb./cu. ft.

$$c_s = \frac{\left( \frac{1}{453,600} \frac{\text{lb.}}{\text{mg.}} \right) M_n}{V_{m\text{std}}} = 2.205 \times 10^{-6} \frac{M_n}{V_{m\text{std}}}$$

Equation 5-5

where:

$c_s$  = Concentration of particulate matter in stack gas, lb./s.c.f., dry basis.

453,600 = Mg/lb.

$M_n$  = Total amount of particulate matter collected, mg.

$V_{m\text{std}}$  = Volume of gas sample through dry gas meter (standard conditions) cu. ft.

6.7 Isokinetic variation.

$$I = T_s \frac{\left[ \frac{0.00267 \text{ in. Hg-cu. ft.}}{\text{ml-OR}} \right] V_{1s} + \frac{V_m}{T_m} \left( P_{\text{bar}} + \frac{H}{13.6} \right) \left( 1.667 \frac{\text{min}}{\text{sec}} \right)}{\Theta V_s P_s A_n}$$

Equation 5-6

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where:

- I = Percent of isokinetic sampling.
- $V_{1c}$  = Total volume of liquid collection in impingers and silica gel (See Figure 5-3) ml.
- $\rho_{H_2O}$  = Density of water, 1 g./ml.
- R = Ideal gas constant, 21.83 inches Hg-cu. ft./lb. mole-°R.
- $M_{H_2O}$  = Molecular weight of water, 18 lb./lb.-mole.
- $V_m$  = Volume of gas sample through the dry gas meter (meter conditions) cu. ft.
- $T_m$  = Absolute average dry gas meter temperature (see Figure 5-2) °R.
- $P_{bar}$  = Barometric pressure at sampling site, inches Hg.
- $\Delta H$  = Average pressure drop across the orifice (See Figure 5-2) inches,  $H_2O$ .
- $T_s$  = Absolute average stack gas temperature (See Figure 5-2) °R.
- $\theta$  = Total sampling time, min.
- $V_s$  = Stack gas velocity calculated by Method 2, Equation 2-2, ft./sec.
- $P_s$  = Absolute stack gas pressure, inches Hg.
- $A_n$  = Cross-sectional area of nozzle, sq. ft.

6.8 Acceptable results. The following range sets the limit on acceptable isokinetic sampling results:

If  $90\% \leq 110\%$ , the results are acceptable; otherwise, reject the results and repeat the test.

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7. References.

- Addendum to Specifications for Incinerator Testing at Federal Facilities, PHS, NCAPC, Dec. 6, 1967.
- Martin, Robert M., Construction Details of Isokinetic Source Sampling Equipment, Environmental Protection Agency, APTD-0581.
- Rom, Jerome J., Maintenance, Calibration and Operation of Isokinetic Source Sampling Equipment, Environmental Protection Agency, APTD-0576.
- Smith, W. S., R. T. Shigehara, and W. F. Todd, A Method of Interpreting Stack Sampling Data, Paper presented at the 63rd Annual Meeting of the Air Pollution Control Association, St. Louis, Mo., June 14-19, 1970.
- Smith, W. S., et al., Stack Gas Sampling Improved and Simplified with New Equipment, APCA Paper No. 67-119, 1967.
- Specifications for Incinerator Testing at Federal Facilities, PHS, NCAPC, 1967.

PLANT \_\_\_\_\_  
 DATE \_\_\_\_\_  
 RUN NO. \_\_\_\_\_

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED, mg		
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
1			
2			
TOTAL			

	VOLUME OF LIQUID WATER COLLECTED	
	IMPINGER VOLUME, ml	SILICA GEL WEIGHT, g
FINAL		
INITIAL		
LIQUID COLLECTED		
TOTAL VOLUME COLLECTED		g <sup>a</sup> ml

CONVERT WEIGHT OF WATER TO VOLUME BY DIVIDING TOTAL WEIGHT INCREASE BY DENSITY OF WATER. (1 g. ml):

$$\frac{\text{INCREASE, g}}{(1 \text{ g/ml})} = \text{VOLUME WATER, ml}$$

Figure 5-3. Analytical data.

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## APPENDIX H NOMENCLATURE

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NOMENCLATURE

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A	Cross sectional area of stack ft. <sup>2</sup>
A <sub>n</sub>	Cross-sectional area of nozzle, sq.ft.
B <sub>wm</sub>	Approximate volumetric proportion of water vapor in the gas stream leaving the impingers, 0.025
B <sub>wo</sub>	Proportion by volume of water vapor in the gas system, dimensionless
C	Concentration of NO <sub>x</sub> as NO <sub>2</sub> (dry basis), lb/s.c.f.
CO	Percent carbon monoxide by volume, dry basis
C <sub>p</sub>	Pitot tube coefficient dimensionless
C <sub>p</sub> std	Pitot tube coefficient of standard type pitot tube (if unknown, use 0.99)
C <sub>p</sub> test	Pitot tube coefficient of type S pitot tube
C <sub>s</sub>	Concentration of particulate matter in stack gas, lb./s.c.f., dry basis
C <sub>SO<sub>2</sub></sub>	Concentration of sulfur dioxide at standard conditions, dry basis, lb./cu.ft.
EA	Percent excess air
ΔH	Average pressure drop across the orifice, inches H <sub>2</sub> O
H <sub>2</sub> O	Density of water, lg./ml.
I	Percent of isokinetic sampling
m	Mass of NO <sub>2</sub> in gas sample, mg.
M <sub>d</sub>	Dry molecular weight, lb./lb-mole
M <sub>H<sub>2</sub>O</sub>	Molecular weight of water, 18 lb./lb-mole
M <sub>n</sub>	Total amount of particulate matter collected, mg.
M <sub>s</sub>	Molecular weight of stack gas (wet basis) lb./lb-mole
N	Normality of barium perchlorate titrant, g.-eq./l
N <sub>2</sub>	Percent nitrogen by volume, dry basis
O <sub>2</sub>	Percent oxygen by volume, dry basis
( $\sqrt{\Delta p}$ ) avg	Average velocity head of stack gas, inches H <sub>2</sub> O
P <sub>bar</sub>	Barometric pressure at the orifice meter, inches Hg.
P <sub>f</sub>	Final absolute pressure of flask, inches Hg.

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$P_{H_2O}$	Density of water, lg./ml.
$P_i$	Initial absolute pressure of flask, inches Hg.
$P_m$	Barometric pressure at the dry gas meter, inches Hg.
$P_s$	Absolute stack gas pressure, inches Hg.
$P_{std}$	Absolute pressure at standard conditions, 29.92 in.Hg.
$\Delta P_{std}$	Velocity head measured by standard type pitot tube
$\Delta P_{test}$	Velocity head measured by type S pitot tube
$Q_s$	Volumetric flow rate, dry basis, standard conditions, cu.ft./hr.
$R$	Ideal gas constant, 21.83 inches Hg-cu.ft./lb. mole- $^{\circ}R$
$T_f$	Final absolute temperature of flask, $^{\circ}R$
$T_i$	Initial absolute temperature of flask, $^{\circ}R$
$T_m$	Average dry gas meter temperature, $^{\circ}R$
$(T_s)_{avg.}$	Average absolute stack gas temperature, $^{\circ}R$
$T_{std}$	Absolute temperature at standard conditions, 530 $^{\circ}R$
$V_a$	Volume of sample aliquot titrated, ml.
$V_f$	Final volume of impinger contents, ml.
$V_i$	Initial volume of impinger contents, ml.
$V_{lc}$	Total volume of liquid collected in impingers & silica gel. ml.
$V_m$	Dry gas volume measured by meter, cu.ft.
$V_{mc}$	Dry gas volume through meter (standard conditions), cu.ft.
$V_m \text{ std.}$	Volume of gas sample through the dry gas meter (standard conditions) cu.ft.
$V_s$	Stack gas velocity, ft. per second (f.p.s.)
$(V_s)_{avg.}$	Stack gas velocity, feet per second (f.p.s.)
$V_{sc}$	Sample volume at standard conditions (dry basis) ml.
$V_{soln}$	Total solution volume of sulfur dioxide, 50 ml.

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$V_t$	Volume of barium perchlorate titrant used for the sample, ml.
$V_{tb}$	Volume of barium perchlorate titrant used for the blank, ml.
$V_{wc}$	Volume of water vapor collected (standard conditions) cu.ft.
$V_{w\text{ std}}$	Volume of water in the gas sample (standard conditions) cu.ft.

Figure 1

SOTDAT/STEEL LIBRARY SYSTEM

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Report Title: *see report*  
Plant and Location: *Inland / E. Chicago*  
SCC: *30300303*  
Testing Date(s): *8/4-8/80*  
By Whom: *Alan Almega*  
Stack Test Review Attached:

Reviewed By:

Problems Seen by Reviewer:

Confidentiality Status:

If status is confidential, list confidential pages or sections:

Source of Determination of the Confidentiality Status:

Report Encoded By:

Date Encoded:

Form Numbers:

Comments:

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