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AP-42 Section 12.2  
Reference  
Report Sect. 4  
Reference 126

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): *12/30-31/80*  
By Whom: *Alta Almega*  
Stack Test Review Attached:  
Reviewed By:  
Problems Seen by Reviewer:

Confidentiality Status:

If status is confidential, list confidential pages or sections:

of Determination of the Confidentiality Status:

ded By:

**The ALMEGA CORPORATION**

JACA-62

Inland Steel

NO. 3 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. 9N-47176

THE ALMEGA CORPORATION  
PROJECT I-5492

DECEMBER 30-31, 1980

# THE ALMEGA CORPORATION

## EMISSION TESTING OF THE NO. 3 COKE SIDE GAS CLEANING CAR: INLAND STEEL COMPANY

Testing was performed December 30-31, 1980, by The Almega Corporation to determine the particulate emission rate from the No. 3 Coke Side Emission Control Gas Cleaning Car in Plant 2 at Inland Steel Company in East Chicago, Indiana.

The 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. D. Chapman and Mr. T. Schroeder of The Almega Corporation. Mr. D. Chapman was team leader and certifies to the accuracy of the report.

Respectfully submitted,

THE ALMEGA CORPORATION



D. Chapman

DC/av

# THE ALMEGA CORPORATION

## EMISSION TESTING OF THE NO. 3 COKE SIDE GAS CLEANING CAR: INLAND STEEL COMPANY

### INTRODUCTION

Particulate emissions testing was performed December 30-31, 1980 on the No. 3 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 was R. Griscom of National Steel Corporation who monitored scrubber operations throughout the test.

Mr. B. DiHu and Mr. S. Wynnchenco of 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 30 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 Method 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.

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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.

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 54 inch long sampling probe and 0.1860 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:

<u>Test Repetition #</u>	1	2	3	AVERAGE
Particulate emission lbs/hr*	7.51	7.67	7.67	
Test time mins.	26.85	26.33	42.45	
Coke production tons/test	116.3	123.7	115.4	
Particulate emissions** lbs/ton of coke	0.0289	0.0272	0.0470	0.0344

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Inland Steel Company  
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**\*NOTE:**

The pounds of particulate per hour figure is calculated based on a continuous pushing operation. This number is used solely to determine pounds of particulate per ton of coke and should not be viewed as the actual pounds of particulate per hour for normal operation.

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

$$\frac{7.51 \times \frac{26.85}{60}}{116.3} = 0.0289 \text{ lbs/ton of coke pushed}$$

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 102.7, 106.6 and 94.1% 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 95 to 135°F and the average velocities from 88 to 98 ft/sec. Stack gas moistures ranged from 9.9 to 14.3% on a vol/vol basis.

4) The sampling time for each point in repetitions #1 and #2 ranged typically between 2 and 2 1/2 minutes. Consequently, the total sampling time for both runs was about 26 minutes. The sampling time for each point in repetition #3 also ranged typically between 2 and 2 1/2 minutes. The total sampling time for repetition #3 was increased by 15 minutes due to a delay in raising the hood on push #10. During this time delay, the scrubber was operated normally, thus permitting the continuation of emission testing. The testing times follow the sampling protocol of Appendix B, but is less than the 1 hour minimum test repetition time required by CFR Title 40 (Ref. 1).

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Inland Steel Company  
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Page Four

5) Due to the shorter test times for repetitions #1 and #2 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 0.20 to 5.50 inches of water.

## CONCLUSION

Particulate emissions testing was performed December 30-31, 1980 on the No. 3 Coke Side Emission Control One Spot Quench Car in Plant 2 at Inland Steel in East Chicago, Indiana.

Emission testing was conducted by D. Chapman and T. Schroeder 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. 3 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	116.3	0.0165	0.0289
2	123.7	0.0173	0.0272
3	115.4	0.0171	0.0470
AVERAGE	118.5	0.0170	0.0344

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## SUMMARY OF EMISSION TEST DATA

TABLE: 1

PLANT: Inland Steel Company, East Chicago, Indiana

LOCATION: No. 3 Coke Side Emission Control One Spot Gas Cleaning Car: Scrubber Exhaust Stack  
D. Chapman and T. Schroeder

TEST DATE:	12/30/80	12/31/80	12/31/80	
REPETITION#:	1	2	3	AVERAGE

### STACK GAS

Average temperature, °F	116.17	118.46	119.29	117.97
Velocity average fps	93.38	94.22	91.13	92.91
Volume flow x 10 <sup>6</sup> scfh db	3.19	3.10	3.15	3.15
Volume flow x 10 <sup>3</sup> acfm	67.64	68.25	66.01	67.30
Moisture %	13.20	14.28	9.98	12.49
Carbon Dioxide %	3.00	3.23	3.37	3.20
Oxygen %	16.33	15.90	15.83	16.02

### PARTICULATE SAMPLE

Time, mins.	26.85	26.33	42.45	
Volume scf db	23.53	22.88	33.46	
Particulates collected, grams	0.0251	0.0257	0.0370	
Isokinetic Ratio, I%	102.7	106.6	94.1	
90 ≤ I ≤ 110				

### COKE PRODUCTION RATE

Tons/Test run (12 pushes)	116.3	123.7	115.4	118.5
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### PARTICULATE

Concentration grains/scf db	0.0165	0.0173	0.0171	0.0170
x 10 <sup>-6</sup> lbs/scf db	2.35	2.48	2.44	2.42
Emissions lbs/hr*	7.51	7.67	7.67	7.62
lbs/ton of coke	0.0289	0.0272	0.0470	0.0344

**\*NOTE:**

The pounds of particulate per hour figure is calculated based on a continuous pushing operation. This number is used solely to determine pounds of particulate per ton of coke and should not be viewed as the actual pounds of particulate per hour for normal operation.

# The ALMEGA CORPORATION

## 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

FIGURE 1

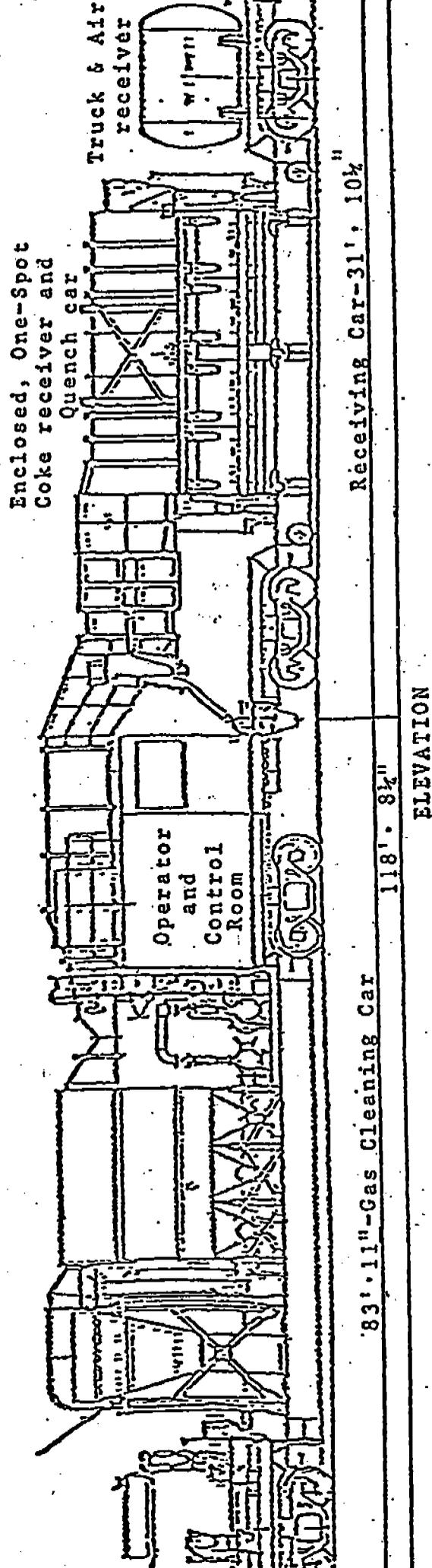
INLAND STEEL COMPANY  
EAST CHICAGO, INDIANA  
COKE BATTERY

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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## **APPENDIX A**

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

# THE ALMEGA CORPORATION

## PARTICULATE CALCULATION SUMMARY

COMPANY: INLAND STEEL  
 SOURCE: #30NC SPOT CAR  
 REPETITION NO: 1  
 TEST DATE: 12/30/80

ENGLISH UNITS  
 (29.92in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[ 17.64 \right] V_m \gamma \left[ \frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m} \right] = \underline{23.532} \text{ dscf.}$$

$\gamma = \underline{1.007}$

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[ 0.04707 \frac{\text{cu. ft.}}{\text{ml}} \right] V_{lc} = \underline{3.5773} \text{ scf.}$$

$V_{lc} = \underline{76} \text{ ml.}$

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{0.1320}$$

Particle concentration in stack gas on dry basis

$$c's = \left[ 0.01543 \frac{\text{gr}}{\text{mg}} \right] \left[ \frac{M_n}{V_{mstd}} \right] = \underline{0.0165} \text{ grains/dscf.}$$

$$= 2.205 \cdot 10^{-6} \frac{M_n}{V_{mstd}} = \underline{2.3519} \times 10^{-6} \text{ lbs/dscf}$$

Stack gas volume flow rate on dry basis

$$Q_s = 3600 (1 - B_{ws}) V_s A_s \left[ \frac{T_{std} \cdot P_s}{(T_s)_{avg} \cdot P_{std}} \right] = \underline{3.1924} \times 10^6 \text{ dscf Ave.}$$

( $A_s = 12073 \text{ sq. ft.}$      $V_s = 92.123 \frac{\text{ft}}{\text{sec}}$  Ave)

Process rate or BTU rating  $P_w =$  \_\_\_\_\_

Emission rate  $Q_s \text{ c's} = \underline{7.51} \text{ lbs/hr}$

$\frac{Q_s \text{ c's}}{P_w} =$  \_\_\_\_\_ lbs/

Isokinetic sampling rate

$$I = \left( 1.667 \frac{\text{min}}{\text{sec}} \right) T_s \left[ \frac{0.002669 \frac{\text{in. Hg. cu. ft.}}{\text{ml. OR}} V_{lc}}{\Theta V_s P_s A_n} + \frac{V_m \gamma}{T_m} \left( \frac{P_{bar} + \frac{\Delta H}{13.6}}{13.6} \right) \right]$$

( $A_n = 0.000189 \text{ sq. ft.}$ )  $= \underline{102.7}$

# The ALMEGA CORPORATION

## STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: INLAND STEEL  
 SOURCE: #3 ONE SPOT CAR.  
 REPETITION NO: 1  
 TEST DATE: 12/30/80

Dry molecular weight of stack gas

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

$$= \underline{29.133} \text{ lb/lb-mole}$$

Molecular weight of stack gas, wet basis

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

$$= \underline{27.663} \text{ lb/lb-mole}$$

Pitot tube coefficient

$$C_p \text{ (from calibration curve)} = \underline{0.84}$$

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

$$(\sqrt{\Delta p}) \text{ avg.} = \frac{\text{INITIAL}}{\text{FINAL}} = \underline{1.6345 / 1.4651}$$

Average absolute stack gas temperature

$$(T_s) \text{ avg.} = \underline{\hspace{2cm}} \text{ OF} + 460 = \underline{568.67 / 583.67} \text{ R}$$

Absolute stack gas pressure

$$P_s = P_b + (\text{Static Pressure}/13.6) = \underline{29.564} \text{ in. Hg}$$

Stack gas velocity

$$(V_s) \text{ avg.} = (85.49) C_p (\sqrt{\Delta p}) \text{ avg.} \sqrt{\frac{(T_s) \text{ avg.}}{P_s M_s}}$$

$$= \underline{97.877 / 88.882} \text{ ft/sec.}$$

Stack gas volume flow rate

$$60 V_s A_s = \underline{70,900 / 64,384} \text{ acfm}$$

Stack gas volume flow rate, dry basis

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

$$= \underline{3.1924} \times 10^6 \text{ dscf/Ave.}$$

$$\underline{3.3876 / 2.9972}$$

# PARTICULATE FIELD DATA

PLANT INLAND STEEL AMBIENT TEMPERATURE 31  
 DATE 12/30/80 BAROMETRIC PRESSURE 29.48  
 LOCATION EAST CHICAGO, IND ASSUMED MOISTURE, % 14  
 OPERATOR DCITS+EA+BJ PROBE LENGTH, in. 54"  
 STACK NO. #3 COKE CAR NOZZLE DIAMETER, in. 1.86  
 RUN NO. 1 STACK DIAMETER, in. 57 x 30 1/2  
 SAMPLE BOX NO. 4 PROBE HEATER SETTING 4 320  
 METER BOX NO. 5 HEATER BOX SETTING 4 320

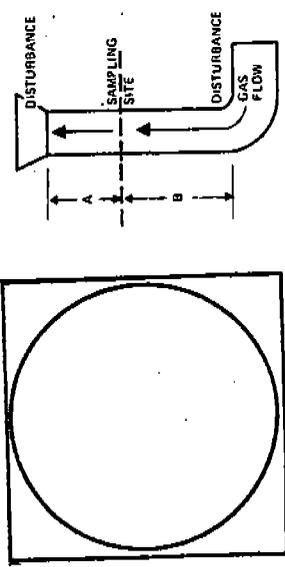
METER ΔHg 84  
 C FACTOR 84

PROCESS WEIGHT RATE

WEIGHT OF PARTICULATE COLLECTED, mg	
SAMPLE	FILTER
FINAL WEIGHT	PROBE WASH
TARE WEIGHT	
WEIGHT GAIN	

TOTAL  
252 00974

SCHEMATIC OF STACK



CROSS SECTION

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H <sub>2</sub> O)	STACK TEMPERATURE (T <sub>s</sub> ), °F	VELOCITY HEAD (V <sub>h</sub> ), (ft/min) <sup>2</sup> / 1.84	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		SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps					
							INLET (T <sub>m</sub> <sup>in</sup> ), °F	OUTLET (T <sub>m</sub> <sup>out</sup> ), °F									
1	0:00	12:30	111	110	50	75	28	5495	342	58	70	70	310	48	3	41.2	
2	2:27	12:47	110	95	105	5:20	4.0	220	96.3	124	72	70	325	46	10	135	
3	5:04	12:56	105	132	160	1.5	90	99.51	67	72	70	325	290	49	5	75	
4	7:05	13:2	105	128	5.00	2.5	210	5500	52	72	70	300	300	45	10	10	
5	9:06	13:2	110	135	250	1.50	140	2.75	86	78	72	320	320	45	6	6	
6	11:27	14:0	120	128	5.10	3.0	215	5.01	81	75	72	320	320	45	10	10	
7	13:38	14:54	105	115	1.50	1.0	85	7.31	65	76	72	325	325	48	5	5	
8	15:51	2:07	110	126	3.00	4.5	160	9.36	66	76	72	325	325	48	6	6	
9	17:54	1:10	108	125	3.00	5.0	160	11.38	66	78	72	325	325	50	6	6	
10	20:08	1:20	135	135	2.50	1.5	140	13.90	66	78	72	330	330	50	10	10	
11	22:15	1:10	125	125	4.50	5.0	190	15.50	66	78	72	325	325	50	10	10	
12	24:36	1:20	105	110	80	25	44	17.32	66	80	72	325	325	50	4	4	
13	26:51							55	19.22								
TOTAL	26:85																
AVERAGE																	

Comments: LEAK CHECK START 2:01CFM 22" Hg AT NOZZLE  
 LEAK CHECK 2.01CFM 20" Hg  
 FINISH © 1973 CHICAGO SCIENTIFIC INC. (312) 766-2013

23.879 7325  
 1.400 108.67  
 1.6545  
 1.9017

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml				SILICA GEL WEIGHT, g	ORSAT MEASUREMENT	TIME	CO <sub>2</sub>	O <sub>2</sub>	CO	N <sub>2</sub>
	1	2	3	4							
FINAL	155	114	-	-	307	1	12:50	3.5	16.0		
INITIAL	100	160	-	-	59	2	2:15	3.0	16.2		
LIQUID COLLECTED	55	141			7	3	2:50	2.5	16.8		
TOTAL VOLUME COLLECTED					16	4	3:00	16.30	80.67		

300 RPM 1100 RPM

# THE ALMEGA CORPORATION

607 C Country Club Drive  
Bensenville, Illinois 60106  
Phone: (312) 595-0175

## SAMPLE ANALYTICAL DATA FORM

PLANT Inland Steel RUN NUMBER 1  
SAMPLE LOCATION #3 One Spot Car  
RELATIVE HUMIDITY 26  
DENSITY OF ACETONE ( $P_a$ ) 0.7856 g/ml  
Liquid level marked and container sealed YES  
Acetone rinse container number 1  
Acetone rinse volume ( $V_{aw}$ ) 159 ml  
Acetone blank residue concentration ( $C_a$ ) 0.0025 mg/g  
 $W_a = C_a V_{aw} P_a = (0.0025) (159) (0.7856) =$  0.3 mg  
Date and time of wt 1-2-81 Gross wt 134973.6 mg  
Date and time of wt 1-4-81 Gross wt 134973.6 mg  
Average gross wt 134973.6 mg  
Tare wt 134960.5 mg  
Less acetone blank wt ( $W_a$ ) 0.3 mg  
Weight of particulate in acetone rinse 12.8 mg  
Filter (s) container number 1  
Date and time of wt 1-2-81 Gross wt 795.9 mg  
Date and time of wt 1-4-81 Gross wt 796.1 mg  
Average gross wt 796.0 mg  
Tare wt 783.7 mg  
Weight of particulate on filter (s) 12.3 mg  
Weight of particulate in acetone rinse 12.9 mg  
Total weight of particulate 25.1 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 Daniel W. Lehman

# THE ALMEGA CORPORATION

## PARTICULATE CALCULATION SUMMARY

COMPANY: INLAND STEEL  
 SOURCE: #3 ONE SPOT C&K  
 REPETITION NO: 2  
 TEST DATE: 12/31/80

ENGLISH UNITS  
 (29.92in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[ \frac{17.64}{Y} \right] V_m \left[ \frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m} \right] = \underline{22.883} \text{ dscf.}$$

$Y = \underline{1.007}$

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[ \frac{0.04707 \text{ cu.ft.}}{\text{ml}} \right] V_{lc} = \underline{3.8127} \text{ scf.}$$

$V_{lc} = \underline{81} \text{ ml.}$

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{0.1428}$$

Particle concentration in stack gas on dry basis

$$c's = \left[ \frac{0.01543 \text{ gr}}{\text{mg}} \right] \left[ \frac{M_n}{V_{mstd}} \right] = \underline{0.0173} \text{ grains/dscf.}$$

$$= 2.205 \cdot 10^{-6} \frac{M_n}{V_{mstd}} = \underline{2.4764} \times 10^{-6} \text{ lbs/dscf}$$

Stack gas volume flow rate on dry basis

$$Q_s = 3600 (1 - B_{ws}) V_s A_s \left[ \frac{T_{std} \cdot P_s}{(T_s)_{avg} \cdot P_{std}} \right] = \underline{3.0981} \times 10^6 \text{ dscf} \text{ Avc}$$

( $A_s = 12.073 \text{ sq. ft.}$      $V_s = 94.235 \text{ ft}^3/\text{sec}$ )

Process rate or BTU rating  $P_w =$  \_\_\_\_\_

Emission rate  $Q_s \text{ c's} = \underline{7.67} \text{ lbs/hr}$

$\frac{Q_s \text{ c's}}{P_w} =$  \_\_\_\_\_ lbs/

Isokinetic sampling rate

$$I = \left( 1.667 \frac{\text{min}}{\text{sec}} \right) T_s \left[ \frac{0.002669 \frac{\text{in. Hg. cu. ft.}}{\text{ml.}^\circ\text{R}} V_{lc}}{Q V_s P_s A_n} + \frac{V_m Y}{T_m} \left( \frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m} \right) \right]$$

( $A_n = 0.000189 \text{ sq. ft.}$ )  $= \underline{106.6} \text{ }^3$

# The ALMEGA CORPORATION

## STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: INLAND STEEL  
 SOURCE: #3 ONE SPOT CHR  
 REPETITION NO: 2  
 TEST DATE: 12/31/80

Dry molecular weight of stack gas

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

$$= \underline{29.153} \text{ lb/lb-mole}$$

Molecular weight of stack gas, wet basis

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

$$= \underline{27.560} \text{ lb/lb-mole}$$

Pitot tube coefficient

$$C_p \text{ (from calibration curve)} = \underline{0.84}$$

Average velocity head of stack gas, inches  $H_2O$  INITIAL FINAL

$$(\sqrt{\Delta p}) \text{ avg.} = \underline{1.5926} / \underline{1.4881}$$

Average absolute stack gas temperature

$$(T_s) \text{ avg.} = \underline{\hspace{2cm}} \text{ OF} + 460 = \underline{573.17} / \underline{583.75} \text{ } ^\circ\text{R}$$

Absolute stack gas pressure

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

$$= \underline{28.920} \text{ in. Hg}$$

Stack gas velocity

$$(V_s) \text{ avg.} = (85.49) C_p (\sqrt{\Delta p}) \text{ avg.} \sqrt{\frac{(T_s) \text{ avg.}}{P_s M_s}}$$

$$= \underline{96.985} / \underline{91.454} \text{ ft/sec.}$$

Stack gas volume flow rate

$$60 V_s A_s = \underline{70,254} / \underline{66,247} \text{ acfm}$$

Stack gas volume flow rate, dry basis

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

$$= \underline{3.0981} \times 10^6 \text{ dscf/ Ave.}$$

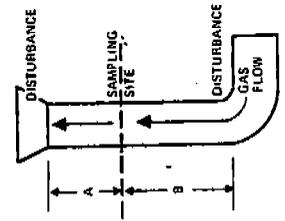
$$\underline{3.2173} / \underline{2.9788}$$

# PARTICULATE FIELD DATA

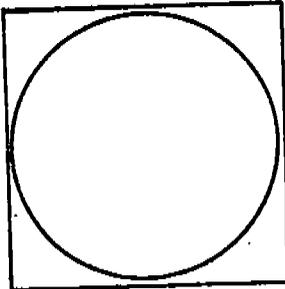
METER A Hg 84  
 C FACTOR 84  
 PROCESS WEIGHT RATE \_\_\_\_\_  
 WEIGHT OF PARTICULATE COLLECTED, mg

AMBIENT TEMPERATURE 36  
 BAROMETRIC PRESSURE 28.84  
 ASSUMED MOISTURE, % 14  
 PROBE LENGTH, in. 54"  
 NOZZLE DIAMETER, in. 1.86  
 STACK DIAMETER, in. 57 x 30 1/2  
 PROBE HEATER SETTING 4 320  
 HEATER BOX SETTING 320

PLANT INLAND STEEL  
 DATE 12/31/80  
 LOCATION EAST CHICAGO, IND  
 OPERATOR DR. TS. A. BT  
 STACK NO. #3 COKE CH. R.  
 RUN NO. 2  
 SAMPLE BOX NO. 6  
 METER BOX NO. 5



SCHEMATIC OF STACK



CROSS SECTION

TRAVERSE POINT NUMBER	SAMPLING TIME (6), min.	STATIC PRESSURE (in. H <sub>2</sub> O)	STACK TEMPERATURE (T <sub>s</sub> ), °F	VELOCITY HEAD (ΔP <sub>s</sub> ) (V <sub>AP</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		SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
							INLET (T <sub>min</sub> ), °F	OUTLET (T <sub>out</sub> ), °F				
1	0:00	+2.5	105	5.0	4.5	55.9700	39	60	23.5	45	2	42
2	2:29	+9.4	110	5.5	2.25	20.73	128	60	27.5	45	8	141
3	4:48	+1.8	120	1.5	1.20	23.55	17	60	32.0	45	4	
4	6:54	+1.8	110	5.0	2.30	25.10	76	62	32.5	45	9	
5	8:02	+1.0	110	2.5	1.30	27.32	80	78	32.0	45	4	
6	11:16	+2.0	105	5.0	2.20	29.48	72	68	32.0	48	8	
7	13:36	+1.0	110	1.5	1.7	32.0	67	70	32.5	50	4	
8	15:10	+1.0	130	4.1	3.0	33.8	108	71	32.5	50	8	
9	17:30	+1.0	110	2.0	1.25	36.5	78	71	32.8	50	5	
10	19:48	+1.5	135	1.6	1.2	38.15	75	71	32.5	50	4	
11	22:05	+1.0	125	5.1	2.4	39.65	24	72	32.5	50	9	
12	24:19	+1.0	110	2.0	1.0	42.59	78	72	32.8	52	2	
	26:20					55.43281						
TOTAL	126:33											
AVERAGE												

COMMENTS: PITOR OK  
 LK CK START  
 20 mg Monitor  
 FINISH 11  
 6.8

ORSAT MEASUREMENT	TIME	CO <sub>2</sub>			O <sub>2</sub>			CO			N <sub>2</sub>		
		1	2	3	1	2	3	1	2	3	1	2	3
1	10:05	3.6	15.9										
2	10:50	3.1	16.0										
3	11:30	3.0	15.8										
4													
		(2.23(15.90)/80.87)											

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml				SILICA GEL WEIGHT, g
	1	2	3	4	
FINAL	146	128	-	-	207
INITIAL	100	100	-	-	50
LIQUID COLLECTED					9
TOTAL VOLUME COLLECTED					81

# THE ALMEGA CORPORATION

607 C Country Club Drive  
Bensenville, Illinois 60106  
Phone: (312) 595-0175

## SAMPLE ANALYTICAL DATA FORM

PLANT Inland Steel RUN NUMBER 2  
SAMPLE LOCATION #3 One Spot Can  
RELATIVE HUMIDITY 26%  
DENSITY OF ACETONE ( $P_a$ ) 0.7856 g/ml  
Liquid level marked and container sealed YES  
Acetone rinse container number 2  
Acetone rinse volume ( $V_{aw}$ ) 158 ml  
Acetone blank residue concentration ( $C_a$ ) 0.0025 mg/g  
 $W_a = C_a V_{aw} P_a = (0.0025) (158) (0.7856) = 0.3$  mg  
Date and time of wt 1-2-81 Gross wt 136326.5 mg  
Date and time of wt 1-4-84 Gross wt 136326.5 mg  
Average gross wt 136326.5 mg  
Tare wt 136313.8 mg  
Less acetone blank wt ( $W_a$ ) 0.3 mg  
Weight of particulate in acetone rinse 12.4 mg  
Filter (s) container number 2  
Date and time of wt 1-2-81 Gross wt 800.5 mg  
Date and time of wt 1-4-81 Gross wt 800.5 mg  
Average gross wt 800.5 mg  
Tare wt 787.2 mg  
Weight of particulate on filter (s) 13.3 mg  
Weight of particulate in acetone rinse 12.4 mg  
Total weight of particulate 25.7 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. Loring

# THE ALMEGA CORPORATION

## PARTICULATE CALCULATION SUMMARY

COMPANY: INLAND STEEL  
 SOURCE: #3 ONE SPOT CAR  
 REPETITION NO: 3  
 TEST DATE: 12/31/80

ENGLISH UNITS  
 (29.92in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[ 17.64 \right] V_m \gamma \left[ \frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m} \right] = \underline{33.463} \text{ dscf.}$$

$\gamma = \underline{1.007}$

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[ 0.04707 \frac{\text{cu.ft.}}{\text{ml}} \right] V_{lc} = \underline{3.6715} \text{ scf.}$$

$V_{lc} = \underline{78} \text{ ml.}$

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{0.0989}$$

Particle concentration in stack gas on dry basis

$$c's = \left[ \frac{0.01543 \text{ gr}}{\text{mg}} \right] \left[ \frac{M_n}{V_{mstd}} \right] = \underline{0.0171} \text{ grains/dscf.}$$

$$= 2.205 \cdot 10^{-6} \frac{M_n}{V_{mstd}} = \underline{2.4381} \times 10^{-6} \text{ lbs/dscf}$$

Stack gas volume flow rate on dry basis

$$Q_s = 3600 (1 - B_{ws}) V_s A_s \left[ \frac{T_{std} \cdot P_s}{(T_s)_{avg} \cdot P_{std}} \right] = \underline{3.1479} \times 10^6 \text{ dscf Avg.}$$

( $A_s = 10.073 \text{ sq. ft.}$      $V_s = 91.06 \frac{\text{ft}}{\text{sec}}$ )

Process rate or BTU rating  $P_w$

Emission rate

$$Q_s \text{ c's} = \underline{7.67} \text{ lbs/hr}$$

$$\frac{Q_s \text{ c's}}{P_w} = \underline{\hspace{2cm}} \text{ lbs/}$$

Isokinetic sampling rate

$$I = \left( 1.667 \frac{\text{min}}{\text{sec}} \right) T_s \left[ \frac{0.002669 \frac{\text{in.Hg.cu.ft.}}{\text{ml.} \cdot \text{OR}} V_{lc}}{\text{OV}_s P_s A_n} + \frac{V_m \gamma \left( \frac{P_{bar} + \Delta H}{13.6} \right)}{T_m} \right]$$

( $A_n = 0.000189 \text{ sq.ft.}$ )      = 94.1 %

# The ALMEGA CORPORATION

## STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: INLAND STEEL  
 SOURCE: #3 ONE SPOT CAR  
 REPETITION NO: 3  
 TEST DATE: 12/31/80

Dry molecular weight of stack gas

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

$$= \underline{29.172} \text{ lb/lb-mole}$$

Molecular weight of stack gas, wet basis

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

$$= \underline{28.067} \text{ lb/lb-mole}$$

Pitot tube coefficient

$$C_p \text{ (from calibration curve)} = \underline{0.84}$$

Average velocity head of stack gas, inches  $H_2O$

	INITIAL	FINAL
$(\sqrt{\Delta p})$ avg.	1.5573	1.4486

$$= \underline{1.5573 / 1.4486}$$

Average absolute stack gas temperature

$$(T_s) \text{ avg.} = \underline{\hspace{2cm}} \text{ OF} + 460 = \underline{571.08 / 587.50} \text{ } ^\circ\text{R}$$

Absolute stack gas pressure

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

$$= \underline{28.937} \text{ in. Hg}$$

Stack gas velocity

$$(V_s) \text{ avg.} = (85.49) C_p (\sqrt{\Delta p}) \text{ avg.} \sqrt{\frac{(T_s) \text{ avg.}}{P_s M_s}}$$

$$= \underline{93.776 / 88.475} \text{ ft/sec.}$$

Stack gas volume flow rate

$$60 V_s A_s = \underline{67.929 / 64,090} \text{ acfm}$$

Stack gas volume flow rate, dry basis

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

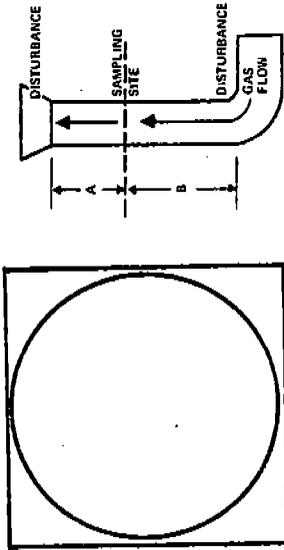
$$= \underline{31479} \times 10^6 \text{ dscf,} \text{ Avg.}$$

$$\underline{3.2841 / 3.0118}$$

# PARTICULATE FIELD DATA

PLANT LUIGIARD STEEL AMBIENT TEMPERATURE 36  
 DATE 12/1/80 BAROMETRIC PRESSURE 28.89  
 LOCATION EAST CHICAGO, IND ASSUMED MOISTURE, % 14  
 OPERATOR DC TS, B PROBE LENGTH, in. 54"  
 STACK NO. #3 COKE CAR NOZZLE DIAMETER, in. 0.186  
 RUN NO. 3 STACK DIAMETER, in. 57 x 30 1/2  
 SAMPLE BOX NO. 2 PROBE HEATER SETTING X30  
 METER BOX NO. 5 HEATER BOX SETTING X320

SCHMATIC OF STACK



CROSS SECTION

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H <sub>2</sub> O)	STACK TEMPERATURE (T <sub>s</sub> ), °F	VELOCITY HEAD (ΔP <sub>s</sub> ) (√AP)	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		SAMPLE BOX TEMPERATURE °F	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				
1	0:00	12:10	105	8.0	2.0	5541.800	49	7270	290	40	3	
2	2:18	11.5	110	4.8	2.0	459	120	7470	310	42	9	
3	4:25		100	1.0	2.0	48.0	53	7572	320	45	3	
4	6:30	2.5	110	5.0	2.0	49.5	78	72	325	45	9	
5	8:43		115	5.5	2.25	51.85	78	72	325	45	9	
6	10:55		125	1.5	1.0	54.8	18	7872	325	45	4	
7	13:09	+2.5	105	5.0	2.2	56.8		7873	325	45	3	
8	15:00		118	4.5	2.0	57.3	115	7474	325	48	9	
9	17:01	2.0	102	1.0	1.1	59.3	53	8075	326	50	3	
10	19:08		110	1.6	2.5	60.6	80	75	320	50	4	
11	35:38	+1.0	115	2.5	1.5	72.22	80	76	330	52	6	
12	39:39		118	4.5	2.0	76.35	115	8277	325	52	9	
42:45						5579.66						
TOTAL												
AVERAGE	42.75	+1.3125	111.08	127.50	1.4486	34.860				75.46		

WEIGHT OF PARTICULATE COLLECTED, mg  
 SAMPLE FILTER  
 FINAL WEIGHT  
 TARE WEIGHT 0.7846  
 WEIGHT GAIN  
 TOTAL 252 0.00979

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml				SILICA GEL WEIGHT, g	ORSAT MEASUREMENT	TIME	CO <sub>2</sub>	O <sub>2</sub>	CO	H <sub>2</sub>
	1	2	3	4							
FINAL	151	110	2		209	1	12:50	3.8	15.4		
INITIAL	100	100			206	2	1:30	3.2	16.0		
LIQUID COLLECTED	51	16	2		9	3	1:45	3.1	16.1		
TOTAL VOLUME COLLECTED					78	4					

COMMENTS: PHOT O.S. 1/11/80  
LK CK. 20 Hg Noz. 2.016 CM  
FINISH  
LK CK 21 Hg Noz. 2.016 CM

# THE ALMEGA CORPORATION

607 C Country Club Drive  
Bensenville, Illinois 60106  
Phone: (312) 595-0175

## SAMPLE ANALYTICAL DATA FORM

PLANT Inland Steel RUN NUMBER 3

SAMPLE LOCATION #3 One Spot Con

RELATIVE HUMIDITY 20

DENSITY OF ACETONE ( $P_a$ ) 0.7856 g/ml

---

Liquid level marked and container sealed YES

Acetone rinse container number 3

Acetone rinse volume ( $V_{aw}$ ) 177 ml

Acetone blank residue concentration ( $C_a$ ) 0.0025 mg/g

$W_a = C_a V_{aw} P_a = (0.0025) (177) (0.7856) = 0.3$  mg

Date and time of wt 1-2-81 Gross wt 131581.8 mg

Date and time of wt 1-3-81 Gross wt 131582.0 mg

Average gross wt 131581.8 mg

Tare wt 131563.2 mg

Less acetone blank wt ( $W_a$ ) 0.3 mg

Weight of particulate in acetone rinse 18.4 mg

Filter (s) container number 3

Date and time of wt 1-2-81 Gross wt 803.2 mg

Date and time of wt 1-5-81 Gross wt 803.2 mg

Average gross wt 803.2 mg

Tare wt 784.6 mg

Weight of particulate on filter (s) 18.6 mg

Weight of particulate in acetone rinse 18.4 mg

Total weight of particulate 37.0 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

# THE ALMEGA CORPORATION

607 C Country Club Drive  
 Bensenville, Illinois 60106  
 Phone: (312) 595-0175

## BLANK ANALYTICAL DATA FORM

PLANT Inland Steel

Sample Location #3 One Spst Can

Relative Humidity 26

Liquid level marked and container sealed YES

Density of acetone ( $P_a$ ) 0.7856 g/ml

Blank volume ( $V_a$ ) 100 ml

Date and time of wt 1-2-51 Gross wt 135437.7 mg

Date and time of wt 1-5-51 Gross wt 135437.7 mg

Average gross wt 135437.7 mg

Tare wt 135437.6 mg

Weight of blank ( $m_a$ ) 0.2 mg

$$C_a = \frac{m_a}{V_a P_a} = \frac{(0.2)}{(100)(0.7856)} = 0.0025 \text{ mg/g}$$

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 Daniel W. Schwing

# The ALMEGA CORPORATION

## STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 1-5-81 Thermocouple number 54" Joy Probe  
 Ambient Temperature 68 °F Barometric pressure 29.24 in. Hg.  
 Calibrator DC + TS Reference: Mercury-in-glass X  
 Other \_\_\_\_\_

REFERENCE POINT NUMBER <sup>b</sup>	SOURCE <sup>b</sup> (Specify)	REFERENCE THERMOMETER TEMPERATURE, °F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, °F	TEMPERATURE DIFFERENCE, %
1	ICE	33.0°	33.0°	0.00
2	BOILING H <sub>2</sub> O	210.0°	211.0°	0.15
3	OIL	330.0°	329.0°	0.13

<sup>a</sup> Every 50°F for each reference point.

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

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

# THE ALMEGA CORPORATION

Calibrated by: Jerry Williams (Jerry Williams)

Box No. # 5

Date 10/17/80

Barometric pressure,  $P_b = 29.650$  in. Hg      Dry gas meter No. C4-3-31597952

Orifice manometer setting $\Delta H$ , in. H <sub>2</sub> O	Gas volume Dry test meter $V_{wt}$ ft <sup>3</sup>	Gas volume Dry gas meter $V_d$ ft <sup>3</sup>	Wet test Meter $t_w$ , OF	Temperature		Average $t_d$ , OF	Time $t_e$ , min	$\gamma$	$\Delta H$ N/A
				Inlet $t_{di}$ , OF	Dry gas meter Outlet $t_{do}$ , OF				
0.5	7.118	7.335	65 66 (65.5)	89 90 (89.5)	82 83 (82.5)	87.3 (87.4)	13.75	1.008	N/A
1.0	10.346	10.68	66 67 (66.5)	90 91 (90.5)	84 85 (84.5)	90.5 (551)	14.17	1.010	
1.5	15.382	15.845	66 67 (66.5)	90 91 (90.5)	84 85 (84.5)	91.5 (552)	17.50	1.013	
2.0	31.998	32.920	67 68 (67.5)	90 91 (90.5)	85 86 (85.5)	91.25 (551)	31.52	1.011	
2.5	43.025	44.36	67 68 (67.5)	92 93 (92.5)	89 90 (89.5)	92.75 (553)	38.25	1.011	
3.0	40.147	41.290	67 68 (67.5)	90 91 (90.5)	87 88 (87.5)	91.83 (552)	32.55	1.011	
Average							(1.0107)		

Average  
 $0.9968^* (1.0107)$

Calculations N/A \*\*

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

Tolerance = + 0.03

# THE ALMEGA CORPORATION

Calibrated by: Jerry W. Smith

Pitotube number: # 2

Date: 10/9/60

Manufacturer: 54

Effective length: 54

## TYPE S PITOT TUBE INSPECTION DATA FORM

Pitot tube assembly level? yes  no

Pitot tube openings damaged? yes (explain below)  no

$\alpha_1 = \underline{1.0}^\circ (<10^\circ)$ ,  $\alpha_2 = \underline{3.5}^\circ (<10^\circ)$ ,  $\beta_1 = \underline{3.0}^\circ (<5^\circ)$ ,

$\beta_2 = \underline{1.0}^\circ (<5^\circ)$

$\gamma = \underline{2.5}^\circ$ ,  $\theta = \underline{1.0}^\circ$ ,  $A = \underline{(0.163)} \text{ cm (in.)}$

$z = A(\sin \gamma) = \underline{(0.033)} \text{ cm (in.)}; <0.32 \text{ cm } (<1/8 \text{ in.}),$

$w = A \sin \theta = \underline{(0.013)} \text{ cm (in.)}; <0.08 \text{ cm } (<1/32 \text{ in.}).$

$P_A = \underline{(0.378)} \text{ cm (in.)}$   $P_b = \underline{(0.385)} \text{ cm (in.)}$

$D_t = \underline{(0.257)} \text{ cm (in.)}$

Comments: Pitot tube Meets all the above criteria, therefore

0.84 cp assumed. (JWL)

Calibration required? yes  no  (JWL)

# THE ALMEGA CORPORATION

## DIFFERENTIAL PRESSURE GAUGE CALIBRATION DATA FORM

Gauge type Magnohelic Serial or ID number 9  
Meter Boy #5

Scale 0-1"

Gauge-oil manometer ΔP	Differential pressure gauge ΔP	Pressure difference %
<p>Side A</p> <p>0.1</p> <p>0.15</p> <p>0.25</p> <p>0.75</p> <p><u>1.0</u></p>	<p>0.1</p> <p>0.15</p> <p>0.25</p> <p>0.75</p> <p><u>1.0</u></p>	<p>0.0</p> <p>0.0</p> <p>0.0</p> <p>0.0</p> <p><u>0.0</u></p>
<p>Side B</p> <p>0.1</p> <p>0.15</p> <p>0.25</p> <p>0.75</p> <p><u>1.0</u></p>	<p>0.1</p> <p>0.15</p> <p>0.25</p> <p>0.75</p> <p><u>1.0</u></p>	<p>0.0</p> <p>0.0</p> <p>0.0</p> <p>0.0</p> <p><u>0.0</u></p>

Calibration: \_\_\_\_\_ initial \_\_\_\_\_ posttest

Date calibrated 11/18/80 by Ferry W Lewis

# THE ALMEGA CORPORATION

## DIFFERENTIAL PRESSURE GAUGE CALIBRATION DATA FORM

Gauge type Magn. Hydraulic Serial or ID number 10  
Meter Box # 5

Scale 0-3"

Gauge-oil manometer ΔP	Differential pressure gauge ΔP	Pressure difference %	
Side A	0.25	0.25	0.0
	0.50	0.50	0.0
	0.75	0.75	0.0
	1.0	1.0	0.0
	1.25	1.25	0.0
	1.50	1.50	0.0
Side B	0.25	0.25	0.0
	0.50	0.50	0.0
	0.75	0.75	0.0
	1.0	1.0	0.0
	1.25	1.25	0.0
	1.50	1.50	0.0

Calibration: \_\_\_\_\_ initial \_\_\_\_\_ posttest

Date calibrated 11/10/80 by George Lewis

# THE ALMEGA CORPORATION

## DIFFERENTIAL PRESSURE GAUGE CALIBRATION DATA FORM

Gauge type MARNEUBLIC Serial or ID number 80921RF68

Scale 0 TO 5 INCHES H<sub>2</sub>O FL

Gauge-oil manometer ΔP	Differential pressure gauge ΔP	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: FL initial  posttest

Date calibrated 8-1-80 by FL

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## NOZZLE CALIBRATION DATA FORM

Date 12/22/80 Calibrated by D. CHAPMAN

Nozzle identification number	Nozzle Diameter a			AD, b mm (in.)	D avg c
	$D_1$ , mm (in.)	$D_2$ , mm (in.)	$D_3$ , mm (in.)		
JOY 3-16-1	0.186"	0.187"	0.185"	0.002" ( $D_2 - D_3$ )	0.186"

where:

a  $D_{1,2,3}$  = three different nozzle diameters, mm (in.); each diameter must be within (0.025 mm) .001 in.

b AD = maximum difference between any two diameters, mm (in.),  
 $AD \leq (0.10 \text{ mm}) 0.004 \text{ in.}$

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

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## 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 CF&I 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.

## 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.

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.

(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.

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## 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.



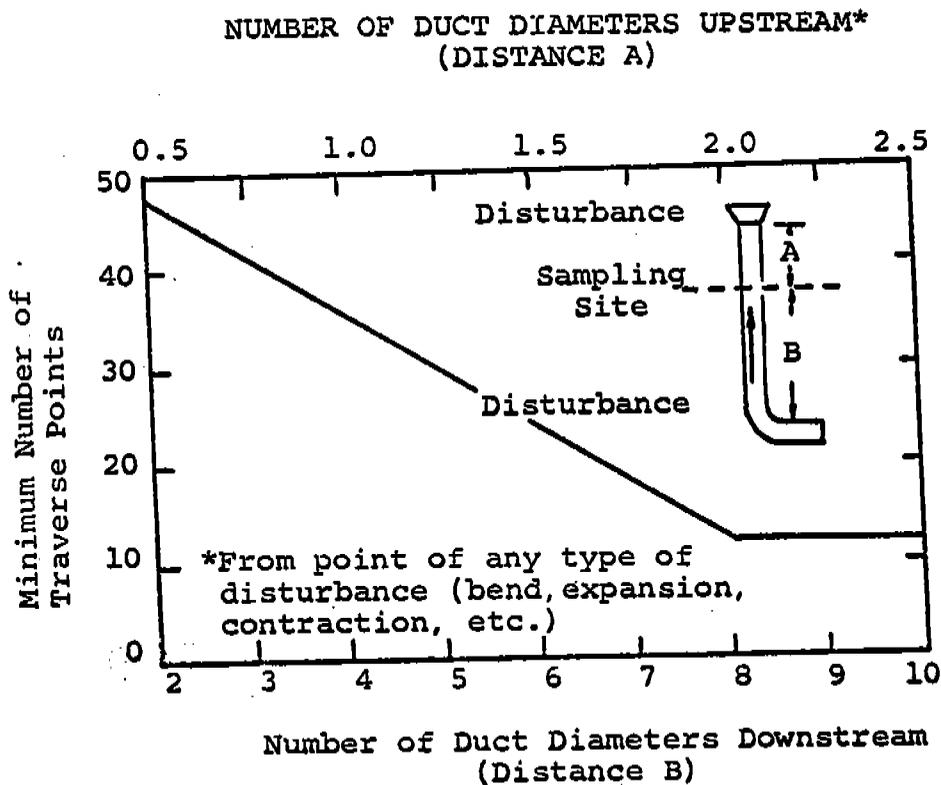


Figure 1-1. Minimum number of traverse points.

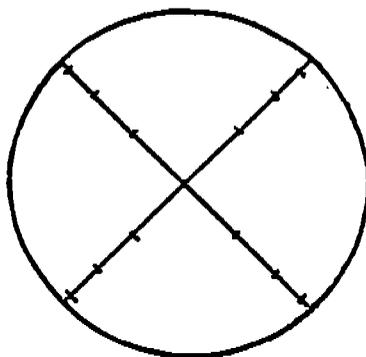


Figure 1-2. Cross section of circular stack divided into 12 equal areas, showing location of traverse points at centroid of each area.

- 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.

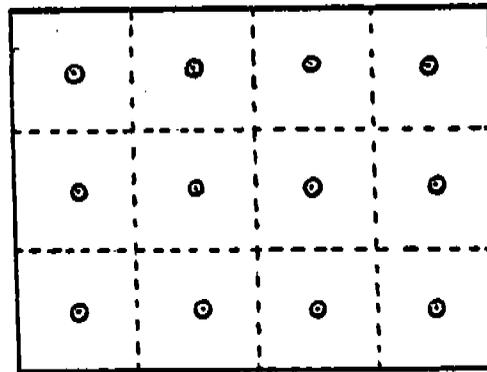


Figure 1-3. Cross section of rectangular stack divided into 12 equal areas, with traverse points at centroid of each area.

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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.

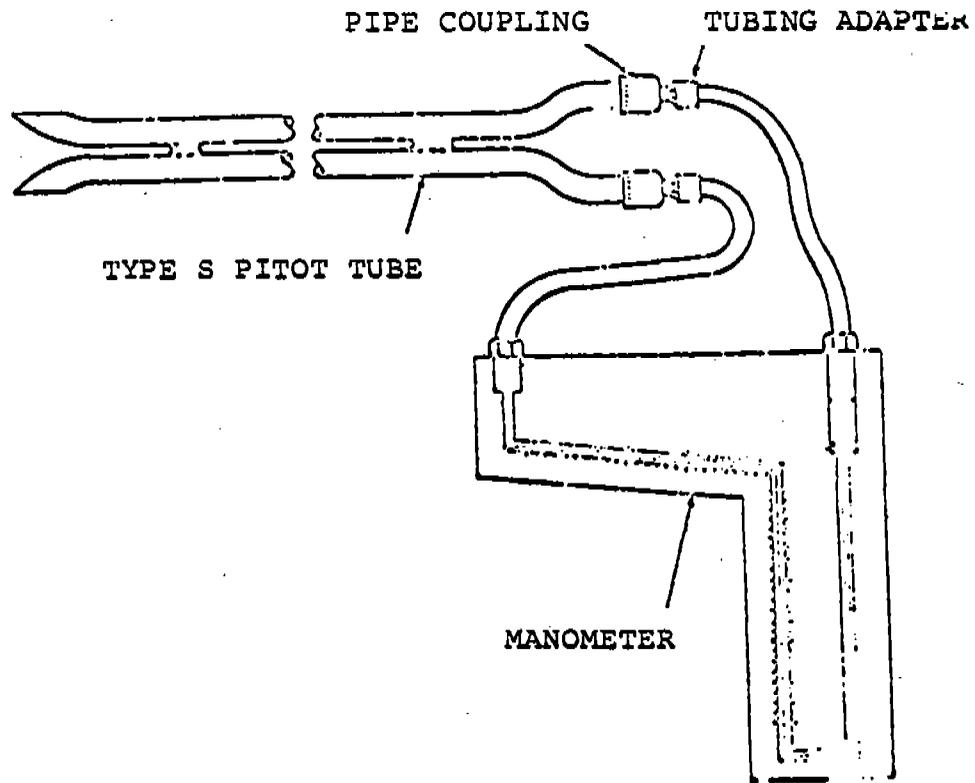


FIGURE 2-1: Pitot Tube  
Manometer Assembly



6. *References.*

Mark, L.S. Mechanical Engineers' Handbook, McGraw-Hill Book Co., Inc., New York, N.Y., 1951.

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.

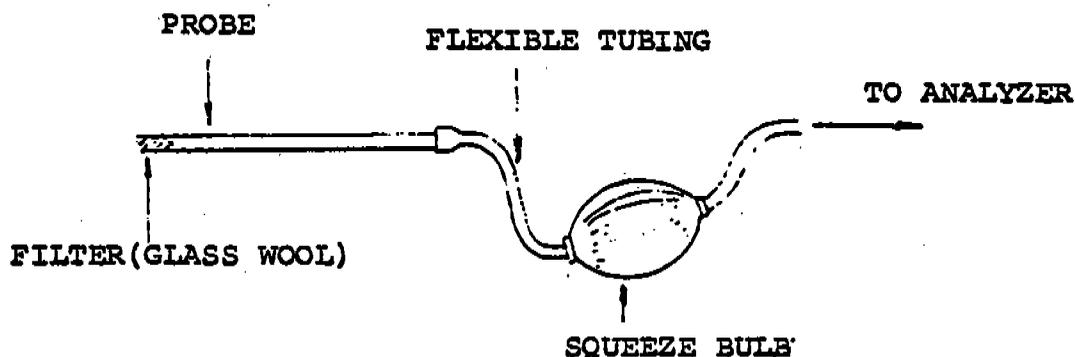


Figure 3-1. Grab-sampling train.

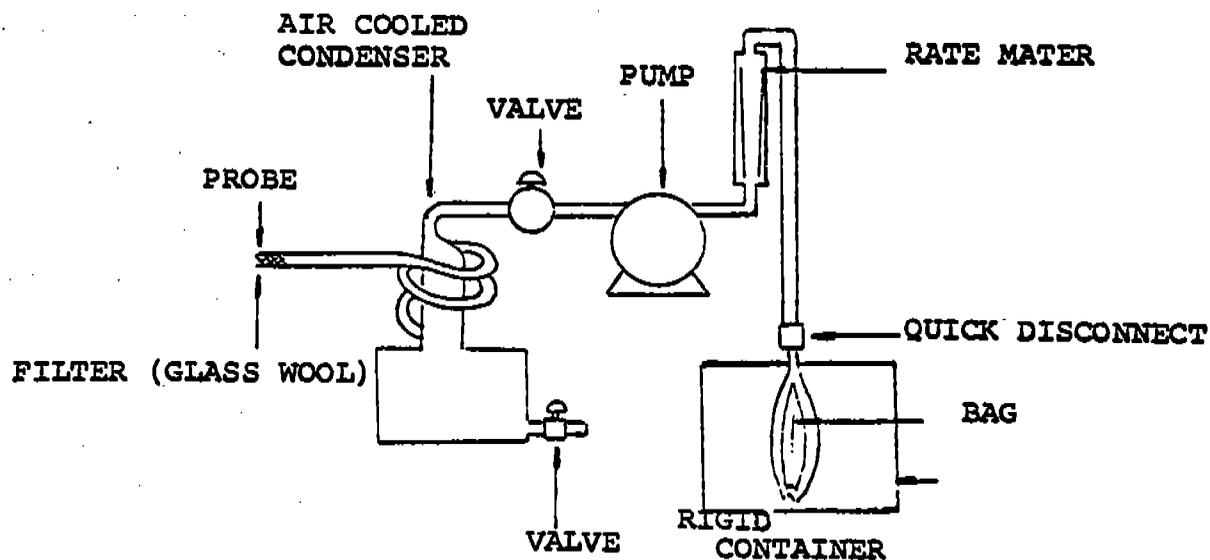


Figure 3-2. Integrated gas - sampling train.

- 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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Method 3 - Page 4 of 4

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.

# **The ALMEGA CORPORATION**

## **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.

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<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.

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

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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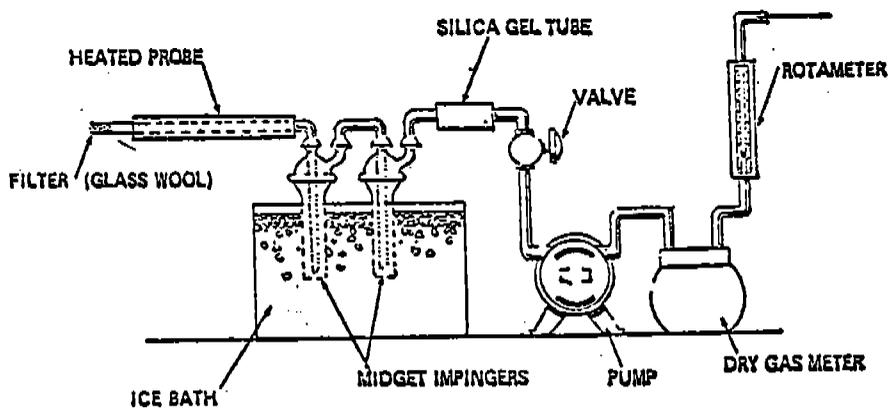


Figure 4-1. Moisture-sampling train.

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.

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<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°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°C. (350° 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.

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

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

Equation 5-2

where:

- $V_{W_{std}}$  = 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.
- $T_{std}$  = Absolute temperature at standard conditions, 530°R.
- $P_{std}$  = Absolute pressure at standard conditions, 29.92 inches Hg.

6.4 Moisture content.

$$B_{wo} = \frac{V_{W_{std}}}{V_{m_{std}} + V_{W_{std}}}$$

Equation 5-3

where:

- $B_{wo}$  = Proportion by volume of water vapor in the gas stream dimensionless.
- $V_{W_{std}}$  = Volume of water in the gas sample (standard conditions) cu.ft.
- $V_{m_{std}}$  = 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.

$$I = T_s \frac{\left[ \left( \frac{0.00267 \text{ in. Hg-cu. ft.}}{\text{ml-OR}} \right) V_{1s} + \frac{V_m}{T_m} \left( P_{\text{bar}} + \frac{H}{13.6} \right) \right] \left( 1.667 \frac{\text{min}}{\text{sec}} \right)}{0.75 P_s A_n}$$

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-<sup>o</sup>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) <sup>o</sup>R.
- $P_{bar}$  = Barometric pressure at sampling site, inches Hg.
- $\Delta H$  = Average pressure drop across the orifice (See Figure 5-2) inches, H<sub>2</sub>O.
- $T_s$  = Absolute average stack gas temperature (See Figure 5-2) <sup>o</sup>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* 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.
$V_{m\ std.}$	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.
$V_w^{std}$	Volume of water in the gas sample (standard conditions) cu.ft.