SECONDARY
LEAD SMELTING
AP-42 Section 7.11
Reference Number
15

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

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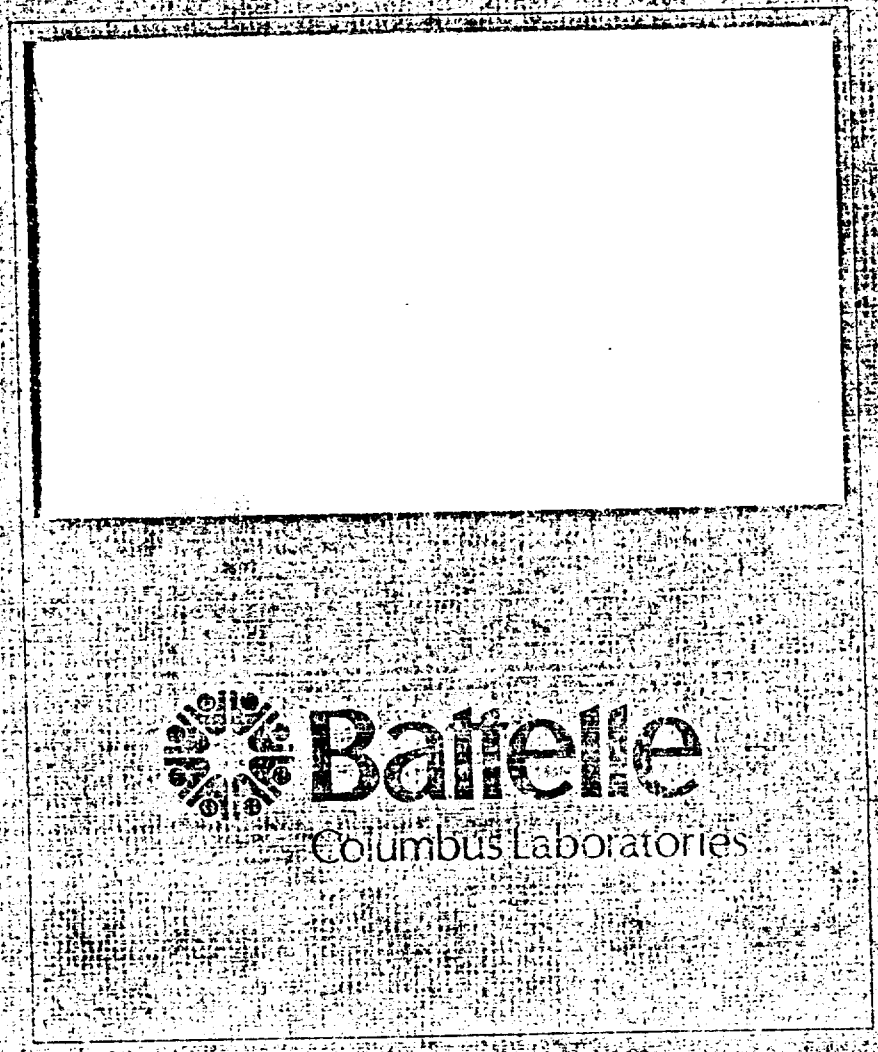
RESEARCH REPORT



Battelle
Columbus Laboratories

7.11 #15

RESEARCH REPORT

on

SECONDARY LEAD PLANT STACK EMISSION SAMPLING AT GENERAL BATTERY CORPORATION, READING, PENNSYLVANIA

Contract No. 68-02-0230

Task Order No. 1

to

ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR PROGRAMS

July 25, 1972

by

Paul R. Webb, H. E. Carlton,
and R. B. Engdahl

BATTELLE
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

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RESEARCH REPORT

on

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INTRODUCTION

Gas and particulate emission measurements were made at General Battery Corporation's secondary lead plant in Reading, Pennsylvania, on December 15 and 16, 1971. The results of the measurements at this and other lead plants will be used in determining standards of performance for secondary lead plants. The effluent gas was sampled from the process system which includes particulate removal by an air cooler, a baghouse, and a venturi scrubber in series. Particulate and SO_2 emissions were determined and an Orsat analysis was made. SO_2 and Orsat analyses also were made on gases sampled from a point between the baghouse and the scrubber.

The process system sampled cleans effluent gases from two blast furnaces, a reverberatory furnace, and hoods over lead refining kettles. During the sampling period, the two blast furnaces were in operation, several lead kettles were in operation, and the reverberatory furnace was hot on a stand-by basis.

The blast furnaces used to melt the scrap batteries and to reduce various lead oxide drosses are fed coke, iron, battery plate groups, limestone, lead oxide, and slag almost continuously. One furnace was charged to produce 3 percent antimony lead and the other furnace was charged to produce 6 percent antimony lead.

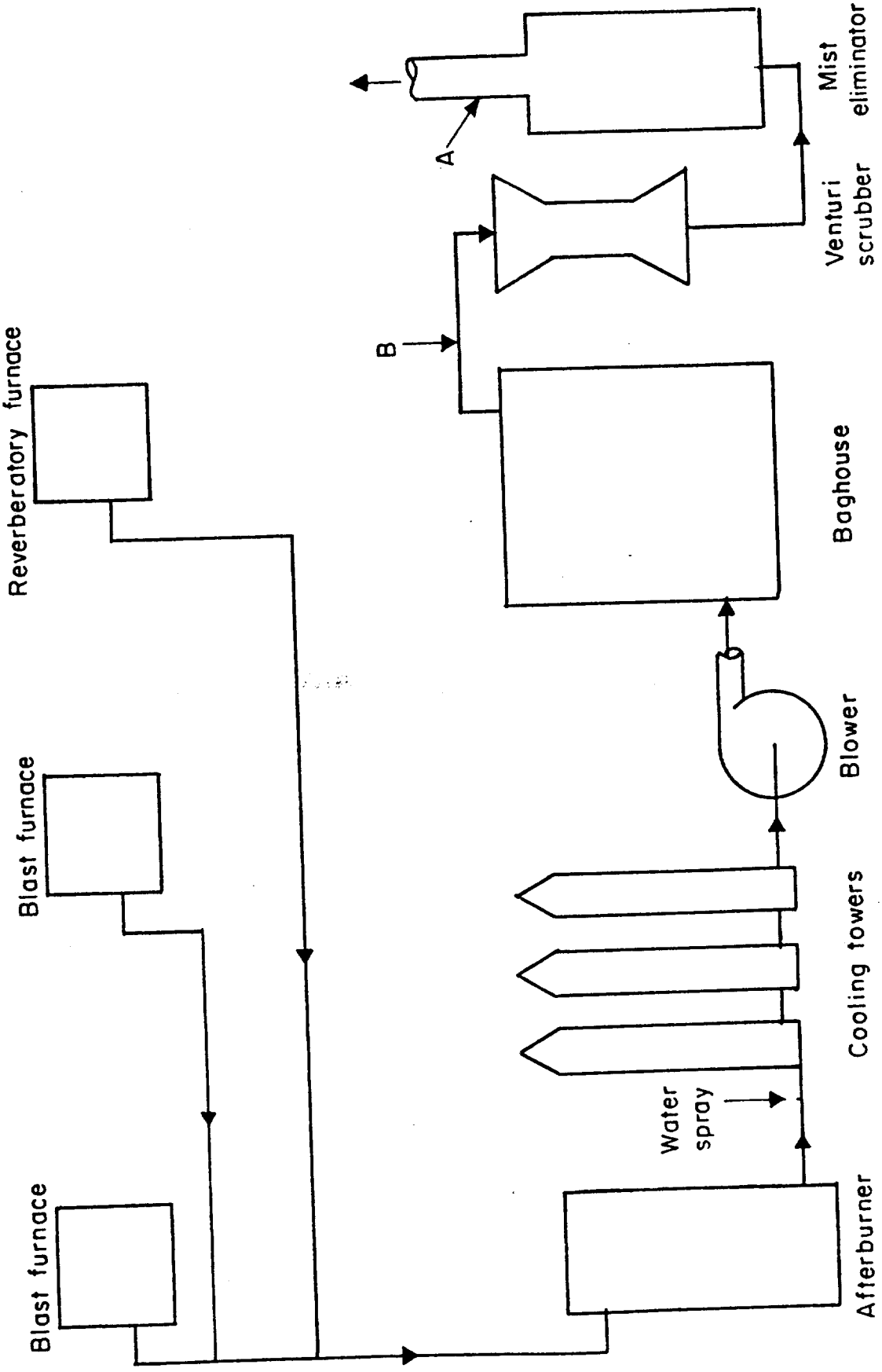

FIGURE 1. DIAGRAM OF GAS FLOW AT THE GENERAL BATTERY PLANT

Run 3 and maintained basic, resulting in an outlet concentration of 140 ppm. Proper operation of the scrubber will result in concentrations below 200 ppm.

The operation of blast Furnace No. 2 was normal for all three runs. The lead production rate from Furnace No. 1 was high during Run 2 because about three tons of pure lead scrap was loaded; the rate was low during Run 3 because preparations were made to shut down the furnace immediately after the run.

From the Orsat analysis of 3.1 percent CO_2 and 16.7 percent O_2, it is apparent that the blast furnace off-gas is diluted with six to twelve times its volume of air (depending on completeness of furnace combustion) by in leakage through the top of the blast furnace and poker door and into the afterburner and U-tubes.

PROCESS DESCRIPTION

The Reading plant processes various lead scraps into refined lead for use in a battery plant on the same site. The combined plants consist of a large receiving yard where the various lead scraps are stored (mainly under roof); blast furnaces to melt or reduce the lead and lead oxide scraps, a reverberatory furnace to melt and refine lead scrap, holding kettles for molten lead, a continuous casting line for small lead balls, and a line for 75-pound ingots.

Most scrap is received in the form of discarded batteries. If rubber, the cases are removed; if polyethylene, the acid is dumped and a few batteries are fed into the blast furnace with each charge. The separators are not removed from the battery plates. Various other forms of lead scraps such as risers from battery plate molds generated at the battery plant are fed to the furnaces. Antimony ore is added to increase the antimony content of the lead.

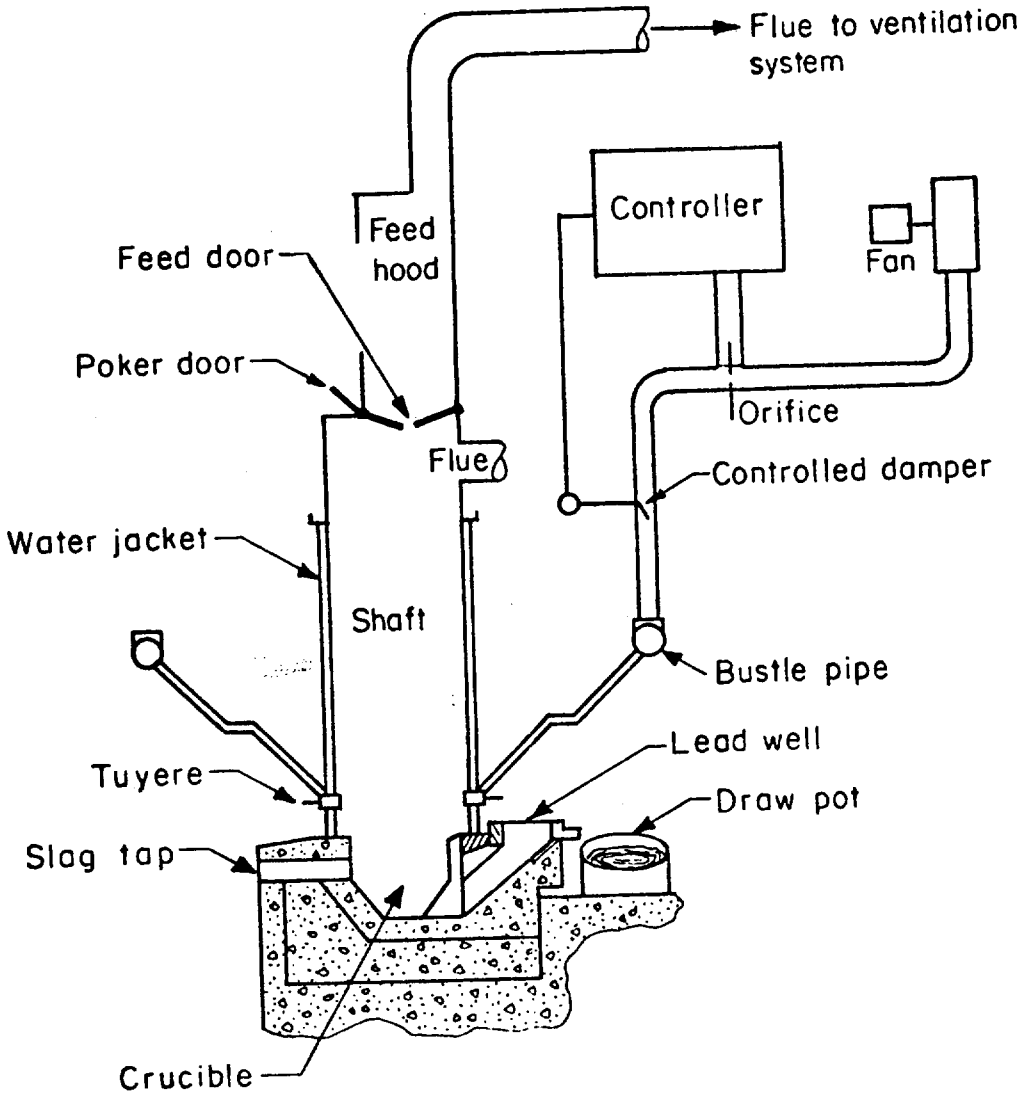

FIGURE 2. LEAD BLAST FURNACE

APPENDIX A

COMPLETE PARTICULATE RESULTS WITH SAMPLE CALCULATIONS

COMPLETE PARTICULATE RESULTS WITH SAMPLE CALCULATIONS

SOURCE TESTING CALCULATION FORMS

No. Runs 3

Test No. 1,2,3

Name of Firm General Battery Corporation

Location of Plant Reading, Pennsylvania

Type of Plant Secondary Lead

Control Equipment Afterburner, Baghouse, Scrubber

Sampling Point Locations Stack; SO_2 Before Scrubber

Pollutants Samples Particulates, SO_2, Orsat

Time of Particulate Test:

Run No. 1	Date 12-15-71	Begin 10:17 am	End 3:15 pm
Run No. 2	Date 12-16-71	Begin 8:30 am	End 12:10 pm
Run No. 3	Date 12-16-71	Begin 2:05 pm	End 5:40 pm

PARTICULATE EMISSION DATA

Run No.	1	2	3
P_b - barometric pressure, in. Hg Absolute	29.53	29.40	29.44
P_m - orifice pressure drop, in. H_2O	0.61	0.74	0.89
V_m - volume of dry gas sampled @ meter conditions, ft^3	89.9	87.9	113.9
T_m - average gas meter temperature, F	68	79	83
$V_{m_{std.}}$ - volume of dry gas sampled @ standard conditions, ft^3, dry	89.13	85.02	109.55
V_w - total H_2O collected, impingers and silical gel., ml.	133.7	218.0	233.0
$V_{w_{gas}}$ - volume of water vapor collected ft^3 @ standard conditions(a)	6.34	10.33	11.04
V_{total} - total gas volume, standard conditions, ft^3	95.47	95.35	120.59
Moisture in the stack gas volume, percent	6.6	10.8	9.2
M_d mole fraction of dry gas	0.93	0.89	0.91

(a) 70 F 29.92 in. Hg

PARTICULATE EMISSION DATA (Cont'd)

Run No.	1	2	3
CO_2, dry, percent	3.2	2.8	3.4
O_2, dry, percent	16.8	17.0	16.4
CO, dry, percent	< 0.1	0.2	0.4
N_2, dry, percent	79.9	80.0	79.8
$M W_d$ - molecular weight of dry stack gas	29.2	29.1	29.2
M W - molecular weight of stack gas	28.4	27.9	28.2
T_s - stack temperature, F	124	121	118
$\sqrt{\Delta P_s \times (T_s + 460)}$	12.181	11.563	14.661
P_s - stack pressure, in. Hg absolute	29.53	29.4	29.2
V_s - stack velocity @ stack conditions, fpm	1828	1755	2214
A_s - stack area, in^2	3020	3020	3020
Q_s - stack gas volume @ standard conditions,(a) ft^3 dry	32060	29420	38060
T_t - net time of test, min.	195	200	200
D_n - sampling nozzle diameter, in.	0.235	0.235	0.235
Percent I - percent isokinetic	98	100	99
m_f - particulate-probe and filter, mg	45.8	23.1	82.0
m_t - particulate-total, mg	241.1	200.8	323.3
C_{an} - particulate, probe, and filter, gr/scf, dry	0.0079	0.0042	0.0115
C_{ao} - particulate, total, gr/scf	0.0417	0.0364	0.0454

PARTICULATE EMISSION DATA (Cont'd)

Run	1	2	3
C_{at} - particulate; probe and filter, gr/ft^3 @ stack conditions	0.0066	0.0033	0.0094
C_{au} - particulate; total, gr/ft^3 @ stack conditions	0.0348	0.0290	0.0372
C_{aw} - particulate; probe and filter, lb/hr	2.1743	1.0551	3.7600
C_{ax} - particulate; total, lb/hr	11.4461	9.1715	14.8245
C_{p} - particulate; probe and filter, lb/ton lead	0.5177	0.2153	1.0743
C_{pt} - particulate; total lb/ton lead	2.7253	1.8717	4.2356
C_{ls} - lead emission; probe and filter, gr/scf	0.00011	0.00013	0.00016
C_{la} - lead emission; probe and filter, gr/ft^3	0.00009	0.00010	0.00013
C_{lh} - lead emission; probe and filter, lb/hr	0.0300	0.0328	0.0506
C_{lt} - lead emission; probe and filter, lb/ton	0.0071	0.0067	0.0145

EXAMPLE PARTICULATE CALCULATIONS

SAMPLE NUMBER 1

1. Volume of dry gas sampled at standard conditions - 70 F, 29.92 in. Hg, ft^3

$$V_{m_{std}} = \frac{17.7 \times V_m \left(P_b + \frac{P_m}{13.6}\right)}{(T_m + 460)}$$

$$= \frac{17.7 \times 89.9 \left(29.53 + \frac{0.61}{13.6}\right)}{} \quad \text{dry}$$

$$= 89.13 \text{ ft}^3$$

2. Volume of water vapor at 70 F and 29.92in. Hg, ft^3

$$V_{w_{gas}} = 0.0474 \times V_w$$

$$V_{w_{gas}} = 0.0474 \times 133.7$$

$$= 6.34 \text{ ft}^3$$

3. Percent moisture in stack gas

$$\%\,M = \frac{100 \times V_{w_{gas}}}{V_{m_{std}} + V_{w_{gas}}}$$

$$= \frac{100 \times 6.34}{89.13 + 6.34}$$

$$= 6.6$$

4. Mole fraction of dry gas

$$M_d = \frac{100 - \%M}{100}$$

$$= \frac{100 - 6.6}{100}$$

$$= 0.933$$

EXAMPLE PARTICULATE CALCULATIONS (Cont'd)

5. Average molecular weight of dry stack gas

$$M W_d = (CO_2 \times \frac{44}{100}) + (O_2 \times \frac{32}{100}) + (N_2 + CO) \times \frac{28}{100}$$

$$= (3.2 \times \frac{44}{100}) + (16.8 \times \frac{32}{100}) + (80.0 \times \frac{28}{100})$$

$$= 29.2$$

6. Molecular weight of stack gas

$$M W = M W_d \times M_d + 18 (1 - M_d)$$

$$= 29.2 \times 0.93 + 18 (1 - 0.93)$$

$$= 28.4$$

7. Stack velocity @ stack conditions, fpm

$$V_s = 4350 \times \sqrt{\Delta P_s \times (T_s + 460)} \left(\frac{1}{P_s \times M W}\right)^{1/2} \text{ fpm}$$

$$= 4350 \times 12.181 \left[\frac{1}{29.53 \times 28.4}\right]^{1/2}$$

$$= 1828 \text{ fpm}$$

8. Stack gas volume at standard conditions, scfm

$$Q_s = \frac{0.123 \times V_s \times A_s \times P_s}{(T_s + 460)} M_d \text{ scfm}$$

$$= \frac{0.123 \times 1828 \times 3020 \times 29.53 \times 0.93}{584}$$

$$= 32,060 \text{ scfm}$$

EXAMPLE PARTICULATE CALCULATIONS (Cont'd)

9. Sampling velocity, percent of isokinetic

$$\%I = \frac{1032 \times (T + 460) \times V_{mstd}}{V_s \times T_t \times P_s \times M_d \times (D_n)^2}$$

$$= \frac{1032 \times 584 \times 89.13}{1828 \times 195 \times 29.53 \times (0.235)^2}$$

$$= 98 \text{ percent}$$

10. Percent excess air at sampling point

$$\% EA = \frac{100 \times \% O_2}{(0.266 \times \% N_2) - \% O_2}$$

$$= \frac{100 \times 16.80}{(0.266 \times 79.9) - 16.8}$$

$$= 390 \text{ percent}$$

11. Particulate - probe and filter, gr/scf

$$C_{an} = 0.0154 \times \frac{M_f}{V_{m_{std}}}$$

$$= 0.0154 \times \frac{45.8}{89.13}$$

$$= 0.0079 \text{ gr/scf}$$

12. Particulate - total, gr/scf

$$C_{ao} = 1.54 \times 10^{-2} \left(\frac{M_t}{V_{m_{std}}} \right)$$

$$= 1.54 \times 10^{-2} \ \frac{241.1}{89.9}$$

$$= 0.0417 \text{ gr/scf.}$$

EXAMPLE PARTICULATE CALCULATIONS (Cont'd)

13. Particulate - probe and filter, gr/ft^3 at stack conditions

$$C_{at} = \frac{17.7 \times C_{an} \times P_s \, M_d}{(T_s + 460)}$$

$$= \frac{17.7 \times 0.0079 \times 29.53 \times 0.93}{584}$$

$$= 0.0066 \text{ gr/ft}^3$$

14. Particulate, total, gr/ft^3 at stack conditions

$$C_{au} = \frac{17.7 \, C_{ao} \, P_s \, M_d}{(T_s + 460)}$$

$$= \frac{17.7 \times 0.0417 \times 29.53 \times 0.93}{584}$$

$$= 0.0348 \text{ gr/ft}^3$$

15. Particulate - probe and filter

$$C_{aw} = 0.00857 \times C_{an} \times Q_s \text{ lb/hr}$$

$$= 0.00857 \times 0.0079 \times 32{,}060$$

$$= 2.1743 \text{ lb/hr}$$

16. Particulate - total, lb/hr

$$C_{ax} = 8.57 \times 10^{-3} \, C_{ao} \, Q_s$$

$$= 8.57 \times 10^{-3} \times 0.0417 \times 32{,}060$$

$$= 11.4461 \text{ lb/hr}$$

EXAMPLE PARTICULATE CALCULATIONS (Cont'd)

17. Particulate; probe and filter, lb/ton lead

$C_p = C_{aw}/R$

$= 2.1743/4.2$

$= 0.5177$ lb/ton lead

18. Particulate; total lb/ton lead

$C_{pt} = C_{ax}/R$

$= 11.4461/4.2$

$= 2.7253$ lb/ton lead

19. Lead emission; probe and filter, gr/scf

$$C_{ls} = 0.0154 \times \frac{M_l}{V_{m\ std}}$$

$$= 0.0154 \times \frac{630}{89.13}$$

$= 0.00011$ gr/scf

20. Lead emission; probe and filter, gr/scf

$$C_{la} = \frac{17.7 \times C_{ls} \times P_s \times M_d}{(T_s + 960)}$$

$$= \frac{17.7 \times 0.00011 \times 29.53 \times 0.93}{584}$$

$= 0.00009$ gr/scf

21. Lead emission; probe and filter, lb/hr

$C_{lh} = 8.57 \times 10^{-3} \times C_{ls} \times Q_s$

$= 8.57 \times 10^{-3} \times 0.00011 \times 32,060$

$= 0.0300$ lb/hr

22. Lead emission; probe and filter, lb/ton lead

$C_{lt} = C_{lh}/R$

$= 0.030/4.2$

$= 0.0071$ lb/ton lead

APPENDIX B

COMPLETE GASEOUS RESULTS WITH SAMPLE CALCULATIONS

APPENDIX B

COMPLETE GASEOUS RESULTS WITH SAMPLE CALCULATIONS

SO_2 EMISSION DATA

Run No. Date Time	1(a) 12/14/71 2:40 pm	1(b) 12/14/71 3:55 pm	2(a) 12/15/71 10:30 am	2(b) 12/15/71 12:30 pm	3(a) 12/15/71 2:35 pm	3(b) 12/15/71 4:35 pm	4(a) 12/16/71 8:30 am	4(b) 12/16/71 10:30 am	5(a) 12/16/71 12:45 pm	5(b) 12/16/71 3:00 pm
T_m - average gas meter temperature, F	46	49	65	58	64	54	87	65	75	65
P_b - barometric pressure, in. Hg absolute	29.78	29.78	29.57	29.57	29.42	29.42	29.46	29.46	29.40	29.40
V_m - volume of dry gas sampled at meter conditions, ft^3	8.0	8.2	12.7	13.1	12.7	11.6	13.0	12.44	12.0	12.7
V_m standard	8.33	8.49	12.7	13.2	12.6	11.8	12.4	12.4	11.7	12.6
V_t - volume barium perchlorate, ml	33.70	17.90	49.9	32.6	62.0	15.1	32.0	9.0	52.0	4.1
V_{tb} - volume barium perchlorate, blank, ml	0	0	0	0	0	0	0	0	0	0
N - normality of barium perchlorate	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
V_{soln} - volume SO_2 soln, ml	100	100	100	100	100	100	100	100	100	100
V_a - volume aliquot, ml	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
C_{SO_2} - $lb/ft^3 \times 10^{-5}$	28.5	14.8	27.7	17.3	34.6	9.1	18.2	5.1	31.4	2.3
C_{SO_2} - ppm	1720	900	1680	1050	2100	550	1100	310	1900	138
W_{SO_2} - lb/hr	(c)	(c)	534	334	666	174	320	90	718	52

(a) Sample taken before scrubber.
(b) Sample taken after scrubber. Simultaneous samples; time under (a) - beginning, time under (b) - end.
(c) Not available.

SO_2 EXAMPLE CALCULATIONS

1. $V_{m_{std}} = V_m \frac{(T_{std})\ (P_{Bar})}{(T_m)\ \ (P_{std})}$

$= 12.7 \times \frac{530}{524} \times \frac{29.4}{29.9}$

$= 12.6\ ft^3$

2. $C_{SO_2} = \frac{7.05 \times 10^{-5}\ (V_t - V_{tb})\ (N)\ (V_{soln})}{(V_{m_{std}})\ (V_a)}$ lb/ft^3

$= \frac{7.05 \times 10^{-5} \times 62.0 \times 0.01 \times 100}{(12.6)\ (1)}$

$= 34.6 \times 10^{-5}\ lb/ft^3$

3. $C_{SO_2}\ ppm = 6.04 \times 10^6 \times C_{SO_2}$

$= 6.04 \times 10^6 \times 34.6 \times 10^{-5}$

$= 2100\ ppm$

4. $W_{SO_2} = C_{SO_2} \times Q_s \times 60$

$= 34.6 \times 10^{-5} \times 32{,}060 \times 60$

$= 660\ lb/hr$

APPENDIX C

FIELD DATA

APPENDIX C

PRELIMINARY FIELD DATA

STACK GEOMETRY

Plant General Battery Corporation

Test No. ___

Location Stack (Sample Point A)

Inside diameter of stack 62 in.

Date 12/14/71

Stack area 3020 in^2
21.0 ft^3

Point	Percent Diameter for Circular Stack	Distance from Outside of Sample Port, in.
1	1.1	3/4 + 3-1/2 = 4-1/4
2	3.5	2-1/4 + 3-1/2 = 5-3/4
3	6.0	3-3/4 + 3-1/2 = 7-1/4
4	8.7	5-1/4 + 3-1/2 = 8-3/4
5	11.6	7-1/4 + 3-1/2 = 10-3/4
6	14.6	9 + 3-1/2 = 12-1/2
7	18.0	11 + 3-1/2 = 14-1/2
8	21.8	13-1/2 + 3-1/2 = 17
9	26.1	15-1/2 + 3-1/2 = 19
10	31.5	19-1/2 + 3-1/2 = 23
11	39.3	24-1/4 + 3-1/2 = 27-3/4
12	60.7	37-3/4 + 3-1/2 = 41-1/4
13	68.5	42-1/2 + 3-1/2 = 46
14	73.9	45-3/4 + 3-1/2 = 49-1/4

PRELIMINARY FIELD DATA

STACK GEOMETRY

Plant General Battery Corporation

Test No. ___

Location Stack (Sample Point A)

Date 12/14/71 (Cont'd)

Point	Percent Diameter for Circular Stack	Distance from Outside of Sample Port, in.
15	78.2	48-1/2 + 3-1/2 = 52
16	82.0	50-3/4 + 3-1/2 = 54-1/4
17	85.4	52-3/4 + 3-1/2 = 56-1/4
18	88.4	54-3/4 + 3-1/2 = 58-1/4
19	91.3	56-1/2 + 3-1/2 = 60
20	94.0	58-1/4 + 3-1/2 = 61-3/4
21	96.5	60 + 3-1/2 = 63-1/2
22	98.9	61 + 3-1/2 = 64-1/2

VELOCITY TRAVERSE FIELD DATA

Plant General Battery Corporation

Date 12/14/71 Time 10:00 am

Location Sample Point A Meter ΔH 1.84

Operator Paul R. Webb Temperature 135 F

Point	SW Traverse ΔP, in. H_2O	SW Traverse $\sqrt{\Delta P}$	SE Traverse ΔP, in. H_2O	SE Traverse $\sqrt{\Delta P}$
1 (a)	---	---	---	---
2 (a)	---	---	---	---
3 (a)	---	---	---	---
4 (a)	---	---	---	---
5 (a)	---	---	---	---
6	0.15	0.39	---	---
7	0.10	0.32	0.20	0.45
8	0.10	0.32	0.15	0.39
9	0.10	0.32	0.15	0.39
10	0.07	0.26	0.15	0.39
11	0.07	0.26	0.15	0.39
12	0.30	0.55	0.10	0.32
13	0.45	0.67	0.10	0.32
14	0.50	0.71	0.25	0.50
15	0.55	0.74	0.25	0.50
16	0.55	0.74	0.30	0.55
17	0.55	0.74	0.30	0.55
18	0.55	0.74	0.35	0.59
19	0.60	0.78	0.35	0.59
20	0.50	0.71	0.35	0.59
21	0.40	0.63	0.35	0.59
22	0.20	0.45	0.35	0.59
	(average $\sqrt{\Delta P})^2$ = 0.27			

(a) ΔP to low to measure.

VELOCITY TRAVERSE FIELD DATA

Plant General Battery Corporation

Date 12/16/71 Time 12:30 pm

Location Sample Point B Meter ΔH 1.84

Operators Tom Logan, Jack Divita Temperature 280 F

Point	SW Traverse ΔP	SW Traverse $\sqrt{\Delta P}$	Distance, in.	SE Traverse ΔP	SE Traverse $\sqrt{\Delta P}$
1	0.39	0.625	1.2	0.46	0.680
2	0.40	0.632	3.9	0.46	0.680
3	0.44	0.665	5.6	0.49	0.700
4	0.45	0.671	8.5	0.50	0.708
5	0.50	0.708	12.0	0.57	0.755
6	0.79	0.889	17.0	0.82	0.906
7	0.82	0.906	31.0	0.84	0.912
8	0.86	0.928	36.0	0.89	0.944
9	0.86	0.928	39.0	0.87	0.933
10	0.86	0.928	42.5	0.88	0.938
11	0.86	0.928	44.5	0.88	0.938
12	0.82	0.906	47.0	0.79	0.889
	(average $\sqrt{\Delta P})^2$ = 0.67				

PARTICULATE CLEANUP SHEET

Plant General Battery Corporation

Date 12/15-16/71

Operators P.R. Webb, B.E. Campbell

Run No.	1	2	3
Impinger water volume, ml			
Final	315	398	409
Initial	200	200	200
Collected	115	198	209
Drierite, weight, gm			
Final	533.7	442.2	457.4
Initial	515.0	421.9	433.2
Gain	18.7	20.3	24.2
Total moisture, gm plus ml	134	218	233
Probe, acetone wash residue, mg (a)	37.0	17.1	72.2
Filter weight, mg			
Final	283.5	282.4	306.0
Tare	274.7	276.4	296.2
Gain	8.8	6.0	9.8
Total particulate weight, probe residue and filter, mg	45.8	23.1	82.0
Weight residue from chloroform-ether extract, mg			
Impinger water	37.2	24.8	31.0
Impinger wash water	3.1	3.3	3.0
Total	40.3	28.1	34.0
Weight residue from aqueous phase, mg (a)			
Impinger water	152.2	148.4	202.8
Impinger wash water	2.4	0.5	3.5
Total	154.6	148.9	206.3
Weight residue from acetone wash, mg (a)	0.4	0.7	1.0
Total weight, back half residue, mg	195.3	177.7	241.3
Total weight, front half plus back half, mg	241.1	200.8	323.3

(a) Water and acetone blanks subtracted;
Acetone blank = 0.028 mg/ml,
Water blank = 0.03 mg/ml.

nt General Battery Corporation

te 12/15/71

n No. 1

erator P.R. Webb, B.E. Campbell

mple Box No. 1

ter Box No. 1

ter ΔH @ 1.84

Factor 1.0

Ambient Temperature, F 54

Barometric Pressure, in. Hg 29.62

Assumed Moisture, Percent 5

Heater Box Setting, F 255

Probe Tip Diameter, Inches 0.235

Probe Length 8 ft.

Probe Heater Setting 5 - 252 F

Average ΔP _____ Average ΔH _____

Point	Clock Time	Dry Gas Meter, CF	Pitot, In. H_2O ΔP	Orifice ΔH, In. H_2O Desired	Orifice ΔH, In. H_2O Actual	Dry Gas Temp., F Inlet	Dry Gas Temp., F Outlet	Pump Vacuum, In. Hg Gauge	Box Temp., F	Impinger Temp., F	Stack Press, In. Hg	Stack Temp., F
21	10:17 am	596.7	0.27		0.60	49	45	4.5	240	48	(a)	121
20	10:22 am	598.5	0.28		0.63	50	50	4.5	243	50	(a)	121
19	10:27 am	601.2	0.29		0.66	55	51	4.5	242	50	(a)	121
18	10:32 am	603.3	0.30		0.70	59	53	5.5	242	55	(a)	121
17	10:37 am	605.9	0.25		0.61	64	57	4.5	245	58	(a)	128
16	10:42 am	608.5	0.25		0.61	67	58	4.5	247	59	(a)	128
15	10:47 am	610.9	0.22		0.55	70	60	4.1	252	59	(a)	128
14	10:52 am	613.0	0.21		0.51	71	64	3.9	254	57	(a)	128
13	10:57 am	614.9	0.19		0.47	73	67	3.5	252	57	(a)	128
12	11:02 am	617.6	0.18		0.43	75	69	3.5	254	56	(a)	128
11	11:07 am	619.3	0.14		0.35	76	69	2.5	---	57	(a)	128
10	11:12 am	620.9	0.13		0.32	76	72	2.5	---	57	(a)	128
9	11:17 am	622.6	0.17		0.41	76	72	3.5	---	--	(a)	128
8	11:22 am	624.2	0.17		0.41	78	73	3.5	---	--	(a)	130
7	11:27 am	626.0	0.20		0.49	78	74	4.0	---	---	(a)	128
6	11:32 am	627.9	0.18		0.43	79	75	3.5	---	---	(a)	124

(a) Atmospheric.

Comments: Eliminate Point Nos. 44, 23, 22, 1.
Orsat sample started at 10:35 am from SW port, ended 11:57 am.

Plant General Battery Corporation

Date 12/15/71

Run No. 1 (Cont'd)

Point	Clock Time	Dry Gas Meter, CF	Pitot, In. H_2O Δ P	Orifice ΔH, In. H_2O		Dry Gas Temp., F		Pump Vacuum, In. Hg Gauge	Box Temp., F	Impinger Temp., F	Stack Press, In. Hg	Stack Temp., F
				Desired	Actual	Inlet	Outlet					
5	11:37 am	629.9	0.19		0.47	81	78	3.5	---	---	(a)	124
4	11:42 am	631.9	0.16		0.39	80	76	3.2	---	---	(a)	124
3	11:47 am	633.8	0.16		0.39	80	78	3.2	240	---	(a)	124
2	11:52 am	635.7	0.14		0.35	81	78	2.8	240	---	(a)	124
1-end	11:57 am	637.1	---		---	--	--	--	245	49	(a)	124
44	---	---	---		---	--	--	--	---	---	(a)	124
43	12:50 pm	637.1	0.40		0.91	60	64	7.0	210	52	(a)	124
42	12:55 pm	639.8	0.47		1.05	68	65	7.0	225	48	(a)	126
41	1:00 pm	643.0	0.45		1.05	70	64	7.0	253	52	(a)	124
40	1:05 pm	647.8	0.49		1.12	73	67	7.0	260	53	(a)	124
39	1:10 pm	650.0	0.49		1.12	76	68	7.0	252	53	(a)	124
38	1:15 pm	654.0	0.47		1.05	78	68	7.0	252	53	(a)	124
37	1:20 pm	657.8	0.47		1.05	80	71	6.6	252	53	(a)	124
36	1:25 pm	660.6	0.42		0.96	80	71	6.0	252	53	(a)	124
35	1:30 pm	663.5	0.38		0.85	81	71	5.5	252	53	(a)	124

(a) Atmospheric.

nt General Battery Corporation

e 12/15/71

n No. 1 (Cont'd)

oint	Clock Time	Dry Gas Meter, CF	Pitot, In. H_2O ΔP	Orifice ΔH, In. H_2O Desired	Orifice ΔH, In. H_2O Actual	Dry Gas Temp., F Inlet	Dry Gas Temp., F Outlet	Pump Vacuum, In. Hg Gauge	Box Temp., F	Impinger Temp., F	Stack Press, In. Hg	Stack Temp., F
34	1:35 pm	666.4	0.42		0.95	82	74	6.0	252	53	(a)	124
33	1:40 pm (b)	668.8	---		---	--	--	---	---	--	---	---
32	2:30 pm	668.8	0.12		0.27	60	62	2.5	---	--	(a)	121
31	2:35 pm	670.0	0.15		0.32	61	63	2.5	230	48	(a)	121
30	2:40 pm	672.1	0.17		0.36	64	62	2.5	---	--	(a)	121
29	2:45 pm	673.6	0.15		0.32	63	63	2.5	---	--	(a)	121
28	2:50 pm	675.3	0.20		0.45	66	64	4.2	---	--	(a)	121
27	2:55 pm	677.4	0.25		0.54	68	64	4.5	---	--	(a)	121
26	3:00 pm	679.9	0.25		0.54	70	65	4.5	---	--	(a)	121
25	3:05 pm	681.5	0.25		0.54	72	66	4.5	---	--	(a)	121
24	3:10 pm	684.2	0.29		0.64	73	67	5.1	---	--	(a)	121
3-end	3:15 pm	686.6	---		---	--	--	---	---	--	---	---
OTAL	3 hr 15 min	89.9	10.36		23.87							
ERAGE			0.27		0.61	70.8	66.1			54	29.16	124

Comments: Orsat bag sample taken before scrubbers at 2:48 and 3:50 pm.

(a) Atmospheric.

(b) Stopped. Furnace down.

Plant General Battery Corporation

Date 12/16/71

Run No. 2

Operator P.R. Webb, B.E. Campbell

Sample Box No. _____

Meter Box No. _____

Meter ΔH @ 184

C Factor 1.0

Ambient Temperature, F 63

Barometric Pressure, in. Hg 29.46

Assumed Moisture, Percent 5

Heater Box Setting, F _____

Probe Tip Diameter, Inches 0.235

Probe Length 8 ft.

Probe Heater Setting _____

Average ΔP _____ Average ΔH _____

Point	Clock Time	Dry Gas Meter, CF	Pitot, In. H_2O ΔP	Orifice ΔH, In. H_2O			Dry Gas Temp., F		Pump Vacuum, In. Hg Gauge	Box Temp., F	Impinger Temp., F	Stack Press, In. Hg	Stack Temp., F
				Desired		Actual	Inlet	Outlet					
44	---	---	---			---	--	--	---	---	--	---	---
43	8:30 am	686.7	0.30			0.75	57	60	5.5	236	52	(a)	126
42	8:35 am	689.6	0.35			0.87	63	62	6.5	248	56	(a)	126
41	8:40 am	691.9	0.35			0.87	69	62	6.5	258	61	(a)	126
40	8:45 am	694.7	0.38			0.99	73	64	7.8	254	65	(a)	126
39	8:50 am	698.3	0.32			0.80	80	68	6.2	254	68	(a)	126
38	8:55 am	700.5	0.38			0.99	82	70	7.0	252	67	(a)	126
37	9:00 am	703.5	0.40			1.05	87	75	7.5	247	64	(a)	126
36	9:05 am	706.5	0.37			0.98	91	78	7.0	246	63	(a)	126
35	9:10 am	709.7	0.31			0.77	93	82	5.5	244	63	(a)	126
34	9:15 am	712.4	0.24			0.60	88	80	4.5	247	61	(a)	126
33	9:20 am	715.1	0.20			0.45	88	82	4.8	249	61	(a)	126
32	9:25 am	717.8	0.20			0.40	88	82	3.5	253	--	(a)	126
31	9:30 am	719.5	0.06			0.14	82	80	3.5	253	--	(a)	126
30	9:35 am	721.0	0.09			0.25	79	79	2.5	250	--	(a)	126
29	9:40 am	722.5	0.12			0.30	79	79	2.7	250	--	(a)	117

Comments:

(a) Atmospheric.

Plant General Battery Corporation

Date 12/16/71

Run No. 2 (Cont'd)

Point	Clock Time	Dry Gas Meter, CF	Pitot, In. H_2O ΔP	Orifice ΔH, In. H_2O		Dry Gas Temp., F		Pump Vacuum, In. Hg Gauge	Box Temp., F	Impinger Temp., F	Stack Press, In. Hg	Stack Temp., F
				Desired	Actual	Inlet	Outlet					
28	9:45 am	724.0	0.16		0.38	80	79	3.5	250	--	(a)	117
27	9:50 am	725.7	0.17		0.40	80	77	3.5	250	--	(a)	117
26	9:55 am	727.5	0.18(b)		0.38	80	78	3.5	250	--	(a)	117
25	10:00 am	729.0	0.19		0.41	78	77	3.7	250		(a)	121
24	10:05 am	731.0	0.19		0.41	78	77	3.7	250	--	(a)	121
23	10:10 am	732.8	---		---	--	--	---	---	--	---	---
22	---	---	---		---	--	--	---	---	--	---	---
21	10:30 am	732.8	0.32		0.70	75	75	5.5	230	59	(a)	119
20	10:35 am	735.0	0.30		0.66	80	76	5.0	260	61	(a)	119
19	10:40 am	738.2	0.28		0.60	81	78	5.0	265	64	(a)	119
18	10:45 am	740.3	0.28		0.60	81	78	5.0	265	64	(a)	119
17	10:50 am	742.8	0.27		0.57	81	77	4.75	265	66	(a)	119
16	10:55 am	745.0	0.24		0.51	82	79	4.1	267	66	(a)	119
15	11:00 am	746.9	0.24		0.51	85	79	4.0	265	68	(a)	119
14	11:05 am	748.9	0.20		0.43	84	79	4.0	265	65	(a)	119
13	11:10 am	751.0	0.20		0.43	83	79	3.5	266	65	(a)	119

(a) Atmospheric.

(b) Adjusted nomograph.

Comments: Orsat integrated sample at venturi inlet -
Stop 10:3[illegible]
Start 9:3[illegible]

Plant General Battery Corporation

Date 12/16/71

Run No. 2 (Cont'd)

Point	Clock Time	Dry Gas Meter, CF	Pitot, In. H_2O ΔP	Orifice ΔH, In. H_2O		Dry Gas Temp., F		Pump Vacuum, In. Hg Gauge	Box Temp., F	Impinger Temp., F	Stack Press, In. Hg	Stack Temp., F
				Desired	Actual	Inlet	Outlet					
28	9:45 am	724.0	0.16		0.38	80	79	3.5	250	--	(a)	117
27	9:50 am	725.7	0.17		0.40	80	77	3.5	250	--	(a)	117
26	9:55 am	727.5	0.18(b)		0.38	80	78	3.5	250	--	(a)	117
25	10:00 am	729.0	0.19		0.41	78	77	3.7	250	--	(a)	121
24	10:05 am	731.0	0.19		0.41	78	77	3.7	250	--	(a)	121
23	10:10 am	732.8	---		---	--	--	---	---	--	---	---
22	---	---	---		---	--	--	---	---	--	---	---
21	10:30 am	732.8	0.32		0.70	75	75	5.5	230	59	(a)	119
20	10:35 am	735.0	0.30		0.66	80	76	5.0	260	61	(a)	119
19	10:40 am	738.2	0.28		0.60	81	78	5.0	265	64	(a)	119
18	10:45 am	740.3	0.28		0.60	81	78	5.0	265	64	(a)	119
17	10:50 am	742.8	0.27		0.57	81	77	4.75	265	66	(a)	119
16	10:55 am	745.0	0.24		0.51	82	79	4.1	267	66	(a)	119
15	11:00 am	246.9	0.24		0.51	85	79	4.0	265	68	(a)	119
14	11:05 am	748.9	0.20		0.43	84	79	4.0	265	65	(a)	119
13	11:10 am	751.0	0.20		0.43	83	79	3.5	266	65	(a)	119

(a) Atmospheric.

(b) Adjusted nomograph.

Comments: Orsat integrated sample at venturi inlet -
Stop 10:30 am
Start 9:30 am.

C-1-

Plant General Battery Corporation

Date 12/16/71

Run No. 2 (Cont'd)

Point	Clock Time	Dry Gas Meter, CF	Pitot, In. H_2O ΔP	Orifice ΔH, In. H_2O Desired	Orifice ΔH, In. H_2O Actual	Dry Gas Temp., F Inlet	Dry Gas Temp., F Outlet	Pump Vacuum, In. Hg Gauge	Box Temp., F	Impinger Temp., F	Stack Press, In. Hg	Stack Temp., F
12	11:15 am	753.0	0.17		0.36	83	79	3.2	262	64	(a)	119
11	11:20 am	755.0	0.17		0.36	82	80	3.5	260	64	(a)	119
10	11:25 am	756.8	0.20		0.43	82	80	3.5	260	64	(a)	119
9	11:30 am	758.6	0.22		0.46	82	80	3.5	---	---	(a)	119
8	11:35 am	760.8	0.23		0.49	84	82	4.0	---	--	(a)	119
7	11:40 am	762.8	0.24		0.51	86	84	4.1	---	--	(a)	119
6	11:45 am	764.9	0.22		0.46	85	82	4.0	---	--	(a)	119
5	11:50 am	767.0	0.20		0.43	88	85	3.6	---	--	(a)	114
4	11:55 am	769.0	0.19		0.40	85	78	3.5	---	--	(a)	114
3	12:00 pm	771.0	0.19		0.40	84	78	3.5	---	--	(a)	114
2	12:05 pm	772.9	0.17		0.36	88	85	3.0	---	--	(a)	114
1	12:10 am	774.6	Stop		---	--	--	---	---	--	---	---
TOTAL	3 hr 20 min	87.9	9.09		21.48					1387	(a)	
AVERAGE			0.33		0.74	81.4	77.1			63	(a)	121

(a) Atmospheric.

Comments: Orsat integrated sample at mist eliminator -
Stop 1:00 pm
Start 12:00 pm.

Plant General Battery

Date 12/16/71

Run No. 3

Operator P. R. Webb, B. E. Campbell

Sample Box No. -

Meter Box No. -

Meter ΔH @ 184

Factor 1.0

Ambient Temperature, F 67

Barometric Pressure, in. Hg 29.40

Assumed Moisture, Percent 5

Heater Box Setting, F

Probe Tip Diameter, Inches 0.235

Probe Length 8'

Probe Heater Setting -

Average ΔP Average ΔH

Point	Clock Time	Dry Gas Meter, CF	Pitot, In. H_2O ΔP	Orifice ΔH, In. H_2O		Dry Gas Temp., F		Pump Vacuum, In. Hg Gauge	Box Temp., F	Impinger Temp., F	Stack Press, In. Hg	Stack Temp., F
				Desired	Actual	Inlet	Outlet					
22	--	--	--		--	--	--	--	--	--	--	--
21	2:05	774.6	0.36		0.80	69	66	6	240	55	(a)	119.5
20	2:10	777.6	0.36		0.80	71	71	6.5	250	54	(a)	119.5
19	2:15	780.6	0.37		0.82	73	71	6.5	262	56	(a)	119.5
18	2:20	783.0	0.34		0.74	76	72	7	265	57	(a)	119.5
17	2:25	785.9	0.34		0.74	78	74	7	260	57	(a)	119.5
16	2:30	788.6	0.30		0.67	82	76	6.5	260	5.8	(a)	119.5
15	2:35	791.0	0.26		0.56	83	77	5.2	257	58	(a)	119.5
14	2:40	793.7	0.23		0.50	82	78	5	257	59	(a)	119.5
13	2:45	796.1	0.20		0.44	82	79	4.1	258	59	(a)	119.5
12	2:50	797.7	0.18		0.39	83	79	3.9	262	59	(a)	119.5
11	2:55	799.0	0.19		0.41	84	82	4.1	262	60	(a)	119.5
10	3:00	801.5	0.22		0.47	85	83	5.0	--	--	(a)	119.5
9	3:05	803.8	0.25		0.55	88	84	5.5	--	--	(a)	119.5
8	3:10	805.5	0.23		0.51	90	85	5.5	--	--	(a)	119.5
7	3:15	808.2	0.23		0.51	92	88	5.5	--	--	(a)	119.5

Comments:

PARTICULATE FIELD DATA

ant General Battery
te 12/16/71
n No. 3 cont.
erator P. R. Webb, B. E. Campbell
mple Box No. --
ter Box No. --
ter ΔH @ 1.84
Factor 1.0

Ambient Temperature, F 62
Barometric Pressure, in. Hg 29.44
Assumed Moisture, Percent 5
Heater Box Setting, F --
Probe Tip Diameter, Inches 0.235
Probe Length 8'
Probe Heater Setting 5-6
Average ΔP ____ Average ΔH ____

Point	Clock Time	Dry Gas Meter, CF	Pitot, In. H_2O ΔP	Orifice ΔH, In. H_2O		Dry Gas Temp., F		Pump Vacuum, In. Hg Gauge	Box Temp., F	Impinger Temp., F	Stack Press, In. Hg	Stack Temp., F
				Desired	Actual	Inlet	Outlet					
6	3:20 p	810.2	0.21		0.45	89	85	4.8	250	--	(a)	119.5
5	3:25	812.5	0.23		0.49	89	85	4.9	245	--	(a)	119.5
4	3:30	814.1	0.20		0.45	89	85	5.0	--	--	(a)	119.5
3	3:35	816.9	0.20		0.45	89	85	5.0	--	--	(a)	121.5
2	3:40	818.4	0.15		0.32	88	85	3.2	--	--	(a)	125.
1-end	3:45	820.5	--		--	--	--	--	--	--	(a)	--
44	--	--	--		--	--	--	--	--	--	--	--
43	4:00	820.5	0.35		0.75	80	79	7.5	240	52	(a)	125.
42	4:05	822.0	0.39		0.86	81	81	7.5	232	50	(a)	125.
41	4:10	825.2	0.40		0.89	83	82	7.5	238	50	(a)	125.
40	4:15	827.9	0.47		1.10	84	83	11.0	260	53	(a)	121.
39	4:20	831.1	0.57		1.40	89	82	14.0	262	58	(a)	121.
38	4:25	835.0	0.55		1.30	90	82	12.2	258	58	(a)	119.5
37	4:30	838.6	0.57		1.40	91	82	13.0	253	60	(a)	119.5
36	4:35	842.5	0.55		1.3	91	82	12.0	252	60	(a)	117

Comments:

lant General Battery

ate 12/16/71

un No. 3 cont.

perator P. R. Webb, B. E. Campbell

ample Box No. --

leter Box No. --

leter ΔH @ 1.84

Factor 1.0

Ambient Temperature, F 62

Barometric Pressure, in. Hg 29.44

Assumed Moisture, Percent 5

Heater Box Setting, F --

Probe Tip Diameter, Inches 0.235

Probe Length 8'

Probe Heater Setting 5-6

Average ΔP _____ Average ΔH _____

Point	Clock Time	Dry Gas Meter, CF	Pitot, In. H_2O ΔP	Orifice ΔH, In. H_2O		Dry Gas Temp., F		Pump Vacuum, In. Hg Gauge	Box Temp., F	Impinger Temp., F	Stack Press, In. Hg	Stack Temp., F
				Desired	Actual	Inlet	Outlet					
35	4:40	846.5	0.51		1.12	92	84	10.1	253	58	(a)	117
34	4:45	849.5	0.51		1.12	91	84	10.1	253	58	(a)	117
33	4:50	853.7	0.35		0.75	90	84	7.0	253	58	(a)	117
32	4:55	854.5	0.29		0.63	88	84	6.0	253	58	(a)	117
31	5:00	858.0	0.33		0.70	88	83	7.0	253	58	(a)	117
30	5:05	860.8	0.67	1.70	1.50	90	85	13.5	253	58	(a)	117
29	5:10	864.9	0.69	1.72	1.60	92	85	13.5	253	58	(a)	117
28	5:15	868.9	0.67	1.70	1.60	92	84	13.2	253	58	(a)	117
27	5:20	872.5	0.66	1.65	1.65	91	84	13.2	253	58	(a)	117
26	5:25	876.9	0.66	1.65	1.65	92	84	12.4	253	58	(a)	117
25	5:30	880.9	0.68	1.71	1.65	92	85	12.4	253	58	(a)	117
24	5:35	884.6	0.68	1.71	1.65	92	84	12.4	253	58	(a)	117
23-end	5:40	888.5	--	--	--	--	--	--	--	--	--	--
Total	200 min	113.9 CF										
Avg.			0.39		0.89	86.0	81.3			57 F		118 F

Comments: Points 24-31 Δp questionable (condensate in pitot tubing)

GAS SAMPLING FIELD DATA

Date 12/15/71

Plant General Battery Corporation

Material Sampled for SO_2

Comments: Sample Position A after scrubber. Stack temperature, 120 F; probe temperature, 190 F. Recovered 66 ml - diluted to 100 ml.

Barometric Pressure 29.78 in. Hg

Ambient Temperature 47 F

Run Number 1

Power Stat Setting Heated

Filter Used: Yes X No

Operator W.C. Baytos, H. Hess

Titration		
Aliquot, ml	Titer, ml	0.01 N $Ba(ClO_4)_2$
1	17.9	
blank	0	

Clock Time	Meter (ft^3)	Flow Meter Setting (CFH)	Meter Temperature F
2:35 pm	459.3	6	42
2:40 pm	459.9	6	41
2:45 pm	460.3	6	44
2:50 pm	460.8	6	38
2:55 pm	461.3	6	38
3:00 pm	462.0	6	45
3:05 pm	462.5	6	46
3:10 pm	463.1	6	45
3:15 pm	463.5	6	51
3:20 pm	464.1	6	52
3:25 pm	464.7	6	53
3:30 pm	465.3	6	53
3:35 pm	465.9	6	56
3:40 pm	466.4	6	57
3:45 pm	466.9	6	59
3:50 pm	467.5	6	60

GAS SAMPLING FIELD DATA

Date 12/15/71 Plant General Battery Corporation

Material Sampled for SO_2

Barometric Pressure 29.78 in. Hg Comments: Sample position A after scrubber.

Ambient Temperature 47 F

Run Number 1

Power Stat Setting Heated

Filter Used: Yes X No ___

Operator W.C. Baytos, H. Hess

Stack temperature, 120 F; probe temperature, 190 F. Recovered 66 ml - diluted to 100 ml.

Titration

Aliquot, ml	Titer, ml
1	17.9
blank	0

0.01 N $Ba(ClO_4)_2$

Clock Time	Meter (ft^3)	Flow Meter Setting (CFH)	Meter Temperature, F
2:35 pm	459.3	6	42
2:40 pm	459.9	6	41
2:45 pm	460.3	6	44
2:50 pm	460.8	6	38
2:55 pm	461.3	6	38
3:00 pm	462.0	6	45
3:05 pm	462.5	6	46
3:10 pm	463.1	6	45
3:15 pm	463.5	6	51
3:20 pm	464.1	6	52
3:25 pm	464.7	6	53
3:30 pm	465.3	6	53
3:35 pm	465.9	6	56
3:40 pm	466.4	6	57
3:45 pm	466.9	6	59
3:50 pm	467.5	6	60

GAS SAMPLING FIELD DATA

Date 12/14/71

Material Sampled for SO_2

Barometric Pressure 29.78 in. Hg

Ambient Temperature 47 F

Run Number 1

Power Stat Setting Heated

Filter Used: Yes X No ___

Operator W.C. Baytos, H. Hess

Plant General Battery Corporation

Comments: Sample position B before scrubber. Stack temperature >200 F; probe temperature, 240 F. Recovered 92 ml - diluted to 100 ml.

Titration — 0.01 N $Ba(ClO_4)_2$

Aliquot, ml	Titer, ml
1.0	33.62
blank	0

Clock Time	Meter (ft^3)	Flow Meter Setting (CFH)	Meter Temperature F
2:42 pm	108.1	6.5	44
2:50 pm	109.0	6.0	45
3:00 pm	109.9	6.0	45
3:05 pm	110.5	--	--
3:10 pm	111.0	6.0	45
3:15 pm	111.6	6.0	45
3:20 pm	112.1	6.0	45
3:25 pm	112.9	6.5	46
3:30 pm	113.3	6.0	46
3:35 pm	113.8	6.0	--
3:40 pm	114.4	6.0	46
3:45 pm	115.1	6.0	46
3:50 pm	115.6	6.0	48
3:55 pm	116.9	6.0	46

GAS SAMPLING FIELD DATA

Date 12/15/71

Material Sampled for SO_2

Barometric Pressure 29.58 in. Hg

Ambient Temperature 54 F

Run Number 2

Power Stat Setting Heated

Filter Used: Yes X No ___

Operator W.C. Baytos, H. Hess

Plant General Battery Corporation

Comments: Sample position A after scrubber. Stack temperature, 125 F; probe temperature, 220 F. Recovered 76 ml - diluted to 100 ml.

Titration Aliquot,	Titer, 0.01 N $Ba(ClO_4)_2$
1.0	32.62
blank	0

Clock Time	Meter (ft^3)	Flow Meter Setting (CFH)	Meter Temperature, F
10:15 am	470.7	6.0	49
10:20 am	471.3	6.0	49
10:25 am	471.9	6.0	50
10:30 am	472.4	6.0	50
10:35 am	473.0	6.0	51
10:40 am	473.5	6.0	52
10:45 am	474.0	6.0	53
10:50 am	474.5	6.0	54
10:55 am	475.0	6.0	50
11:00 am	475.6	6.0	57
11:05 am	476.2	6.0	58
11:10 am	476.8	6.0	60
11:15 am	477.3	6.0	60
11:20 am	477.8	6.0	62
11:25 am	478.3	6.0	62
11:30 am	478.9	6.0	63
11:35 am	479.4	6.0	65
11:40 am	480.0	6.0	64
11:45 am	480.5	6.0	66
11:50 am	481.0	6.0	67
11:55 am	481.5	6.0	67
12:00 pm	482.1	6.0	68
12:05 pm	482.6	6.0	69
12:10 pm	483.3	6.0	70
12:15 pm	483.8	6.0	70

GAS SAMPLING FIELD DATA

Date 12/15/71

Material Sampled for SO_2

Barometric Pressure 29.60 in. Hg

Ambient Temperature 57 F

Run Number 2

Power Stat Setting Heated

Filter Used: Yes X No ___

Operator W.C. Baytos, H. Hess

Plant General Battery Corporation

Comments: Sample position B before scrubber. Stack temperature, 300 F; probe temperature, 210 F. Recovered 83 ml - diluted to 100 ml.

Titration, 0.01 N $Ba(ClO_4)_2$

Aliquot, ml	Titer, ml
1.0	49.37
blank	0

Clock Time	Meter (ft^3)	Flow Meter Setting (CFH)	Meter Temperature, F
10:30 am	116.4	6.0	60
10:35 am	117.1	6.0	60
10:40 am	117.5	6.0	60
10:45 am	118.2	6.0	62
10:50 am	118.6	6.0	63
10:55 am	119.1	6.0	--
11:00 am	119.6	6.0	64
11:05 am	120.2	6.0	65
11:10 am	120.6	6.0	65
11:15 am	121.2	6.0	65
11:20 am	121.7	6.0	66
11:25 am	122.1	6.0	66
11:30 am	--	6.0	--
11:35 am	123.4	6.0	66
11:40 am	123.9	6.0	65
11:45 am	124.4	6.0	65
11:50 am	124.9	6.0	65
11:55 am	125.5	6.0	65
12:00 pm	126.1	6.0	65
12:05 pm	126.5	6.0	65
12:12 pm	127.0	6.0	64
12:15 pm	127.5	6.0	65
12:20 pm	128.3	6.0	65
12:25 pm	128.5	6.0	65
12:30 pm	129.1	6.0	65

GAS SAMPLING FIELD DATA

Date 12/15/71

Material Sampled for SO2

Barometric Pressure 29.42 in. Hg

Ambient Temperature 52 F

Run Number 3

Power Stat Setting Heater

Filter Used: Yes X No ___

Operator W.C. Baytos, H. Hess

Plant General Battery Corporation

Comments: Sample position A after scrubber.

Stack temperature 121 F; probe temperature, 250 F. Recovered 64 ml - diluted to 100 ml.

Titration		
Aliquot, ml	Titer, ml	0.01 N $Ba(ClO_4)_2$
1.0	15.00	

Clock Time	Meter (ft^3)	Flow Meter Setting (CFH)	Meter Temperature, F
2:35 pm	484.5	6.0	50
2:40 pm	485.1	6.0	50
2:45 pm	485.6	6.0	50
2:50 pm	485.9	6.0	50
2:55 pm	486.4	6.0	51
3:00 pm	487.0	6.0	51
3:05 pm	487.6	6.0	52
3:10 pm	488.2	6.0	54
3:15 pm	488.7	6.0	53
3:20 pm	489.5	6.0	54
3:25 pm	---	6.0	--
3:30 pm	490.4	6.0	56
3:35 pm	---	6.0	--
3:40 pm	491.1	6.0	58
3:45 pm	491.6	6.0	56
3:50 pm	492.6	6.0	57
3:55 pm	492.7	6.0	59
4:00 pm	493.2	6.0	59
4:05 pm	493.7	6.0	59
4:10 pm	494.3	6.0	57
4:15 pm	494.9	6.0	57
4:22 pm	494.4	6.0	57
4:25 pm	495.7	6.0	57
4:30 pm	496.1	6.0	58

GAS SAMPLING FIELD DATA

Date 12/15/71

Material Sampled for SO_2

Barometric Pressure 29.40 in. Hg

Ambient Temperature 54 F

Run Number 3

Power Stat Setting Heated

Filter Used: Yes X No ___

Operator W.C. Baytos, H. Hess

Plant General Battery Corporation

Comments: Sample position B before scrubber, 15.6 in. H_2O pressure.

Stack temperature, 280 F; probe temperature, 220 F. Recovered 87 ml - diluted to 100 ml.

Titration		
Aliquot, ml	Titer, ml	0.01 N $Ba(ClO_4)_2$
1.0	62.00	
blank	0	

Clock Time	Meter (ft^3)	Flow Meter Setting (CFH)	Meter Temperature, F
2:35 pm	129.6	6.0	59
2:40 pm	129.0	6.0	59
2:45 pm	130.3	6.0	60
2:50 pm	130.8	6.0	60
2:55 pm	131.4	6.0	60
3:00 pm	131.9	6.0	60
3:05 pm	132.4	6.0	60
3:10 pm	132.9	6.0	61
3:15 pm	133.5	6.0	61
3:20 pm	134.0	6.0	61
3:25 pm	134.6	6.0	61
3:30 pm	135.1	6.0	63
3:35 pm	135.6	6.0	63
3:40 pm	136.0	6.0	63
3:45 pm	136.7	6.0	65
3:50 pm	137.3	6.0	65
3:55 pm	137.8	6.0	66
4:00 pm	138.4	6.0	66
4:05 pm	138.9	6.0	67
4:10 pm	139.4	6.0	68
4:15 pm	140.0	6.0	68
4:20 pm	140.5	6.0	68
4:25 pm	141.1	6.0	69
4:30 pm	141.6	6.0	70
4:35 pm	142.3	6.0	70

GAS SAMPLING FIELD DATA

Date 12/16/71
Material Sampled for SO_2
Barometric Pressure 29.44 in. Hg
Ambient Temperature 67 F
Run Number 4
Power Stat Setting Heated
Filter Used: Yes X No ___
Operator W.C. Baytos, H. Hess

Plant General Battery Corporation
Comments: Sample position A after scrubber. Stack temperature, 120 F; probe temperature, 180 F. Recovered 81 ml - diluted to 100 ml.

Titration

Aliquot, ml	Titer, ml
1.0	9.10
1.0	8.80
blank	0

0.01 N $Ba(ClO_4)_2$

Clock Time	Meter (ft^3)	Flow Meter Setting (CFH)	Meter Temperature, F
9:00 am	498.5	6.0	58
9:05 am	499.1	6.0	58
9:10 am	499.5	6.0	59
9:15 am	500.1	6.0	59
9:20 am	500.6	6.0	61
9:25 am	501.1	6.0	63
9:30 am	501.6	7.8	64
9:35 am	502.1	7.8	66
9:40 am	502.6	7.5	68
9:45 am	503.0	7.5	68
9:50 am	503.5	7.4	69
9:55 am	503.9	7.5	69
10:00 am	504.4	7.4	67
10:05 am	504.9	7.5	67
10:10 am	505.3	7.5	67
10:20 am	505.8	7.5	67
10:25 am	505.9	7.5	65
10:30 am	506.5	7.5	66
10:35 am	506.8	7.5	66
10:40 am	507.3	7.5	67
10:45 am	507.7	7.5	67
10:50 am	508.2	7.5	67
10:55 am	508.7	7.5	67
11:00 am	509.1	7.5	67
11:05 am	509.6	7.5	67
11:10 am	510.1	7.5	67

GAS SAMPLING FIELD DATA

Date 12/16/71

Material Sampled for SO_2

Barometric Pressure 29.46 in. Hg

Ambient Temperature 68 F

Run Number 4

Power Stat Setting Heated

Filter Used: Yes X No ___

Operator W.C. Baytos, H. Hess

Plant General Battery Corporation

Comments: Sample position B before scrubber, 13.7 in. H_2O pressure.

Stack temperature, 300 F; probe temperature, 212 F. Recovered 69 ml - diluted to 100 ml.

Titration	
Aliquot, ml	Titer, ml
1.0	32.00
blank	0

Clock Time	Meter (ft^3)	Flow Meter Setting (CFH)	Meter Temperature, F
8:30 am	142.7	6.0	80
8:35 am	143.1	6.0	80
8:40 am	143.7	6.0	80
8:45 am	144.2	6.0	80
8:50 am	144.7	6.0	81
8:59 am	145.6	6.0	--
9:00 am	146.0	6.0	85
9:05 am	146.4	6.0	86
9:10 am	146.8	6.0	85
9:15 am	147.5	6.0	88
9:20 am	148.0	6.0	90
9:25 am	148.6	6.0	92
9:30 am	149.1	6.0	92
9:35 am	149.7	6.0	92
9:40 am	150.3	6.0	92
9:45 am	150.8	6.0	93
9:50 am	151.3	6.0	93
9:55 am	151.9	6.0	93
10:00 am	152.4	6.0	90
10:05 am	153.0	6.0	89
10:10 am	153.6	6.0	88
10:15 am	154.2	6.0	88
10:20 am	154.7	6.0	88
10:25 am	155.2	6.0	88
10:30 am	155.7	6.0	87

GAS SAMPLING FIELD DATA

Date 12/16/71

Material Sampled for SO_2

Barometric Pressure 29.40 in. Hg

Ambient Temperature 67 F

Run Number 5

Power Stat Setting Heated

Filter Used: Yes X No ___

Operator W.C. Baytos, H. Hess

Plant General Battery Corporation

Comments: Sample position A after scrubber. Stack temperature, 120 F; probe temperature, 220 F. Recovered 73 ml - diluted to 100 ml.

Titration	
Aliquot, ml	Titer, ml
1.0	4.10
1.0	4.28
blank	0

Clock Time	Meter (ft^3)	Flow Meter Setting (CFH)	Meter Temperature, F
12:45 pm	510.8	6.0	61
12:50 pm	511.4	6.0	61
12:55 pm	512.0	6.0	62
1:00 pm	512.5	6.0	61
1:05 pm	513.0	6.0	62
1:10 pm	513.5	6.0	62
1:15 pm	514.0	6.0	64
1:20 pm	514.6	6.0	64
1:25 pm	515.1	6.0	64
1:30 pm	515.7	6.0	66
1:35 pm	516.2	6.0	67
1:40 pm	516.7	6.0	67
1:45 pm	517.2	6.0	68
1:50 pm	517.7	6.0	69
1:55 pm	518.3	6.0	69
2:00 pm	518.8	6.0	69
2:05 pm	519.4	6.0	70
2:10 pm	519.9	6.0	69
2:15 pm	520.4	6.0	69
2:20 pm	520.9	6.0	69
2:25 pm	521.5	6.0	70
2:30 pm	522.0	6.0	70
2:35 pm	522.5	6.0	70
2:40 pm	523.0	6.0	70
2:45 pm	523.5	6.0	70

GAS SAMPLING FIELD DATA

Date 12/16/71

Material Sampled for SO_2

Barometric Pressure 29.40 in. Hg

Ambient Temperature 65 F

Run Number 5

Power Stat Setting Heated

Filter Used: Yes X No ___

Operator W.C. Baytos, H. Hess

Plant General Battery Corporation

Comments: Sample position B before scrubber.

Stack temperature, 276 F; probe temperature, 220 F. Recovered 74 ml - diluted to 100 ml.

Titration	
Aliquot, ml	Titer, ml
1.0	52.02
blank	0

Clock Time	Meter (ft^3)	Flow Meter Setting (CFH)	Meter Temperature, F
12:55 pm	158.0	6.0	70
1:00 pm	158.4	6.0	69
1:05 pm	159.0	6.0	--
1:12 pm	159.4	6.0	70
1:15 pm	159.9	6.0	70
1:20 pm	--	6.0	--
1:25 pm	160.6	6.0	73
1:30 pm	161.1	6.0	73
1:35 pm	161.6	6.0	--
1:40 pm	162.2	6.0	78
1:45 pm	162.7	6.0	78
1:50 pm	163.0	5.5	78
1:55 pm	163.6	6.0	78
2:00 pm	164.1	6.0	80
2:05 pm	164.6	6.0	80
2:10 pm	165.0	6.0	80
2:15 pm	165.6	6.0	82
2:20 pm	165.9	6.0	81
2:25 pm	166.5	6.0	81
2:30 pm	167.1	6.0	78
2:35 pm	167.2	6.0	78
2:40 pm	168.1	6.0	78
2:45 pm	168.5	6.0	--
2:50 pm	169.1	6.0	78
3:00	170.0	6.0	78

ORSAT GAS COMPOSITION

Plant General Battery Corporation

Run	Date (1971)	Time	CO_2, Percent	O_2, Percent	CO, Percent	N_2, Percent
1A	12-15	2:48 - 3:50 pm	3.2	16.8	0	80.0
1B	12-15	10:35 -11:57 am	3.4	16.6	0	80.0
2A	12-16	12:00 - 1:00 pm	2.8	17.0	0.2	80.0
2B	12-16	9:30 -10:30 am	3.0	15.6	1.4	80.0
3A	12-16	3:18 - 3:43 pm	3.4	16.4	0.4	79.8
3B	12-16	3:45 - 4:23 pm	2.2	18.4	0.2	79.2

A - Sample Point A

B - Sample Point B

APPENDIX D

STANDARD SAMPLING PROCEDURES

APPENDIX D

STANDARD SAMPLING PROCEDURES

The sampling procedures as described in the August 17, 1971 issue of the Federal Resgister, reproduced as a part of this appendix, has been used as a reference for the source emission test conducted at The General Battery Corporation, Reading, Pennsylvania.

After selecting the appropriate stack sampling location, number and position of sampling points as described in Method 1, a preliminary traverse of the stack was completed to determine the average Δp and average gas temperature. These data were then used, with the aid of a nomograph, to determine the appropriate nozzle diameter which would allow isokinetic sampling at an air flow rate consistent with proper sampling train operation.

The sample train was prepared for operation as outlined in Method 5. The glass filter used for particulate collection was desiccated for 24 hours and the tare weight determined. Two-hundred grams of indicating drierite, which had been stored in a sealed container, was placed in one of the three modified impingers.

One hundred ml of distilled water was placed in each of two impingers. The sample train was then assembled and leak checked to within the specified tolerances.

During the sampling period, isokinetic flow was maintained by adjusting the sampling flow rate to compensate for stack Δp and temeperature variations. Appendix C is a record of the field data for the three tests completed at General Battery.

After the completion of each test and the recording of the appropriate field data, the sampling train was removed from the sampling platform and cleaned. The probe assembly was removed from the sampling train; the ends were plugged and the probe allowed to cool. They pyrex tube and stainless steel nozzle were then thoroughly cleaned with a nylon brush and rinsed with reagent-grade acetone into a precleaned screw-cap glass container. The

glass filter was removed from its holder and placed into an appropriate container. The weight of acetone wash residue and the net filter weight now comprise the "front half" of the collected sample.

The water from the first three impingers was measured to determine the volume increase and then poured into precleaned screw-cap glass containers. The weight gain from the water volume increase plus the weight increase of the drierite was used to determine the stack gas moisture content. All of the glassware from the back half of the filter holder, up to, but not including the drierite container was rinsed with distilled water and the rinse water poured into a precleaned screw-cap glass container. This same glassware was then rinsed with reagent-grade acetone and the acetone rinse poured into a precleaned screw-cap glass container. These three solutions were then extracted and evaporated as outlined in the Federal Register and the weight residue determined. These weights comprise the "back Half" of the collected sample.

Samples of the water and acetone used to clean the glassware were taken from each container that was used in the field to determine the amount of residue from blank water and blank acetone. These values were subtracted from the sample data to obtain net values. The blank values were relatively high and may have reduced the results by as much as ten percent.

FEDERAL REGISTER, VOL. 36, NO. 159-TUESDAY, AUGUST 17, 1971

PROPOSED RULE MAKING

15708

APPENDIX—TEST METHODS

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

New Source Performance Standards. 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 a rectangular cross section, determine an equivalent diameter from the following equation:

$$\text{equivalent diameter} = 2\left[\frac{(\text{length})(\text{width})}{\text{length}+\text{width}}\right] \qquad \text{equation 1-1}$$

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.

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 four, and for rectangular stacks the number follows the criteria of section 2.2.2.

2.2 Cross sectional layout and location of traverse points.

2.2.1 For circular stacks locate the traverse points on two perpendicular diameters according to Figure 1-2 and Table 1-1.

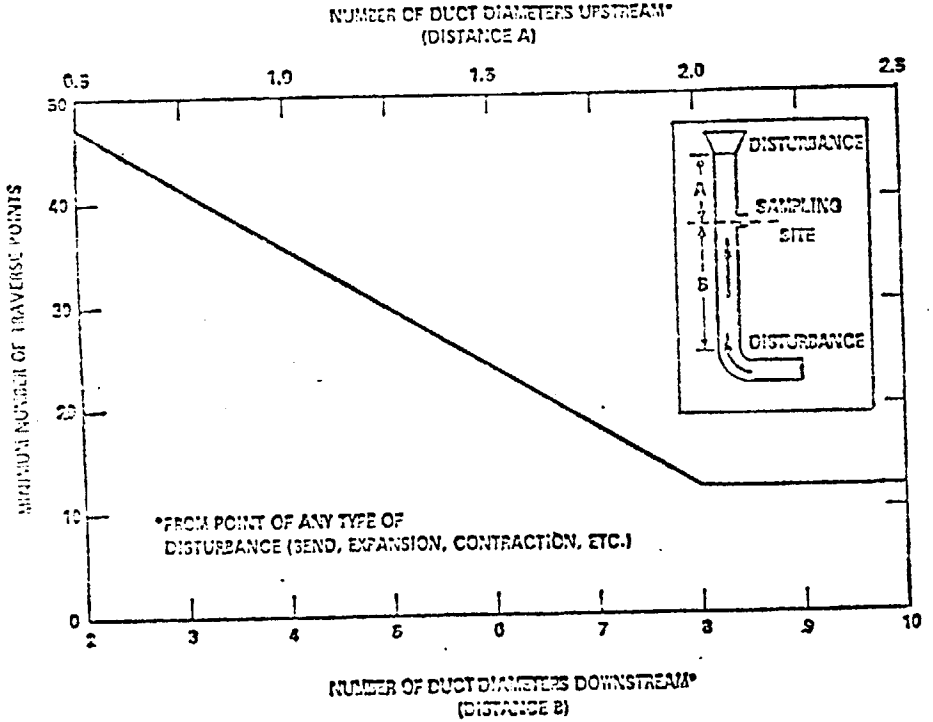

Figure 1-1. Minimum number of traverse points.

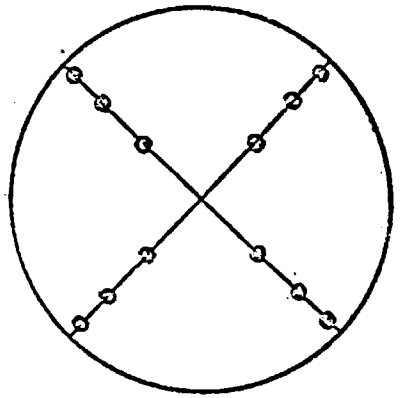

Figure 1-2. Cross section of circular stack showing location of traverse points on perpendicular diameters.

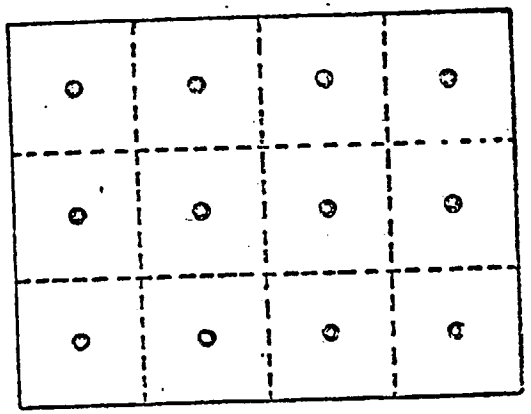

Figure 1-3. Cross section of rectangular stack divided into 12 equal areas, with traverse points at centroid of each area.

Table 1-1. Location of traverse points in circular stacks
(Percent of stack diameter from inside wall to traverse point)

Traverse point number on a diameter	Number of traverse points on a diameter									
	6	8	10	12	14	16	18	20	22	24
1	4.4	3.3	2.5	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	14.7	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3	29.5	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4	70.5	32.3	22.6	17.7	14.5	12.5	10.9	9.7	8.7	7.9
5	85.3	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6	95.6	80.6	65.8	35.5	26.9	22.0	18.8	16.5	14.6	13.2
7		89.5	77.4	64.5	35.6	28.3	23.6	20.4	18.0	16.1
8		96.7	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9			91.8	82.3	73.1	62.5	38.2	30.6	26.1	23.0
10			97.5	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11				93.3	85.4	78.0	70.4	61.2	39.3	32.3
12				97.9	90.1	83.1	76.4	69.4	60.7	39.8
13					94.3	87.5	81.2	75.0	68.5	60.2
14					98.2	91.5	85.4	79.6	73.9	67.7
15						95.1	89.1	83.5	78.2	72.8
16						98.4	92.5	87.1	82.0	77.0
17							95.6	90.3	85.4	80.6
18							98.6	93.3	88.4	83.9
19								96.1	91.3	86.8
20								98.7	94.0	89.5
21									96.5	92.1
22									98.9	94.5
23										96.8
24										98.9

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. 1957.

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

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

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

METHOD 2—DETERMINATION OF STACK GAS VELOCITY (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 New Source Performance Standards. Being a directional instrument, a pitot tube should not be used in the case of nondirectional flow.

2. *Apparatus.*

2.1 Pitot tube—Type S (Figure 2-1), or equivalent.

2.2 Differential pressure gauge—Inclined manometer, or equivalent, to measure velocity head to within 10 percent of the minimum value.

2.3. Temperature gauge—Thermocouples, bimetallic thermometers, liquid filled systems, or equivalent, to measure stack temperature to within 1.5 percent 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 at the traverse points specified by Method 1.

3.2 Measure the temperature of the stack gas. If the total temperature variation with time is less than 50° F., a point measurement will suffice. Otherwise, conduct a temperature traverse.

3.3 Measure the static pressure in the stack.

3.4 Determine the stack gas molecular weight by gas analysis and appropriate calculation as indicated in Method 3.

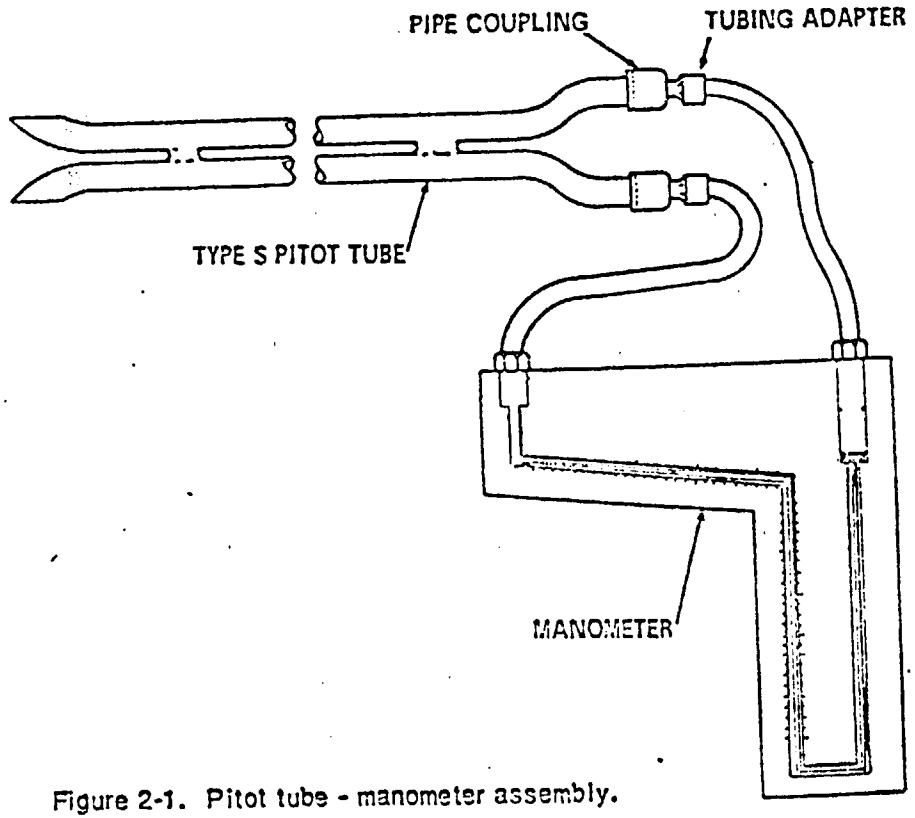

Figure 2-1. Pitot tube - manometer assembly.

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. The velocity of the flowing gas stream should be within the normal working range.

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

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

where:

$C_{p_{test}}$ = Pitot tube coefficient of Type S pitot tube.

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

ΔP_{std} = Velocity head measured by standard type pitot tube.

ΔP_{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.

$$V_s = K_p C_p \sqrt{\frac{T_s \Delta_p}{P_s M_s}} \quad \text{equation 2-2}$$

where:

V_s = Stack gas velocity, feet per second (f.p.s.).

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

C_p = Pitot tube coefficient, dimensionless.

T_s = Absolute stack gas temperature, °R.

Δ_p = Velocity head of stack gas, in H_2O (see fig. 2-2).

P_s = Absolute stack gas pressure, in Hg.

M_s = Molecular weight of stack gas, lb./lb.-mole.

PLANT_____

DATE_____

RUN NO._____

STACK DIAMETER, in._____

BAROMETRIC PRESSURE, in. Hg._____

STATIC PRESSURE IN STACK (P_g), in. Hg._____

OPERATORS_____

SCHEMATIC OF STACK CROSS SECTION

Traverse point number	Velocity head, in. H_2O	$\sqrt{\Delta_p}$	Stack Temperature (T_s), °F
	AVERAGE:		

Figure 2-2. Velocity traverse data.

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.

6. *References.*

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

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

Shigehara, R. T., W. F. Todd, and 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, 1971. ASTM Designation D-2928-71.

Vennard, J. K. Elementary Fluid Mechanics. John Wiley and Sons, Inc., New York, 1947.

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 New Source Performance Standards.

2. *Apparatus.*

2.1 Grab sample (Figure 3-1).

2.1.1 Probe—Stainless steel or Pyrex[1] 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[1] glass equipped with a filter to remove particulate matter.

2.2.2 Air-cooled condenser—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 c.f.m.

2.2.6 Flexible bag—Tedlar,[1] 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.

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. Place the probe in the stack at a sampling point and purge the sampling line.

[1] Trade name.

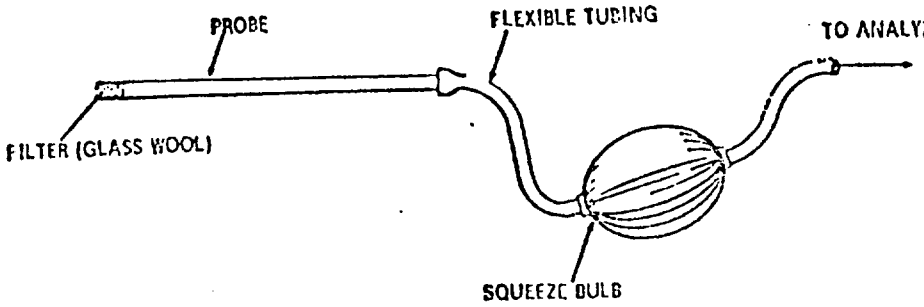

Figure 3-1. Grab-sampling train.

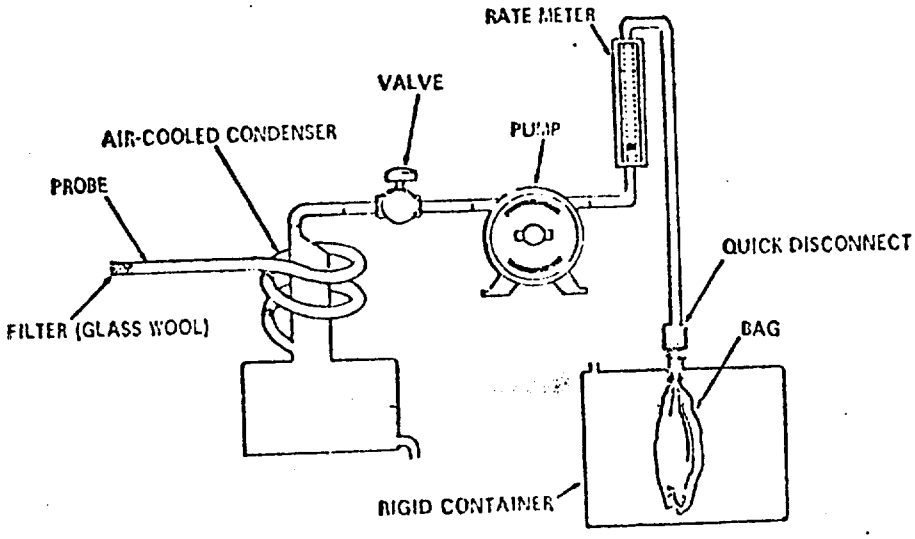

Figure 3-2. Integrated gas - sampling train.

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 gas velocity.

3.3 Analysis.

3.3.1 Determine the CO_2, O_2, and CO concentrations as soon as possible. Make as many passes as are necessary to give constant readings. If more than 10 passes are necessary, replace the absorbing solution.

3.3.2 For integrated sampling, repeat the analysis until three consecutive runs 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 result to the nearest 0.1 percent CO_2.

4.2 Excess air. Use Equation 3-1 to calculate excess air, and average the runs. Report the result to the nearest 0.1 percent excess air.

$$\%\ EA = \frac{(\%\ O_2) - 0.5(\%\ CO)}{0.264(\%\ N_2) - (\%\ O_2) + 0.5(\%\ CO)} \times 100$$

Equation 3-1

where:

%EA = Percent excess air.

$\%O_2$ = Percent oxygen by volume, dry basis.

$\%N_2$ = 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.

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

Equation 3-2

where:

M_d = Dry molecular weight, lb./lb.-mole.

$\%CO_2$ = Percent carbon dioxide by volume, dry basis.

$\%O_2$ = Percent oxygen by volume, dry basis.

$\%N_2$ = 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 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. November 1963.

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 gravimetrically.

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.[2]

Other methods such as drying tubes, wet bulb-dry bulb techniques, and volumetric condensation technique may be used subject to the approval of the Administrator.

2. *Apparatus.*

2.1 Probe—Stainless steel or Pyrex[1] 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—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 percent of the total sample volume.

2.8 Rotameter—To measure a flow range from 0 to 0.1 c.f.m.

2.9 Balance—Capable of measuring to the nearest 0.1 g.

2.10 Barometer—Sufficient to read to within 0.1 in. Hg.

2.11 Pilot 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 about 5 ml. distilled water in each impinger and weigh the impinger and contents to the nearest 0.1 g. 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 percent 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 not to exceed 0.075 c.f.m. 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 reading as required by Figure 4-2.

3.3 After collecting the sample, weigh the impingers and their contents again to the nearest 0.1 g.

---

[1] Trade name.

[2] If liquid droplets are present in the gas stream, assume the stream to be saturated, determine the average stack gas temperature (Method 1), and use a psychrometric chart to obtain an approximation of the moisture percentage.

4. *Calculations.*

4.1 Volume of water collected.

$$V_{wc} = \frac{(W_f - W_i)RT_{std}}{P_{std}M_w} = \left(0.0474 \frac{ft.^3}{g.}\right)(W_f - W_i) \quad \text{equation 4-1}$$

where:

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

W_f = Final weight of impingers and contents, g.

W_i = Initial weight of impingers and contents, g.

R = Ideal gas constant, 21.83-in. Hg—cu. ft./lb. mole-° R.

T_{std} = Absolute temperature at standard conditions, 530° R.

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

M_w = Molecular weight of water, 18 lb./lb. mole.

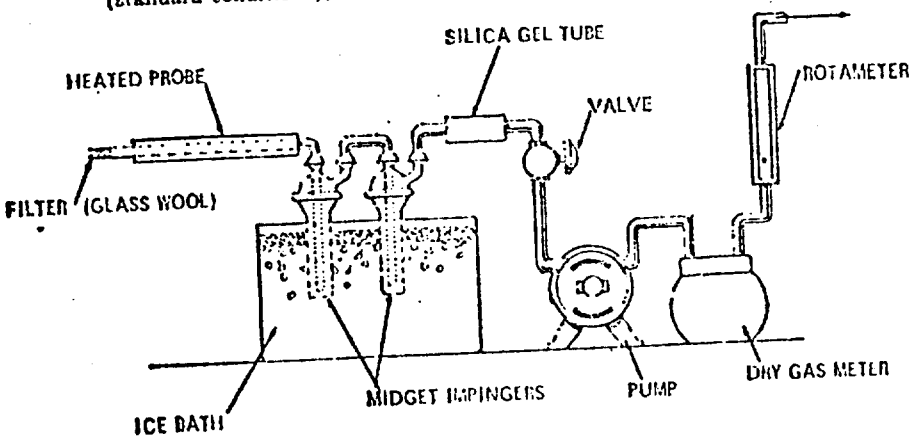

Figure 4-1. Moisture-sampling train.

LOCATION _____ COMMENTS

TEST _____

DATE _____

OPERATOR _____

BAROMETRIC PRESSURE _____

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

Figure 4-2. Field moisture determination.

4.2 Gas volume.

$$V_{mc} = V_m\left(\frac{P_m}{P_{std}}\right)\left(\frac{T_{std}}{T_m}\right) = \left(17.71 \frac{°R}{in.\ Hg}\right)\frac{V_m P_m}{T_m} \quad \text{equation 4-2}$$

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, in. Hg.

P_{std} = Pressure at standard conditions, 29.92-in. Hg.

T_{std} = Absolute temperature at standard conditions, 530° R.

T_m = Absolute temperature at meter (°F. + 460), °R.

4.3 Moisture content.

$$B_{wo} = \frac{V_{wc}}{V_{wc} + V_{mc}} + B_{wm} = \frac{V_{wc}}{V_{wc} + V_{mc}} + (0.025) \quad \text{equation 4-3}$$

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.

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, Calif. November 1963.

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

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® glass with a heating system capable of maintaining a gas temperature of 250° F. at the exit end during sampling. When temperature or length limitations are encountered, 316 stainless steel, or equivalent, may be used, as 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[1] glass with heating system capable of maintaining any temperature to a maximum of 225° F.

2.1.5 Impingers—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 ½-inch from the bottom of the flask. The second impinger is of the Greenburg-Smith design with the standard tip.

2.1.6 Metering system—Vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 5° F., dry gas meter with 2 percent accuracy, and related equipment, or equivalent, as required to maintain an isokinetic sampling rate and to determine sample volume.

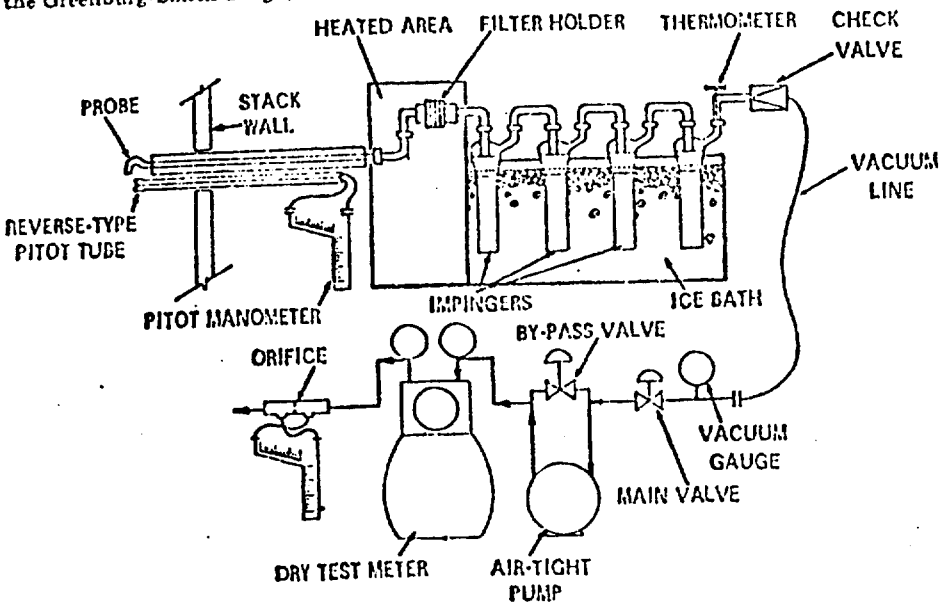

Figure 5-1. Particulate-sampling train.

2.1.7 Barometer—To measure atmospheric pressure to ±0.1 in. 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 ±0.1 mg.

2.3.4 Beakers—250 ml.

2.3.5 Separatory funnels—500 ml. and 1,000 ml.

2.3.6 Trip balance—300 g. capacity, to measure to ±0.05 g.

2.3.7 Graduated cylinder—25 ml.

3. *Reagents.*

3.1 Sampling

3.1.1 Filters—Glass fiber, MSA 1106 BH, or equivalent, numbered for identification and preweighed.

3.1.2 Silica gel—Indicating type, 6 to 16 mesh, dried at 175° C. (350° F.) for 2 hours.

3.1.3 Water—Deionized, distilled.

3.1.4 Crushed ice.

3.2 Sample recovery

3.2.1 Water—Deionized, distilled.

3.2.2 Acetone—Reagent grade.

3.3 Analysis

3.3.1 Water—Deionized, distilled.

3.3.2 Chloroform—Reagent grade.

3.3.3 Ethyl ether—Reagent grade.

3.3.4 Desiccant—Drierite,[2] 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[2] for at least 24 hours and weigh to the nearest 0.5 mg. in a room where the relative humidity is less than 50 percent. 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. Save a portion of the water for use as a blank in the sample analysis. Set up the train without the probe as in Figure 5-1. Leak check the sampling train at the sampling site by plugging 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 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 at 70° F. or less.

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. Maintain isokinetic sampling throughout the sampling period. Nomographs are available which aid in the rapid adjustment of the sampling rate without other computations. 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.

[1] Trade name.

[2] Dry using Drierite[1] at 70° ± 10° F.

PLANT_____
LOCATION_____
OPERATOR_____
DATE_____
RUN NO._____
SAMPLE BOX NO._____
METER BOX NO._____
METER $\Delta H_@$_____
C FACTOR_____

SCHEMATIC OF STACK CROSS SECTION

AMBIENT TEMPERATURE_____
BAROMETRIC PRESSURE_____
ASSUMED MOISTURE, %_____
HEATER BOX SETTING_____
PROBE LENGTH, in._____
NOZZLE DIAMETER, in._____
PROBE HEATER SETTING_____

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (P_s), in. Hg.	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s),	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH), in. H_2O	GAS SAMPLE VOLUME (V_m), ft^3	GAS SAMPLE TEMPERATURE AT DRY GAS METER		SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
							INLET ($T_{m\ in.}$), °F	OUTLET ($T_{m\ out}$), °F		
TOTAL							Avg.	Avg.		
AVERAGE							Avg.			

Figure 5-2. Particulate field data.

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 portions of the water and acetone used in the sample recovery as blanks for analysis. 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 loosen adhering particles.

Container No. 3. Measure the volume of water from the first three impingers and place the water in this container. Place water rinsings of all sample-exposed surfaces between the filter and fourth impinger in this container prior to sealing.

Container No. 4. 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.

Container No. 5. Thoroughly rinse all sample-exposed surfaces between the filter and fourth impinger with acetone, place the washings in this container, and seal.

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. Extract organic particulate from the impinger solution with three 25 ml. portions of chloroform. Complete the extraction with three 25 ml. portions of ethyl ether. Combine the ether and chloroform extracts, transfer to a tared beaker and evaporate at 70° F. until no solvent remains. Desiccate, dry to a constant weight, and report the results to the nearest 0.5 mg.

Container No. 4. Weigh the spent silica gel and report to the nearest gram.

PLANT_____

DATE_____

RUN NO._____

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED, mg		
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
1			
2			
3a*			
3b**			
5			
TOTAL			

*3a - ORGANIC EXTRACT FRACTION.
**3b - RESIDUAL WATER FRACTION.

	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.

Container No. 5. Transfer the acetone washings to a tared beaker and evaporate to dryness at ambient temperature and pressure. Desiccate, dry to a constant weight, and report the results to the nearest 0.5 mg.

5. *Calibration.*

Use standard methods and equipment approved by the Administrator to calibrate the orifice meter, pitot tube, dry gas meter, and probe heater.

6. *Calculations.*

6.1 Sample concentration method.

6.1.1 Average dry gas meter temperature. See data sheet (Figure 5-2).

6.1.2 Dry gas volume. Correct the sample volume measured by the dry gas meter to standard conditions (70° F., 29.92 in. Hg) by using Equation 5-1.

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

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

equation 5-1

where:

$V_{m_{std}}$ = 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_{std} = Absolute temperature at standard conditions, 530 °R.

T_m = Average dry gas meter temperature, °R.

P_{bar} = Barometric pressure at the orifice meter, in. Hg.

ΔH = Pressure drop across the orifice meter, in H_2O.

13.6 = Specific gravity of mercury.

P_{std} = Absolute pressure at standard conditions, 29.92 in. Hg.

6.1.3 Volume of Water vapor.

$$V_{w_{std}} = V_{l_c}\left(\frac{\rho_{H_2O}}{M_{H_2O}}\right)\left(\frac{RT_{std}}{P_{std}}\right) =$$

$$\left(0.0474\ \frac{\text{cu. ft.}}{\text{ml.}}\right)V_{l_c}$$

equation 5-2

where:

$V_{w_{std}}$ = Volume of water vapor in the gas sample (standard conditions), cu. ft.

V_{l_c} = Total volume of liquid collected in impingers and silica gel (see Figure 5-3), ml.

ρ_{H_2O} = Density of water, 1 g./ml.

M_{H_2O} = Molecular weight of water, 18 lb. lb. mole.

R = Ideal gas constant, 21.83 in Hg-cu. ft./lb. mole-°R.

T_{std} = Absolute temperature at standard conditions, 530° R.

P_{std} = Absolute pressure at standard conditions, 29.92 in. Hg.

6.1.4 Total gas volume.

$$V_{total} = V_{m_{std}} + V_{w_{std}} \quad \text{equation 5-3}$$

where:

V_{total} = Total volume of gas sample (standard conditions), cu. ft.

$V_{m_{std}}$ = Volume of gas through dry gas meter (standard conditions), cu. ft.

$V_{w_{std}}$ = Volume of water vapor in the gas sample (standard conditions), cu. ft.

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

6.1.6 Concentration.

$$c_s' = \left(0.0154\ \frac{\text{gr.}}{\text{mg.}}\right)\left(\frac{M_n}{V_{total}}\right)$$

equation 5-4

where:

c_s' = Concentration of particulate matter in stack gas (Sample Concentration Method), gr./s.c.f.

M_n = Total amount of particulate matter collected, mg.

V_{total} = Total volume of gas sample (standard conditions), cu. ft.

6.2 Ratio of area method.

6.2.1 Stack gas velocity. Collect the necessary data as detailed in Method 2. Correct the

stack gas velocity to standard conditions (29.92 in. Hg, 530° R) as follows:

$$V_{s,std} = V_s\left(\frac{P_s}{P_{std}}\right)\left(\frac{T_{std}}{T_s}\right) = \left(17.71\ \frac{°R}{in.\ Hg}\right)\left(\frac{V_s P_s}{T_s}\right) \quad \text{equation 5-5}$$

where:

$V_{s,std}$ = Stack gas velocity at standard conditions ft./sec.

V_s = Stack gas velocity calculated by Method 2, Equation 2-2, ft./sec.

P_s = Absolute stack gas pressure, in. Hg.

P_{std} = Absolute pressure at standard conditions, 29.92 in. Hg.

T_{std} = Absolute temperature at standard conditions, 530° R.

T_s = Absolute stack gas temperature (average), °R.

6.2.2 Concentration.

$$c_s = \frac{\frac{M_n}{\theta}}{Q_s} = \frac{\frac{M_n}{\theta}}{A_n V_{s,std}} = \left(2.67\times10^{-4}\ \frac{gr.-min.}{mg.-sec.}\right)\left(\frac{M_n}{\theta V_{s,std} A_n}\right) \quad \text{equation 5-6}$$

where:

c_s = Concentration of particulate matter in the stack gas (Ratio of Area Method), gr./s.c.f.

M_n = Particulate mass flow rate through the stack (standard conditions), mass/time.

Q_s = Volumetric flow rate of gas stream through the stack (standard conditions), volume/time.

M_n = Total amount of particulate matter collected by train, mg.

θ = Total sampling time, min.

A_s = Cross-sectional area of stack, sq. ft.

A_n = Cross-sectional area of nozzle, sq. ft.

$V_{s,std}$ = Stack gas velocity at standard conditions, ft./sec.

6.3 Isokinetic variation.

$$I = \frac{c'_s}{c_s}\times100 = \frac{T_s\left[\frac{V_{lc}\rho_w R}{M_{w,w}P_{std}} + \frac{V_m}{T_m}\left(P_{bar}+\frac{\Delta H}{13.6}\right)\right]}{\theta V_s P_s A_n}\times100 = \frac{\left(1.667\ \frac{min.}{sec.}\right)\left[\left(0.00267\ \frac{in.\ Hg\text{-}cu.\ ft.}{ml.-°R}\right)V_{lc}+\frac{V_m}{T_m}\left(P_{bar}+\frac{\Delta H}{13.6}\right)\right]T_s}{\theta V_s P_s A_n} \quad \text{equation 5-7}$$

where:

I = Percent of isokinetic sampling.

c_s = Concentration of particulate matter in the stack gas (Ratio of Area Method), gr./s.c.f.

c'_s = Concentration of particulate matter in the stack gas (Sample Concentration Method), gr./s.c.f.

V_{lc} = Total volume of liquid collected in impingers and silica gel (see Figure 5-6), ml.

ρ_w = Density of water, 1 g./ml.

R = Ideal gas constant, 21.83 in. Hg-cu. ft./lb. mole-°R.

$M_{w,w}$ = Molecular weight of water, 18 lb./lb. mole.

V_m = Volume of gas sample through the dry gas meter (meter conditions), cu. ft.

T_m = Absolute average dry gas meter temperature (see Figure 5-2), °R.

P_{bar} = Barometric pressure at sampling site, in Hg.

ΔH = Average pressure drop across the orifice (see Figure 5-2), in H_2O.

T_s = Absolute average stack gas temperature (see Figure 5-2), °R.

θ = Total sampling time, min.

V_s = Stack gas velocity calculated by Method 2, Equation 2-2, ft./sec.

P_s = Absolute stack gas pressure, in. Hg.

A_n = Cross-sectional area of nozzle, sq. ft.

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

If 92 percent ≤ I ≤ 120 percent, the results are acceptable; otherwise, reject the results and repeat the test.

6.5 Average particulate concentration. If the criteria for acceptability are met, calculate the average concentration of particulate in the stack from the following equation:

$$\bar{c}_s = \frac{\bar{c}_s + c'_s}{2} \qquad \text{Equation 5-8}$$

where:

$\bar{c}_s$ = Average particulate concentration in the stack gas, gr./s.c.f.

c_s = Concentration of particulate matter in the stack gas (Ratio of Area Method), gr./s.c.f.

c'_s = Concentration of particulate matter in the stack gas (Sample Concentration Method), gr./s.c.f.

7. *References.*

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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.

METHOD 6—DETERMINATION OF SULFUR DIOXIDE EMISSIONS FROM STATIONARY SOURCES

1. *Principle and applicability.*

1.1 Principle. A gas sample is extracted from the sampling point in the stack, and the acid mist including sulfur trioxide is separated from the sulfur dioxide. The sulfur dioxide fraction is measured by the barium-thorin titration method.

1.2 Applicability. This method is applicable for the determination of sulfur dioxide emissions from stationary sources only when specified by the test procedures for determining compliance with New Source Performance Standards.

2. *Apparatus.*

2.1 Sampling. See Figure 6-1

2.1.1 Probe—Pyrex[1] glass, approximately 5-6 mm. ID, with a heating system to prevent condensation and a filter to remove particulate matter including sulfuric acid mist.

2.1.2 Midget bubbler—One, with glass wool packed in top to prevent sulfuric acid mist carryover.

2.1.3 Glass wool.

2.1.4 Midget impingers—Three.

2.1.5 Drying tube—Packed with 6 to 16 mesh indicating-type silica gel, or equivalent, to dry the sample.

2.1.6 Pump—Leak-free, vacuum type.

2.1.7 Rate meter—Rotameter, or equivalent, to measure a 0-10 s.c.f.h. flow range.

2.1.8 Dry gas meter—Sufficiently accurate to measure the sample volume within 1 percent.

2.1.9 Pitot tube—Type S, or equivalent, necessary only if a sample traverse is required or if stack gas velocity varies with time.

2.2 Sample recovery.

2.2.1 Glass wash bottles—Two.

2.2.2 Polyethylene storage bottles—To store impinger samples.

2.3 Analysis.

[1] Trade name.

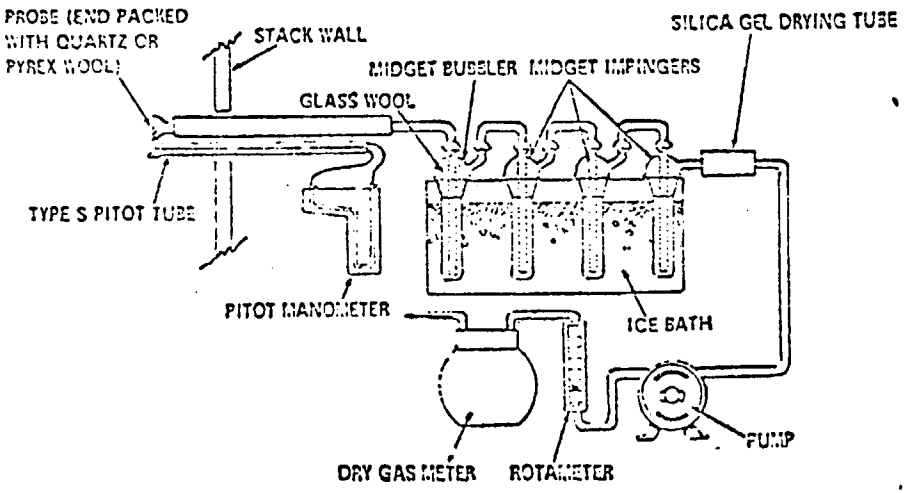


Figure 6-1. SO_2 sampling train.

2.3.1 Pipettes—Transfer type, 5 ml. and 10 ml. sizes (0.1 ml. divisions) and 25 ml. size (0.2 ml. divisions).

2.3.2 Volumetric flasks—50 ml., 100 ml., and 1,000 ml.

2.3.3 Burettes—5 ml. and 50 ml.

2.3.4 Erlenmeyer flask—125 ml.

3. *Reagents.*

3.1 Sampling.

3.1.1 Water—Deionized, distilled.

3.1.2 Isopropanol, 80 percent—Mix 80 ml. of isopropanol with 20 ml. of distilled water.

3.1.3 Hydrogen peroxide, 3 percent—dilute 100 ml. of 30 percent hydrogen peroxide with 900 ml. of distilled water. Prepare fresh daily.

3.2 Sample recovery.

3.2.1 Water—Deionized, distilled.

3.2.2 Isopropanol, 80 percent.

3.3 Analysis.

3.3.1 Water—Deionized, distilled.

3.3.2 Isopropanol.

3.3.3 Thorin indicator—1-(o-arsonophenylazo)-2-naphthol-3, 6-disulfonic acid, disodium salt (or equivalent). Dissolve 0.20 g. in 100 ml. distilled water.

3.3.4 Barium perchlorate (0.01*N*)—Dissolve 1.95 g. of barium perchlorate ($Ba(ClO_4)_2 \cdot 3H_2O$) in 200 ml. distilled water and dilute to 1 liter with isopropanol. Standardize with sulfuric acid.

3.3.5 Sulfuric acid standard (0.01*N*)—Purchase or standardize against a primary standard to ±0.0002*N*.

4. *Procedure.*

4.1 Sampling.

4.1.1 Preparation of collection train. Pour 15 ml. of 80 percent isopropanol into the midget bubbler and 15 ml. of 3 percent hydrogen peroxide to each of the first two midget impingers. Leave the final midget impinger dry. Assemble the train as shown in Figure 6-1. Leak check the sampling train at the sampling site by plugging the probe inlet and pulling a 10-in. Hg vacuum. A leakage rate not in excess of 1 percent of the sampling rate is acceptable. Carefully release the probe inlet plug and turn off the pump. Place crushed ice around the impingers. Add more ice during the run to keep the temperature of the gases leaving the last impinger at 70° F. or less.

4.1.2 Sample collection. Adjust the sample flow rate proportional to the stack gas velocity. Take readings at least every 5 minutes and when significant changes in stack conditions necessitate additional adjustments in flow rate. To begin sampling, position the nozzle with the tip pointing directly into the gas stream and start the pump. Sample proportionally throughout the run. At the conclusion of each run, turn off the pump and record the final readings. Remove the probe from the stack and disconnect it from the train. Drain the ice bath and purge the remaining part of the train by drawing clean ambient air through the system for 15 minutes.

4.2 Sample recovery. Disconnect the impingers after the purging period. Discard the contents of the midget bubbler. Pour the contents of the midget impingers into a polyethylene shipment bottle. Rinse the three midget impingers and the connecting tubes with distilled water and add these washings to the same storage container.

4.3 Sample analysis. Transfer the contents of the storage container to a 50-ml. volumetric flask. Dilute to the mark with deionized, distilled water. Pipette a 10 ml. aliquot of this solution to a 125-ml. erlenmyer flask. Add 40 ml. of isopropanol and 2 to 4 drops of thorin indicator. Titrate to a pink endpoint using 0.01*N* barium perchlorate. Run a blank with each series of samples.

5. *Calibration.*

5.1 Use standard methods and equipment approved by the Administrator to calibrate the orifice meter, pitot tube, dry gas meter, and probe heater.

5.2 Standardize the sulfuric acid with potassium acid phthalate as a primary standard. Standardize the barium perchlorate with 25 ml. of standard sulfuric acid containing 100 ml. of isopropanol.

6. *Calculations.*

6.1 Dry gas volume. Correct the sample volume measured by the dry gas meter to standard conditions (70° F. and 29.92 in. Hg) by using Equation 6-1.

$$V_{m_{std}} = V_m \left(\frac{T_{std}}{T_m}\right)\left(\frac{P_{bar}}{P_{std}}\right) = \left(17.71 \frac{^\circ R}{in.\ Hg}\right)\frac{V_m P_{bar}}{T_m} \quad \text{equation 6-1}$$

where:

$V_{m_{std}}$ = 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_{std} = Absolute temperature at standard conditions, 530° R.

T_m = Average dry gas meter temperature, °R.

P_{bar} = Barometric pressure at the orifice meter, in. Hg.

P_{std} = Absolute pressure at standard conditions, 29.92 in. Hg.

6.2 Sulfur dioxide concentration.

$$c_{SO_2} = \left(7.05 \times 10^{-2} \frac{lb.\text{-}mol.}{g.\text{-}mol.}\right)\frac{(V_t - V_{tb})(N)\left(\frac{V_{sol}}{V_a}\right)}{V_{m_{std}}} \quad \text{equation 6-2}$$

where:

c_{SO_2} = Concentration of sulfur dioxide at standard conditions, dry basis, lb./cu. ft.

7.05×10^{-2} = Conversion factor including the number of grams per gram equivalent of sulfur dioxide (32 g./g.-eq.), 453.6 (g./lb., and 1,000 ml./l. lb.-l./g.-ml.

V_t = Volume of barium perchlorate titrant used for the sample, ml.

V_{tb} = Volume of barium perchlorate titrant used for the blank, ml.

N = Normality of barium perchlorate titrant, g.-eq./l.

V_{sol} = Total solution volume of sulfur dioxide, ml.

V_a = Volume of sample aliquot titrated, ml.

$V_{m_{std}}$ = Volume of gas sample through the dry gas meter (standard conditions), see Equation 6-1, cu. ft.

7. *References.*

Atmospheric Emissions from Sulfuric Acid Manufacturing Processes. U.S. DHEW, PHS, Division of Air Pollution. Public Health Service Publication No. 999-AP-13. Cincinnati, Ohio. 1965.

Corbett, P. F. The Determination of SO_3 and SO_2 in Flue Gases. Journal of the Institute of Fuel. 24:237-243. 1961.

Matty, R. E. and E. K. Diehl. Measuring Flue-Gas SO_2 and SO_3. Power *101*:94-97. November 1957.

Patton, W. F. and J. A. Brink, Jr. New Equipment and Techniques for Sampling Chemical Process Gases. Paper presented at the 55th Annual Meeting of APCA. Chicago, Ill. May 20-24, 1962.

METHOD 7—DETERMINATION OF NITROGEN OXIDE EMISSIONS FROM STATIONARY SOURCES

1. *Principle and applicability.*

1.1 Principle. A grab sample is collected in an evacuated flask containing a dilute sulfuric acid-hydrogen peroxide absorbing solution, and the nitrogen oxides, except nitrous oxide, are measured colorimetrically using the phenoldisulfonic acid (PDS) procedure.

1.2 Applicability. This method is applicable for the measurement of nitrogen oxides from stationary sources only when specified by the test procedures for determining compliance with New Source Performance Standards.

2. *Apparatus.*

2.1 Sampling. See Figure 7-1.

2.1.1 Probe—Pyrex[1] glass, heated, with filter to remove particulate matter. Heating is unnecessary if the probe remains dry during the purging period.

2.1.2 Collection flask—Two liter, Pyrex[1] round bottom with short neck and 24/40 standard taper opening, protected against implosion or breakage.

2.1.3 Flask valve—T-bore stopcock connected to a 24/40 standard taper joint.

2.1.4 Temperature gauge—Dial-type thermometer, or equivalent, capable of measuring 2° F. intervals from 25° to 125° F.

2.1.5 Vacuum line—Tubing capable of withstanding a vacuum of 3-in. Hg absolute pressure, with "T" connection and T-bore stopcock, or equivalent.

2.1.6 Pressure gauge—U-tube manometer, 36 inches, with 0.1 inch divisions, or equivalent.

2.1.7 Pump—Capable of producing a vacuum of 3-in. Hg absolute pressure.

2.1.8 Squeeze bulb—One way.

2.2 Sample recovery.

2.2.1 Pipette or dropper.

2.2.2 Glass storage containers—Cushioned for shipping.

[1] Trade name.

APPENDIX E

LABORATORY REPORT

APPENDIX E

LABORATORY REPORT

BACK HALF IMPINGER WATER RESIDUE PHASE
ANALYSIS BY WET CHEMISTRY

Plant General Battery Corporation, Reading, Pa.

Date December 16, 1971

Run 3

	Organic, mg	Inorganic, mg	Total, mg
Split Residue Mass Before Analysis	15.5	101.4	116.9
Constitutent Mass per Split Residue			
SO_3	0.4	0.8	1.2
SO_4	1.07	62.1	63.17
Total Sample Residue Mass	31.0	202.8	233.8
Constituent Mass per Total Residue			
SO_3	0.8	1.6	2.4
SO_4	2.14	124.2	126.34

Plant General Battery Corporation, Reading, Pa.

Date December 15 and 16, 1971

FRONT HALF LABORATORY REPORT
ANALYSIS BY ATOMIC ABSORPTION

Run	Probe Acetone Wash Residue, μg(a)	Pb, μg, per Residue, μg	Pb, μg, per Total Residue	Filter Catch, μg	Pb, μg, per Split Filter Sample, μg	Pb, μg per Total Filter Catch
1	37,000	0.0095	350	8,800	0.032	280
2	17,100	0.0040	68	6,000	0.108	650
3	72,200	0.0028	203	9,800	0.092	900

(a) Acetone blank subtracted; Acetone blank = 0.028 mg/ml.

Note: See analysis flow chart for procedure (E-8).

BACK HALF IMPINGER WATER LIQUID PHASE
ANALYSIS BY WET CHEMISTRY

Plant General Battery Corporation, Reading, Pa.

Date December 15, 1971

Run No. 1

Total Sample Volume - 500 ml

Split Sample Volume Analyzed - 250 ml

Constitutent	µg/ml	mg per Split Sample Volume	mg per Total Sample Volume
Total Acid	12	3.0	6.0
$SO_3^=$	300	75.0	150.0
$SO_4^=$	50	12.5	25.0
Cl^-	2	0.5	1.0
NH_4^+	6	1.5	3.0
NO_3	--	---	---
pH(a)	2.2	2.2	2.2

(a) Value is pH units.

BACK HALF IMPINGER WATER LIQUID PHASE
ANALYSIS BY WET CHEMISTRY

Plant General Battery, Reading, Pa.

Date December 16, 1972

Run No. 3

Total Sample Volume - 409 ml

Split Sample Volume Analyzed - 205 ml

Constituent	µg/ml	mg Split Sample Volume	mg Total Sample Volume
$SO_3^=$	49.6	10.17	2 .4
$SO_4^=$	16.5	3.4	8
Cl^-	3.4	0.7	1 .4
NH_4^+	71.7	14.7	29 .4
NO_3	43.9	< 9	< 20
pH(a)	2.9	2.9	2.

(a) Value is pH units.

BACK HALF IMPINGER WATER RESIDUE PHASE
ANALYSIS BY WET CHEMISTRY

Plant General Battery Corporation, Reading, Pa.

Date December 15, 1971

Run No. 1

	Organic, mg	Inorganic, mg	Total, mg
Split Residue Mass Before Analysis	18.6	76.1	94.7
Constituent Mass per Split Residue			
SO_3	< 0.3	< 0.3	< 0.6
SO_4	0.6	12.5	13.1
Total Sample Residue Mass	37.2	152.2	189.4
Constituent Mass per Total Residue			
SO_3	0.6	0.6	1.2
SO_4	1.2	26.0	27.2

LABORATORY REPORT

OPTICAL EMISSION SPECTROSCOPY TRACE METALS
(μg element per total sample)

Total Sample Volume, Run 1 - 500
Run 3 - 409

Split Sample Volume Analyzed, Run 1 - 250
Run 3 - 205

Element	Impinger Water	
	Run 1	Run 3
Hg(a)	< 0.5	< 0.2
Be	< 0.5	< 0.2
Cd	< 25.	< 20.
As	< 25.	< 20.
V	< 5.	< 2.
Mn	< 1.5	< 2.
Ni	< 15.	< 2.
Sb	< 25.	< 10.
Cr	< 15.	< 2.
Zn	< 50.	< 20.
Cu	2.5	2.
Pb	25.	< 10.
Se(b)	--	--
B	5.	6.
F(b)	--	--
Li	< 50.	< 20.
Ag	0.5	< 0.2
Sn	25.	20.
Fe	50.	8.
Sr	< 15.	< 10.
Na	< 50.	< 20.
K	150.	< 20.
Ca	150.	40.
Si	50.	40.
Mg	25.	4.
Co	< 15.	--
Ba	< 5.	< 2.
Al	15.	< 6.
Total Mass, μg	189,400	233,800

(a) Sample dried and ignited at 450 C prior to analysis; Hg values are not considered significant.

(b) Not detectable by OES. absorption.

LABORATORY REPORT

Plant General Battery Corporation, Reading, Pa.

Date December 15 and 16, 1971

OPTICAL EMISSION SPECTROSCOPY TRACE METAL
(μg of element per total sample)

Element	Probe Residue			Filter			
	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	Blank
Hg(a)	--	--	--	--	--	--	< 1.
Be	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
Cd	< 10.	< 10.	< 10.	< 20.	< 20.	< 20.	< 20.
As	< 20.	< 20.	< 20.	< 40.	< 40.	< 40.	< 40.
V	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.	< 1.
Mn	10.	10.	20.	2.	2.	2.	2.
Ni	150.	100.	300.	< 20.	< 20.	< 20.	< 20.
Sb	< 10.	< 10.	< 10.	< 20.	< 20.	< 20.	< 20.
Cr	100.	200.	500.	< 20.	< 20.	< 20.	< 20.
Zn	100.	< 100.	100.	< 200.	< 200.	< 200.	< 200.
Cu	20.	5.	10.	2.	2.	2.	2.
Pb(b)	--	--	--	--	--	--	--
Se(c)	--	--	--	--	--	--	--
B	5.	1.	10.	0.	0.	0.	4,000.
F(c)	---	--	--	--	--	--	--
Li(d)	---	--	--	--	--	--	--
Ag	3.	< 1.	3.	< 2.	2.	2.	< 2.
Sn	100.	100.	150.	40.	40.	40.	40.
Fe	500.	500.	1,000.	0.	0.	0.	100.
Sr	2.	< 1.	3.	6.	6.	15.	5.
Na	300.	200.	300.	2,000.	6,000.	10,000.	2,000.
K	< 500.	< 500.	< 500.	9,000.	0.	0.	1,000.
Ca	10,000.	2,000.	8,000.	0.	2,000.	10,000.	10,000.
Si	50.	50.	50.	Major	Major	Major	Major
Mg	150.	100.	300.	0.	0.	1,000.	4,000.
Ba	50.	20.	50.	0.	0.	100.	100.
Al	30.	30.	4,000.	0.	0.	0.	4,000.
Total Weight, μg	37,000(e)	17,100(e)	72,200(e)	8,800	6,000	9,800	

(a) Not determined.
(b) Pb determined by Atomic Absorption.
(c) Not determined by this technique.
(d) Not determined - added buffer element.
(e) Acetone blank subtracted.

NOTE: Symbol < indicates minimal detection limits.

Plant General Battery Corporation, Reading, Pa.

EXAMPLE LEAD DETERMINATION
FILTER, RUN 3

A - Initial Extract Volume per Split, Filter Sample, ml	4.5
B - Aliquot, ml	1.0
C - Dilution Factor	10
D - Absorption, Percent	30
E - Absorbance from Atomic Absorbance Tables, Based on Percent Absorption	0.1549
F - Lead, µg/ml of Diluted Aliquot(a)	10
G - Lead, µg/Split Filter Sample	450
H - Lead, µg/Total Filter	900

Example Computation

C x A x F = G

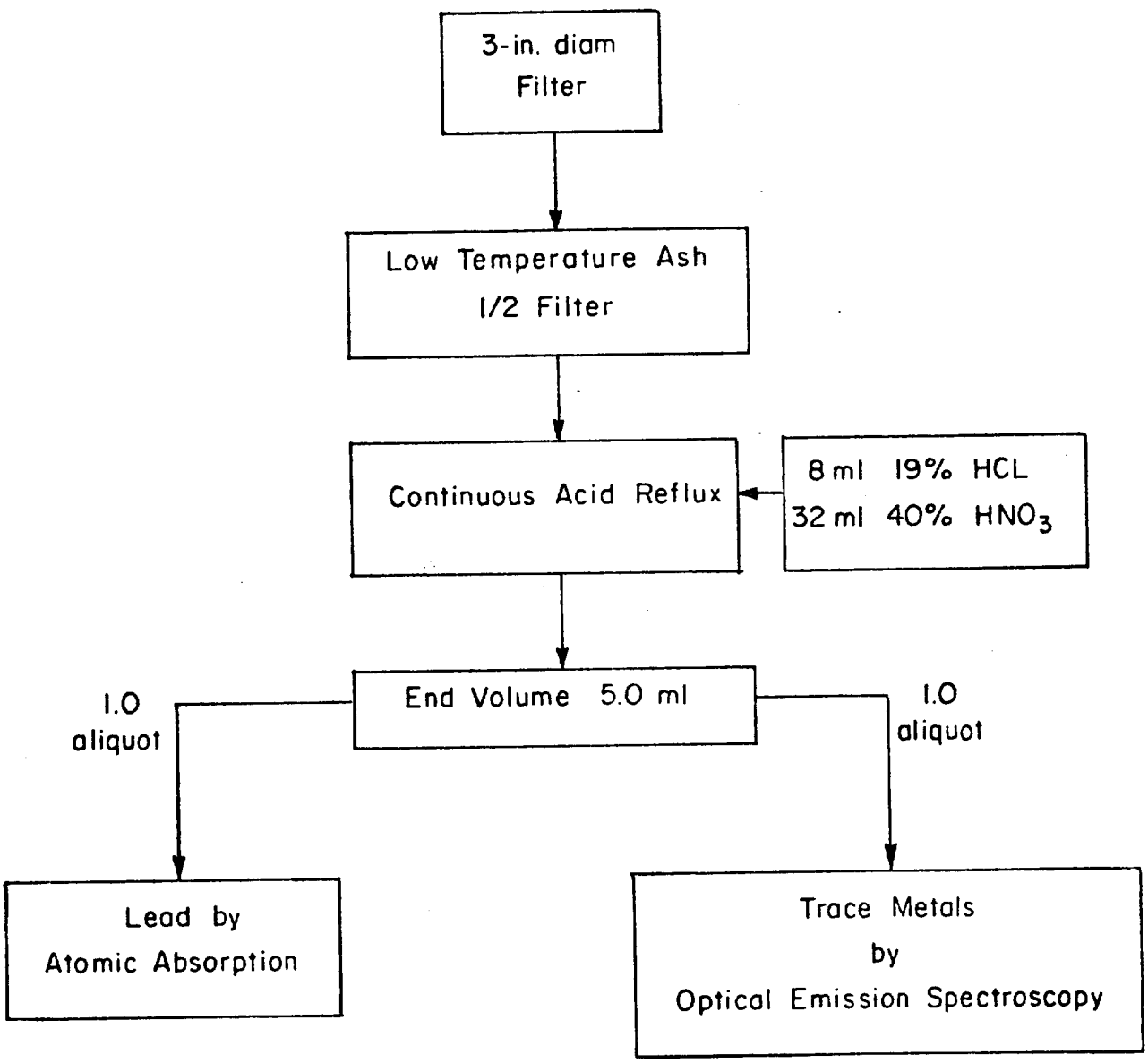
10 x 4.5 x 10 = 450

2 x G = H

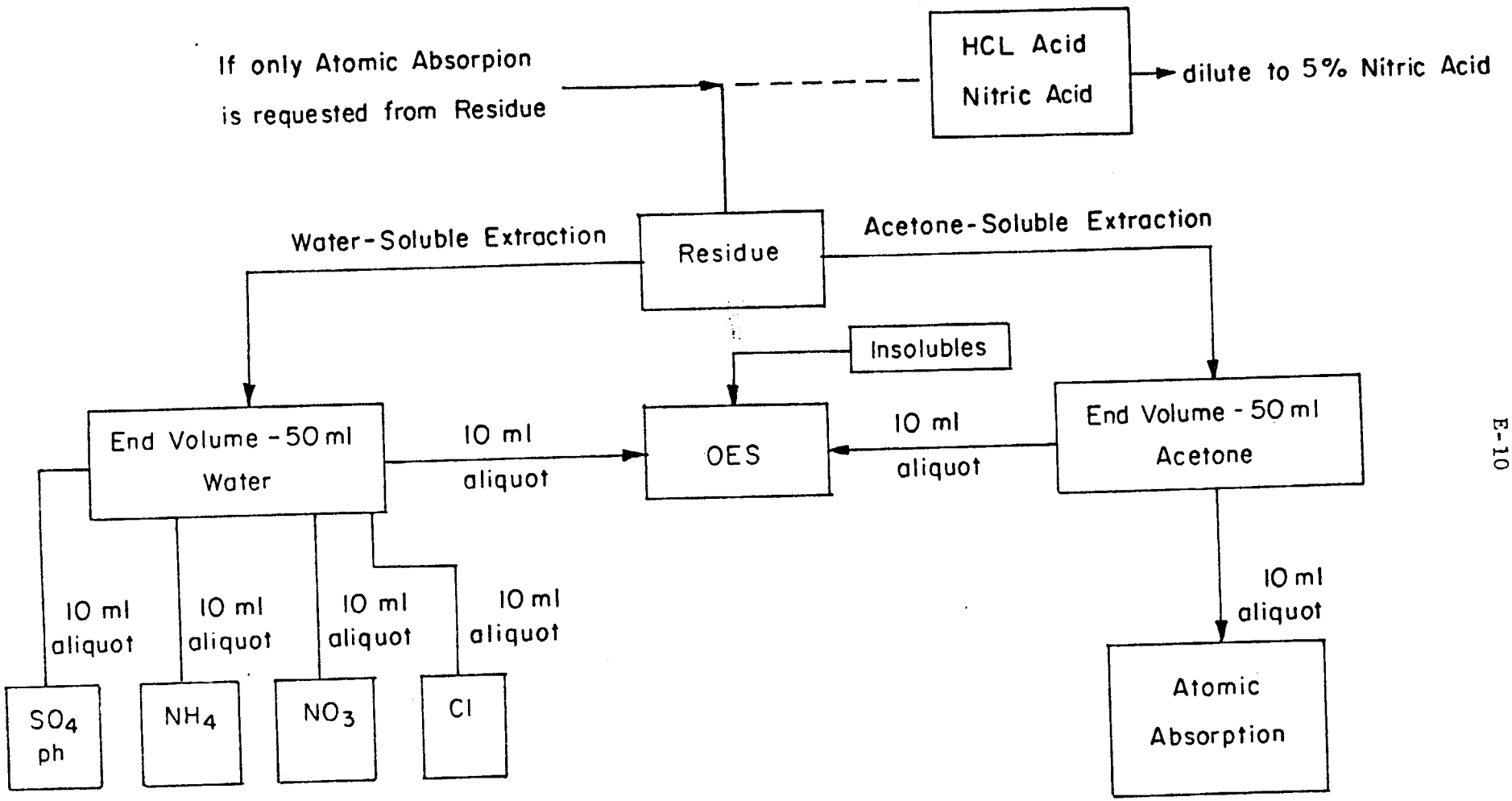
2 x 450 = 900

(a) Determined from calibration curve; based on 0.1549 absorbance.

FILTER ANALYSIS FLOW DIAGRAM



RESIDUE ANALYSIS FLOW DIAGRAM



CHEMICAL METHODS USED TO ANALYZE EPA RESIDUES

Discussion of Methods

The methods used for the chemical analysis of residues were chosen because they represent reliable procedures used almost routinely in our laboratory. Because of this no preliminary testing nor experimentation were required before the analytical work was begun and results could be obtained in the short time allowed. No claim is made that these methods represent the best analytical scheme for this work if measurements of less than 1 milligram is necessary. However, it is capable of determining the occasional high sulfate found in some samples without repeating the determination as would be necessary when using some methods.

Preparation of EPA Residue Samples

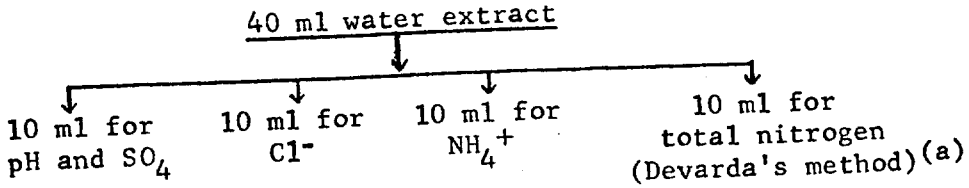
(1) Obtain "water-soluble extract" by extracting residue in beaker with warm water. Adjust volume to 50 ml in a volumetric flask. Remaining materials are "water insoluble" residues.

(2) Obtain "acetone-soluble extract" by extracting "water insoluble" residue in beaker with acetone. Remaining materials are "acetone insoluble" residues. Police beaker thoroughly, making sure that all material is removed, even though insoluble. Adjust volume to 50 ml in a volumetric flask.

(3) Transfer 10 ml of the "water-soluble extract" to crucible for OES. Add 10 ml of the corresponding "acetone-soluble extract" to the 10 ml of "water-soluble extract", being sure to shake the flask well before sampling to assure a representative portion of suspended matter is included. Dry combined extracts and proceed with OES.

(4) Remove 25 ml of the remainder of the acetone-soluble extract", filter on Millipore filter, if necessary, and transfer to tared aluminum dish. Dry down at ~100 C. Reweigh vessel and record weight as "acetone-soluble". Multiply result by 2 to convert to original sample.

(5) Proceed with chemical analysis of the "water-soluble extract" as follows:



(a) NO_3^- will be calculated from the difference between total nitrogen and NH_4^+

Note: "Dry pipetting" (no rinsing of pipette) must be practiced to conserve sample.

(6) "Water Insoluble Residue" may be obtained in the following manner, if needed. Wash the remaining 15 ml of acetone-soluble extract into the same dish used in Step (4). Dry down at ~100 C. Reweigh and record weight as "water insoluble, acetone soluble". Multiply by 5/4 to convert to original sample. (If a filtration step was included in Step (4) weigh the filter pad, air dry after filtration is complete, reweigh to obtain weight of retained residue, and add to "water insoluble, acetone soluble" total before multiplying 5/4).

(7) Wash the suspended matter remaining in the 50 ml volumetric flask after acetone extraction into a tared aluminum dish. Dry down at ~100 C. Reweigh and record weight as "water insoluble, acetone insoluble". Total "water insoluble" may be obtained by adding "water insoluble, acetone insoluble" and "water insoluble, acetone insoluble" results.

Preparation of EPA Filter Samples

Filters may be prepared for chemical analysis as follows:

(1) Remove 1/2 of the filter and carefully cut it up into small pieces. Place the pieces in a 50-ml beaker, add 10 ml of deionized water, and stir with a clean glass stirring rod. Allow to stand an hour, stirring occasionally.

(2) Measure the pH of the solution using the small electrode assembly.

(3) Filter the slurry into a 50 ml volumetric flask. Wash the retained filter material with small increments of deionized water until the 50 ml volume is reached.

(4) Stop the volumetric flask, mix well, and proceed with the chemical determinations as described for the residue samples.

(5) Multiply all results by 4 to obtain the amounts of SO_4, Cl, NH_4, and NO_3 on the entire filter circle.

Analysis for Sulfate ($SO_4^=$)(a)

(The 10 ml of water-soluble portion of the residue has been transferred to a 50-ml volumetric flask, diluted to the mark and mixed).

(1) Add 4 ml of 1:1 HCl to the solution, heat to a boil, and continue boiling for about 5 minutes.

(2) Cool slightly and transfer to a 250-ml beaker, rinsing out the 50-ml beaker well with deionized water.

(3) Heat to near boiling temperatue, add 10 ml of 10 percent $BaCl_2$ solution, stir well, and digest at near boiling temperature for an hour.

(4) Remove from the hot-plate and cool to room temperature. Allow the solution to stand at room temperature at least 2 hours - preferably overnight.

(5) Filter off the precipitated $BaSO_4$ through a tight filter paper (Whatman No. 42 or equivalent). Wash the paper and precipitate with hot deionized water until the washings are free of chloride.

(6) Place the paper and precipitate in a crucible, dry under a gas hot-plate, and then heat in a muffle furnace for at least an hour at a temperature of 900 C.

(7) Remove the crucibles from the muffle furnace, cool in a desiccator, and weigh as $BaSO_4$. Calculate SO_4 by multiplying by the factor 0.4116. Multiply this result by 5 to get total amount of $SO_4^=$ in the residue.

(a) For residue analysis, this determination is made on the 10 ml aliquot used for pH measurement; Step (5)-Preparation of EPA Residue Samples.

For filter analysis, 10 ml of the 50 ml volume, Step (3)-Preparation of EPA Filter Samples, is used for this determination.

APPENDIX F

TEST LOG

APPENDIX F

TEST LOG

December 13, 1971	Arrive on test site.
December 14, 1971	Set up test equipment, make preliminary surverys, SO_2 - Run 1.
December 15, 1971	Scrubber inoperative on arrival at plant. Onstream at about 10:00 a.m., Particulate-Run 1, SO_2-Runs 2 and 3, Orsat-Run 1.
December 16, 1971	Particulate-Runs 2 and 3, Orsat-Runs 2 and 3, SO_2-Runs 4 and 5.
December 17, 1971	Prepare to sample reverberatory furnace effluent. However, it appears furnace will not be onstream today. Pack equipment and leave test site.

APPENDIX G

RELATED REPORTS

APPENDIX G

RELATED REPORTS

(1) RESEARCH REPORT ON SECONDARY LEAD PLANT STACK EMISSION SAMPLING AT N. L. INDUSTRIES PLANT, BEECH GROVE, INDIANA

(2) RESEARCH REPORT ON SECONDARY LEAD PLANT STACK EMISSION SAMPLING AT N.L. INDUSTRIES PLANT, McCOOK, ILLINOIS

(3) RESEARCH REPORT ON SECONDARY LEAD PLANT STACK EMISSION SAMPLING AT QUEMETCO LEAD COMPANY, INDUSTRY, CALIFORNIA

(4) RESEARCH REPORT ON SECONDARY LEAD PLANT STACK EMISSION SAMPLING AT REVERE SMELTING AND REFINING PLANT, NEWARK, NEW JERSEY

APPENDIX H

PROJECT PARTICIPANTS AND TITLES

APPENDIX H

PROJECT PARTICIPANTS AND TITLES

Technical Supervision

Richard B. Engdahl, Senior Project Leader

Field Team

Paul R. Webb, Senior Technologist (Team Leader)

Herbert E. Carlton, P.E., Research Chemical Engineer

Bernard E. Campbell, Physicist

William C. Baytos, Scientist

Harold Hess, Technician

Administrative Support

Richard E. Barrett, Senior Mechanical Engineer

John M. Allen, Division Chief

Irene Whitener, Secretary

APPENDIX I

OPERATIONAL SCHEDULE

APPENDIX I

OPERATIONAL SCHEDULE

BLAST FURNACE CHARGING FORMULA

Furnace 1

Scoop

1 - 500 lb coke
- 200 lb Fe
- 300 lb rerun slag
- 150 lb limestone
- 3 plastic batteries

2 - 1500 lb battery plates

3 - 1500 lb battery plates

4 - 1500 lb battery plates

5 - 1500 lb battery plates

Repeat

Furnace 2

Start to 3:00 p.m. (12/16/71)

Scoop

1 - 180 lb coke
- 400 lb high antimony dross
- 200 lb reverb slag
- 120 lb iron
- 160 lb antimony ore
- 100 lb limestone
- 5 plastic batteries
- 60 lb rerun slag

2 - 1500 lb battery plates
- 100 lb flue dust

Repeat

3:00 p.m. to Finish

1 - 1500 lb battery plates
- 5 plastic batteries
- 100 lb flue dust

2 - 190 lb coke
- 1000 lb dross
- 80 lb limestone
- 100 lb rerun slag
- 120 lb iron

Repeat

APPENDIX J

COMPLETE OPERATIONAL RESULTS

COMPLETE OPERATIONAL RESULTS

Run No.	1	2	3	1	2	3
Start Time[a]	9:30 am	7:40 am	2:00 pm	9:30 am	7:40 am	2:00 pm
End Time	3:30 pm	12:20 pm	5:45 pm	3:30 pm	12:20 pm	5:30 pm
Furnace No.	1	1	1	2	2	2
Materials fed, lb						
Scrap lead	0	5800	0	0	0	0
Battery plates	31500	24000	15000	15000	13500	9000
Coke	2500	2500	1500	2000	1620	930
Iron	1000	1000	600	1200	1080	600
Rerun slag	1500	1500	900	600	540	420
Reverb slag	0	0	0	2000	1800	400
Limestone	750	750	450	1000	900	440
Antimony Ore	0	0	0	1600	1440	320
Antimony dross	0	0	0	4000	3600	3800
Flue dust	0	0	0	1000	900	600
Materials tapped, lb						
Lead	27360	28100	18140[b]	23000	16100	14800[c]
Slag	6000	6000	6000	6000	6000	6000
Lead Production rate, lb/hr	4600	5600	3500[b]	3800	3250	3500[c]

(a) Time does not match exactly with particulate sampling
(b) Time - 12:20 - 5:30 pm.
(c) Time - 1:35 - 5:30 pm.

OPERATIONAL NOTES

Plant General Battery Corporation

Furnace 1 is being used to make a 3 percent antimony lead. The charging cycle is

Scoop 1	500 lb coke
	200 lb scrap iron
	300 lb rerun slag
	150 lb limestone
	3 plastic batteries
Scoop 2	1500 lb battery plates
Scoop 3	1500 lb battery plates
Scoop 4	1500 lb battery plates
Scoop 5	1500 lb battery plates

Slag tap not weighed, about 2000 lb.

Observations

Date 12/15/71

7:30 am	Furance tapped into kettle 4 6,850 lb lead in kettle - 69 in. reading Exhaust temperature 430 F Blast flow reading, 6 oz.
9:30 am	58 in. reading - 20,510 lb lead in kettle
9:45 am	Load B-plates
10:24 am	Load coke
10:30 am	Tap slag
10:40 am	Load B-plates
10:49 am	Load B-plates
10:55 am	Load slag and coke
10:55 am	Load slag and coke
11:15 am	Load B-plates
11:42 am	Load B-plates

Observations

12/15/71 (Cont'd)

11:42 am	Load B-plates
11:45 am	Load B-plates
12:05 pm	Load coke and slag
12:35 pm	Load B plates
12:45 pm	Tap slag
12:55 pm	Load B-plates
1:10 pm	Load B-plates
1:22 pm	Load coke and slag
1:30 pm	Load B-plates
1:30 to 2:30 pm	Furnace not observed
2:30 pm	Lead levels, 45.5 in. = 42,850 lb
3:00 pm	Load B-plates
3:10 pm	Load B-plates
3:20 pm	Load B-plates
3:30 pm	Load B-plates Lead level, 43 in. = 47,870 lb Lead rate, 27,360 lb in 6 hr or 4,600 lb/hr B-plate loaded, 31,300 lb in 6 hr Coke loaded Slag tapped, 6000 lb if slag tapped between 1:30 and 2:30

12/16/71

7:20 am	Outlet temperature, 600 F
7:40 am	Lead level kettle 4, 18 in. = 101,720 lb
8:15 am	Load coke
8:27 am	Load B-plates
8:35 am	Load B-plates
8:42 am	Load B plates
8:47 am	Load coke
8:48 am	Load scrap metallic lead from battery plant, 2,800 lb estimated
9:15 am	Load B-plates
9:20 am	Tap slag
9:25 am	Load slag and acrap iron
9:30 am	Load coke
10:10 am	Load B-plates

Observations

12/16/71 (Cont'd)

10:12 am	Load metallic lead scrap, 3000 lb (at other plants visited this scrap would have been melted in kettles)
10:25 am	Load B-plates
10:40 am	Tap slag
10:45 am	Load B-plates
11:10 am	Load B-plates
11:25 am	Load slag and iron
11:35 am	Load coke (Furnace operator loaded scoop No. 1 in two batches rather than the one listed in recipe)
11:30 am	10 in. lead in kettle, 118,950 lb
11:40 am	Tap slag
11:50 am	Load B-plates
12:00 pm	Load B-plates
12:10 pm	Load coke
12:20 pm	5-1/2 inches lead in kettle, 129,820 lb or 5,600 lb/hr 123,000 lb production in 29 hours of 4,250 lb/hr The high rate during Run 2 is due to loading metallic lead at 8:48 and 10:12
12:20 pm	Switch kettles. 70.5 in. or 4,500 lb loading operation not closely observed 12:20-2:00 pm
2:20 pm	Tap slag
2:30 pm	Load B-plates
3:00 pm	Load B-plates
3:20 pm	Load B-plates
3:35 pm	Load B-plates
3:45 pm	Load slag
4:10 pm	Load coke
4:30 pm	Load B-plates
5:00 pm	Load B-plates
5:10 pm	Tap slag
5:15 pm	Load slag
5:25 pm	Load coke
5:20 pm	56 in. lead in kettle, 23,740 lb
5:40 pm	Load B-plates
5:45 pm	Load B-plates. The level of material in the furnace was lowered during Run 3 in anticipation of shutting down furnace

Observations

12/16/71 (Cont'd)

5:45 am Production rate 18,140 lb in 5 hr 10 min - 3,500 lb/hr
The lower rate is probably due to lowering material level in furnace

Furnace 2 is producing 6 percent antimony lead.

Loading recipe:

Scoop 1	180 lb coke
	400 lb high antimony dross
	200 lb reverb slag
	120 lb scrap iron
	160 lb antimonty ore
	100 lb limestone
	5 plastic batteries
	60 lb blast furnace slag
Scoop 2	1500 lb battery plates
	100 lb flue dust

12/15/71

7:30 am	Exhaust gas temperature, 270 F Blast pressure, 6 oz.
8:10 am	Tap slag
9:30 am	Kettle level 59 in., 18,900 lb
9:46 am	Load Scoop 2
10:13 am	Tap slag
10:22 am	Load Scoop 1
10:35 am	Load Scoop 2
10:47 am	Load Scoop 1
11:10 am	Load Scoop 2
11:22 am	Load Scoop 1
11:30 am	Load Scoop 2
11:50 am	Tap slag
11:59 am	Load Scoop 1
12:08 am	Load Scoop 2
12:17 am	Load Scoop 1

Observations

12/15/71 (Cont'd)

12:33 am	Load Scoop 2
12:40 am	Load Scoop 1
1:15 am	Load Scoop 2
1:23 am	Tap slag
1:35 am	Load Scoop 1
1:35 to 2:30 pm	Furnace not observed
2:30 pm	Load Scoop 2
2:45 pm	Load Scoop 1
3:00 pm	Load extra coke
3:15 pm	Load Scoop 2
3:30 pm	Load Scoop 1 Load level 46 in., 41,850 lb 23,000 lb lead in 6 hours or 3,800 lb/hr

12/16/71

7:40 am	Lead level 23-1/2 in = 89,900 lb
7:50 am	Tap slag
8:15 am	Load slag and limestone (part of Scoop 1)
8:30 am	Load coke and slag (rest of Scoop 1)
8:42 am	Load Scoop 2
8:55 am	Load Scoop 1
9:10 am	Load Scoop 2
9:20 am	Load Scoop 1
9:30 am	Load Scoop 2 Tap slag
9:40 am	Load Scoop 1
9:55 am	Load Scoop 2
10:10 am	Load Scoop 1
10:15 am	Load Scoop 2
10:35 am	Load Scoop 1
10:50 am	Load Scoop 2
11:00 am	Load Scoop 1
11:10 am	Load Scoop 2
11:15 am	Load Scoop 1

Observations

12/16/71 (Cont'd)

11:25 am	Load Scoop 2 Tap slag
11:40 am	Load Scoop 1 Lead level, 17 in., 103,870 lb.
12:05 pm	Load Scoop 2
12:20 pm	Lead level, 16 in., 106,020 lb. 16,100 lb in 4 hr, 40 min 4,150 lb/hr 87,100 lb in 26 hr, 50 min 3,250 lb/hr
12:20 pm	Furnace not carefully watched until 2:00
12:45 pm	Tap slag
1:35 pm	Lead level 14 in., 110,330 lb Switch kettles Lead level 71 in., 5,000 lb
2:00 pm	Tap slag
2:25 pm	Load Scoop 1
2:35 pm	Load Scoop 2 Load Scoop 1
3:00 pm	Load Scoop 2 Change loading recipe Scoop 1 - 1500 lb battery plates 5 plastic batteries 100 lb flue dust Scoop 2 - 120 lb iron 190 lb coke 1000 lb dross 80 lb limestone 100 lb slag
3:15 pm	Load Scoop 1
3:20 pm	Tap slag
3:30 pm	Load Scoop 2
3:45 pm	Load Scoop 1
3:55 pm	Load coke and scrap iron (part Sccop 2)
4:15 pm	Load dross (rest Scoop 2)
4:30 pm	Load plastic batteries (extra)
4:35 pm	Load coke and scrap iron (part Scoop 2)
5:00 pm	Tap slag
5:10 pm	Load Scoop 1
5:15 pm	Load Scoop 2

Observations

12/16/71 (Cont'd)

5:30 pm 58.5 in. lead, 19,800 lb lead

5:45 pm Load Scoop 1
14,800 lbs lead produced in 4 hr, 10 min, or 2,500 lb/hr

Miscellaneous Notes

Management estimates baghouse dust at 9,000 lb per day for 80 tons of lead produced.

12/15/71

7:30 am Afterburner controlled at 1400 F
U-tube inlet - 800 F
U-tube outlet - 300 F
Scrubber pH - 11
Pressure baghouse inlet, 20 in., H_2O positive
Pressure, fan inlet - 8 in. negative
Scrubber water flow estimated by management at 500 ghm
Pulley sheaves on water pump
7.2 in. on motor
15.4 in. on pump
Changed at 1:45 pm to 7.5 in. on motor
12.7 in. on pump to increase water flow
Pump drive motor rated at 1760 rpm

12:15 pm pH meter on scrubber , water-off scale acid

12:40 pm pH - 6.5

1:35 pm pH - 10

1:45 pm Scrubber water pump off

2:30 pm Pump on

Evening - 15.6 in. H_2O pressure Venturi inlet. Exterior of sampling probe is covered with scale.

Operators changed adjustments on scrubber water all day.

12/16/71

7:20 am Scrubber water pH meter read 6
Afterburner temperature controlled at 1400 F
Baghouse fan inlet pressure, 8 in., negative
Baghouse fan outlet pressure, 20 in., positive
U-tubes inlet temperature, 750-800 F
U-tubes outlet temperature, 33 F
Water level in slurry tank is low and tank is being filled with lime slurry

Observations

Miscellaneous Notes (cont"d)

12/16/71 (Cont'd)

7:45 am pH meter reads 11

9:25 am pH meter reads 7
6 in. negative pressure measured at Venturi throat
1/2 in. positive pressure measured at inlet to mist separator
Afterburner off due to malfunction - 9:15 to 9:55, 10:10 to 10:30, 5:15 to 4:30

2:45 pm Afterburner tamperature, 1400 F

12/17/71

Blast furnace, 40 in. ID x 10 ft, maximum charge height
Afterburner manufactured by North American Furnace Company
U-tube coolers consist of 16 U-tubes
3 ft. diameter by 50 ft high.

APPENDIX K

SUMMARY OF RESULTS