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/

The file name refers to the reference number, the AP42 chapter and section. The file name "ref02_c01s02.pdf" would mean the reference is from AP42 chapter 1 section 2. The reference may be from a previous version of the section and no longer cited. The primary source should always be checked.

ALLIED CHEMICAL CORPORATION

Chemicals Company

Environmental Control Laboratory

Request for Services

AP-42 Section 12.2
Reference
Report Sect. 4
Reference 120

Request Location	Request Date	Estimated Start Date	Project Code 000/6/980/9/0
ASHLAND COKE	12/21/79	November, 1980	Lab Project Number /6/980/9/0/001
Submitted By: R. W. MITTENDORF	Telephone Number (606) 325-7631	Requested Complete Date	Priority B Project Leader J. L. Welch
Billing Address P. O. Box 111 Ashland, Kentucky 41101	Account Information: GO 1047 Code 83-9020 Charges 64528		

Basis For Priority Other Than Scheduled:

Description:

Perform compliance testing of number three battery Minister-Stein. Sampling to be done on outlet and clarifier overflow (T.S.S. and D.S.)

cc: B. SUKORNICK
(Seven copies to R. W. Mittendorf)

	Verbal Report	Date
Prepared	John L. Welch	12/12/80
Prepared	E. W. Pollitt	12/12/80
Approved	R. L. Raines	12/12/80

Roberts Printing Co.

SOTDAT/STEEL LIBRARY SYSTEM

Report Title: See Title Page

Plant and Location: Allied Chemical Semet-Solvay Div Ashland KY

SCC: 30300303

Testing Date(s): 11/10/80

By Whom: ~~Allied Chem' Environmental Control Lab.~~ Company

Stack Test Review Attached: No

Reviewed By:

Problems Seen by Reviewer:

Confidentiality Status: Clear

If status is confidential, list confidential pages or sections:

Source of Determination of the Confidentiality Status:
2/1/83 memo from J. Baskerville
to M. Siegler.

Report Encoded By:

Date Encoded:

Form Numbers:

Comments:

Allied Chemical

Semet-Solvay Division
Box 111
Ashland, Kentucky
325-7631

December 15, 1980

Mr. William S. Coakley - Director
Enforcement & Surveillance Program
Dept. for Natural Resources &
Environmental Protection
Bureau of Environmental Quality
West Frankfort Office Complex
U.S. 127 South
Frankfort, KY 40601

Dear Mr. Coakley:

We are pleased to submit the enclosed Compliance Testing Report to verify the Minister-Stein (Pushing Emission Control) System for #3 Battery.

During the week of November 10, 1980, Mr. Dan Gray, Environmental Engineer, Mr. John Jayne, Environmental Specialist of the Frankfort office and Ms. Renee Cahal, Environmental Officer of the Ashland, Kentucky area, witnessed the compliance testing. Mr. Jesse Baskerville, Region 4 Compliance Chief, E.P.A. and Mr. Tom Moore, Inspector, Region 4, witnessed the testing for the Federal E.P.A.

If there are any questions pertaining to testing, please contact John L. Welch (614-533-1040) and any questions pertaining to process operations, contact D. E. Davisson (606-325-7631).

Sincerely,

R. A. Washburn

R. A. Washburn
Plant Manager

RAW/DED/cec
Attachment

cc: Jesse Baskerville

AIR ENFORCEMENT
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ATLANTA, GA.

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II. INTRODUCTION

Three (3) E.P.A. Method 5 modified runs were conducted at Allied Chemical's, Ashland, Kentucky Coke Plant. These tests were conducted to determine emission rates from the Minister-Stein capture system and outlet stack*. Other requirements being hood capture efficiencies and scrubber-clarifier overflow water analysis (for T.S.S. and D.S.). Testing was conducted by Allied Chemical's Environmental Control Laboratory, 3330 South Third Street, Ironton, Ohio 45638.

III. SUMMARY OF RESULTS

The emission results for the three test runs for particulates are given in Table 1 below and a summary of data given in Table 2 (attached).

Table 1

Emission Results

Test Number	Date	Particulate (Filterable) Emissions Pounds Per Ton of Coke
1	11/11/80	.008
2	11/12/80	.013
3	11/13/80	.005
	Average =	.009

All three tests are valid, being within 90% and 110% isokinetic range and being run in accordance with EPA Methods 1 thru 5.

Hood captures are summarized in Table 3 and the water analysis of the clarifier overflow is given in Table 4.

*#3 Battery

TABLE 2

Summary of Data

OUTLET FRONT HALF

	Test Run Number	ONE	TWO	THREE
A.)	Number of Traverse Points	24	24	24
B.)	Test Time per Point (min./push)	1.31	1.53	1.84
C.)	Total Test Time (min.)	31.38	36.71	44.14
D.)	Volume Metered (ACF)	58.144	66.123	82.140
E.)	Volume Metered (DSCF)	59.835	68.791	84.124
F.)	Average Meter Temperature (^{o}F)	53.3	49.6	52.0
G.)	Pressure at Meter (in. Hg)	29.78	29.89	29.56
H.)	Average $\sqrt{\Delta p}$ (in. H_2O)	.415	.414	.428
I.)	Average ΔH (in. H_2O)	2.05	2.00	2.10
J.)	Average Stack Temperature (^{o}F)	92.0	93.6	99.7
K.)	Absolute Stack Pressure (in. Hg)	29.79	29.90	29.57
L.)	Barometric Pressure (in. Hg)	29.78	29.89	29.56
M.)	Diameter of Stack (ft.)	10.0	10.0	10.0
N.)	Area of Stack ($ft.^2$)	78.54	78.54	78.54
O.)	Diameter of Nozzle (ft.)	.0417	.0417	.0417
P.)	Area of Nozzle ($ft.^2$) $\times 10^{-3}$	1.364	1.364	1.364
Q.)	Dry Molecular Wt. of Stack Gas (lb/lb-mole)	28.83	28.88	28.50
R.)	Wet Molecular Wt. of Stack Gas (lb/lb-mole)	28.70	28.70	28.29
S.)	Collected Impinger H_2O (ml)	0.0	6.5	26.0
T.)	Collected Silica Gel H_2O (gm)	15.0	19.0	10.0
U.)	Average Stack Gas Velocity (fps)	23.94	23.87	25.13
V.)	Average Stack Gas Volumetric Flow Rate (dscf/oven pushed) $\times 10^{5}$	1.3880	1.6122	1.9907
W.)	Particulate Weight (gm)	.0194	.0321	.0118
X.)	Isokinetic Variation (%)	103.4	102.4	101.4
Y.)	Processed Coke (tons/oven)	12.32	12.27	12.27
Z.)	Pollutant Concentration (lbs/dscf) $\times 10^{-7}$	7.14	10.2	3.09
AA.)	Pollutant Mass Rate (lb/ton of coke)	.008	.013	.005

TABLE 3

HOOD CAPTURES

Test #1 11/11/80 Oven #	% Capture	Test #2 11/12/80 Oven #	% Capture	Test #3 11/13/80 Oven #	% Capture
4	95	59	95	77	>90
82	90	49	95	57	>90
72	95	39	90	47	>95
62	95	29	90	37	>95
52	95	19	95	17	>95
42	95	9	95	7	>90
32	95	77	95	75	>85
22	90	57	90	65	90
12	95	47	90	55	90
2	90	37	90	35	90
69	95	27	90	27	90
49	90	17	90	5	95
29	90	75	90	83	90
9	95	65	95	73	90
77	90	55	95	63	90
19	95	35	90	53	95
57	95	25	95	45	95
47	95	5	90	43	95
37	90	67	90	25	90
27	95	83	90	33	95
17	95	73	95	23	90
7	90	63	90	13	90
75	95	53	90	3	90
65	90	43	95	81	95
Averages	Approximately 93		Approximately 92		Approximately 92

TABLE 4

CLARIFIER OVERFLOW WATER ANALYSIS

Date	Sample Time		Total Suspended Solids (mg/L)	Total Dissolved Solids (mg/L)
11/11/80	7:00 A.M.		32	597
11/11/80	8:00 A.M.		53	592
11/11/80	9:00 A.M.		16	648
11/11/80	10:00 A.M.		15	684
11/11/80	11:00 A.M.		4	671
11/11/80	NOON		15	736
11/11/80	1:00 P.M.		22	767
11/11/80	2:00 P.M.		7	765
		Range	4 - 53 mg/L	592 - 767 mg/L
		Average	21	682
11/12/80	7:00 A.M.		30	769
11/12/80	8:00 A.M.		60	620
11/12/80	9:00 A.M.		14	825
11/12/80	10:00 A.M.		14	751
11/12/80	11:00 A.M.		11	813
11/12/80	NOON		8	806
11/12/80	1:00 P.M.		54	790
11/12/80	2:00 P.M.		12	814
		Range	8 - 60 mg/L	751 - 825 mg/L
		Average	25	774
11/13/80	7:00 A.M.		70	484
11/13/80	8:00 A.M.		65	541
11/13/80	9:00 A.M.		48	556
11/13/80	10:00 A.M.		38	566
11/13/80	11:00 A.M.		30	550
11/13/80	NOON		30	557
11/13/80	1:00 P.M.		27	557
11/13/80	2:00 P.M.		17	563
		Range	17 - 70 mg/L	484 - 566 mg/L
		Average	41	547

IV. PROCESS INFORMATION

A) Tons Coke Pushed/Oven

B) Battery Heats - See Table 5 and Attached Data Sheets

C) COG - BTU Value

D) Coal Quality

E) Coke Quality

F) COG Consumption on Battery

G) Ovens Pushed and Charged Times

H) Tons Coal Charged/Oven

IV. PROCESS INFORMATION

A) Tons of Coke Pushed Per Oven

Over the years of plant history measurements have shown that a conversion factor of 0.78 from coal charged to coke produced applies for number three battery. Therefore, the amount of coke pushed is arrived at by multiplying the amount of coal charged by 0.78.

Date	Amount Of Coal Charged Per Oven Tons	Conversion Factor Coal to Coke	Amount of Coke Produced Per Oven "Tons"
11/11/80	15.86	0.78	12.37
11/12/80	15.73	0.78	12.27
11-13-80	15.73	0.78	12.27
Average	15.77	0.78	12.30

IV. PROCESS INFORMATION (continued)

B) Number Three Battery Oven Heats

Table 5 gives the flue temperatures of the ovens pushed and sampled during testing. The attached plant data sheets shows all the ovens flue temperatures.

TABLE #5

#3 BATTERY HEATS FLUE TEMPERATURES

Oven Number	11/11/80 Pusher Side (°F)	Coke Side (°F)
4	2461	2541
82	2501	2561
72	2515	2565
62	2463	2523
52	2442	2477
42	2510	2540
32	2493	2543
22	2537	2599
12	2518	2548
2	2411	2621
69	2480	2570
49	2467	2597
29	2473	2643
9	2478	2568
77	2505	2545
19	2447	2627
57	2473	2493
47	2477	2557
37	2490	2600
27	2513	2563
17	2488	2598
7	2451	2511
75	2455	2585
65	2420	2580
Average	2478	2567

Oven Number	11/12/80 Pusher Side (°F)	Coke Side (°F)
59	2463	2523
49	2457	2557
39	2550	2580
29	2843	2543
19	2417	2537
9	2468	2468
77	2525	2525
57	2523	2463
47	2467	2527
37	2510	2380
27	2543	2643
17	2448	2568
75	2515	2585
65	2460	2550
55	2403	2543
35	2453	2573
25	2507	2567
5	2481	2551
67	2430	2470
83	2471	2471
73	2465	2455
63	2480	2520
53	2447	2487
43	2440	2580
	2490	2528

Oven Number	11/13/80 Pusher Side (°F)	Coke Side (°F)
77	2485	2265
57	2503	2493
47	2467	2537
37	2490	2580
17	2428	2528
7	2481	2501
75	2475	2585
65	2440	2550
55	2473	2553
35	2533	2583
27	2563	2583
5	2411	2571
83	2461	2521
73	2365	2595
63	2480	2580
53	2413	2497
45	2429	2513
43	2440	2540
25	2487	2577
33	2483	2523
23	2437	2547
13	2428	2558
3	2361	2531
81	2451	2551
	2457	2536

ASHLAND PLANT

WELL NO.	ZONE 5 FEET	ZONE 6 FEET	ZONE 7 FEET
1		2470	2370
2		2470	2550
3		2470	2570
4		2470	2570
5		2470	2570
6		2470	2570
7		2470	2570
8		2470	2570
9		2470	2570
10		2425	2500
11		2470	2580
12		2408	2520
13		2428	2440
14		2410	2520
15		2448	2558
16		2428	2540
17		2438	2520
18		2437	2527
19		2437	2527
21		2447	2547
22		2457	2549
23		2427	2567
24		2487	2547
25		2507	2577
26		2507	2547
27		2523	2543
28		2483	2543
29		2527	2563
31		2403	2543
32		2443	2533
33		2483	2573
34		2483	2553
35		2443	2573
36		2436	2560
37		2440	2580
38		2460	2570
39		2440	2550
41		2430	2560
42		2450	2570
43		2410	2550
44		2460	2500
45		2419	2449
46		2407	2517
47		2437	2567
48		2437	2487
49		2407	2537
51		2497	2457
52		2417	2477
53		2437	2517
54		2403	2533
55		2453	2563
56		2403	2483
57		2443	2413
58		2437	2503
59		2423	2553
61		2397	2513
62		2403	2553
63		2410	2540
64		2450	2540
65		2460	2580
66		2470	2520
67		2450	2520
68		2460	2519
69		2410	2520
71		2420	2560
72		2485	2577
73		2405	2543
74		2415	2525
75		2475	2565
76		2465	2505
77		2425	2545
78		2415	2525
79		2425	2415
80		2411	2411
81		2451	2511
82		2431	2551
83		2471	2501
84		2461	2511
85			

CONTROL

WELL NO.	ZONE 2 FEET	ZONE 3 FEET
1	2370	2370
2	2550	2550
3	2570	2570
4	2570	2570
5	2570	2570
6	2570	2570
7	2570	2570
8	2570	2570
9	2570	2570
10	2500	2520
11	2520	2580
12	2440	2520
13	2440	2520
14	2520	2540
15	2540	2540
16	2540	2540
17	2520	2540
18	2527	2547
19	2527	2547
21	2547	2547
22	2549	2549
23	2567	2567
24	2547	2547
25	2577	2577
26	2547	2547
27	2543	2543
28	2543	2543
29	2563	2563
31	2543	2543
32	2533	2533
33	2573	2573
34	2553	2553
35	2573	2573
36	2560	2560
37	2580	2580
38	2570	2570
39	2550	2550
41	2560	2560
42	2570	2570
43	2550	2550
44	2500	2500
45	2449	2449
46	2517	2517
47	2567	2567
48	2487	2487
49	2537	2537
51	2457	2457
52	2477	2477
53	2517	2517
54	2533	2533
55	2563	2563
56	2483	2483
57	2413	2413
58	2503	2503
59	2553	2553
61	2513	2513
62	2553	2553
63	2540	2540
64	2540	2540
65	2580	2580
66	2520	2520
67	2520	2520
68	2519	2519
69	2520	2520
71	2560	2560
72	2577	2577
73	2543	2543
74	2525	2525
75	2565	2565
76	2505	2505
77	2545	2545
78	2525	2525
79	2415	2415
80	2411	2411
81	2511	2511
82	2551	2551
83	2501	2501
84	2511	2511
85		

Nov 25-35 / 25-40 / 25-53 / 25-55 / 25-06 / 25-14 / 25-31 / 25-08 / 25-07

CROSSWALL END

FILE NO.	73	73	3-11	11-7
1	2340	2270		
2	SC	SC		
3	2410	2250		
4	2460	2370		
5	2440	2300		
6	SC	SC		
7	2420	SC		
8	SC	2310		
9	2520	2400		
10	2500	2410		
11	2460	2480		
12	2470	2360		
13	2440	2350		
14	2420	SC		
15	2450	2410		
16	SC	2450		
13	2460	2460		
12	2470	2420		
11	2490	2410		
10	2520	2460		
9	2490	2470		
8	2500	2490		
7	2470	2480		
6	2470	2450		
5	2500	2460		
4	2480	2470		
3	2450	2450		
2	2450	2490		
1	—	2420		

REMARKS: Aug 2529

Span 5-12

PINS 43-46

CIW 75-76

73 Rous & Associates 03-11 11-7

ASHLAND PLANT — 73 Battery — DATE 11-21-

WALL NO.	PUSHER SIDE ZONE 1 FLUE 5	PUSHER SIDE ZONE 2 FLUE 10	COKE SIDE ZONE 3 FLUE 10	COKE SIDE ZONE 4 FLUE 5	
1		2417 11	2531 1		
2		2421 11	2621 1		
3		2417 11	2641 1		
4		2419 11	2541 1		
5		2416 11	2541 1		
6		2415 11	2541 1		
7		2411 11	2551 1		
8		2417 8	2551 8		
9		2416 8	2661 8		
11		2415 8	2551 8		
12		2413 8	2551 8		
13		2412 8	2541 8		
14		2411 8	2561 8		
15		2411 8	2551 8		
16		2412 8	2551 8		
17		2417 7	2541 7		
18		2411 7	2561 7		
19		2411 7	2561 7		
21		2413 7	2559 7		
22		2413 7	2562 7		
23		2412 7	2541 7		
24		2411 7	2551 7		
25		2411 7	2551 7		
26		2413 3	2561 3		
27		2414 3	2561 3		
28		2414 3	2561 3		
29		2413 3	2561 3		
31		2414 3	2541 3		
32		2414 3	2546 3		
33		2414 3	2546 3		
34		2413 3	2541 3		
35		2413 3	2561 3		
36		2417 0	2561 0		
37		2411 0	2561 0		
38		2411 0	2561 0		
39		2411 0	2561 0		
41		2411 0	2561 0		
42		2416 0	2561 0		
43		2416 0	2561 0		
44		2417 7	2551 7		
45		2411 7	2561 7		
46		2411 7	2561 7		
47		2411 7	2561 7		
48		2411 7	2561 7		
49		2411 7	2561 7		
51		2411 7	2561 7		
52		2411 7	2561 7		
53		2411 7	2561 7		
54		2413 3	2561 3		
55		2413 3	2561 3		
56		2411 3	2561 3		
57		2411 3	2561 3		
58		2411 3	2561 3		
59		2411 3	2561 3		
61		2411 3	2561 3		
62		2411 3	2561 3		
63		2416 0	2561 0		
64		2411 0	2561 0		
65		2412 0	2561 0		
66		2417 0	2561 0		
67		2412 0	2561 0		
68		2412 0	2561 0		
69		2411 0	2561 0		
71		2411 5	2561 5		
72		2411 5	2561 5		
73		2411 5	2561 5		
74		2411 5	2561 5		
75		2411 5	2561 5		
76		2411 5	2561 5		
77		2411 5	2561 5		
78		2411 5	2561 5		
79		2411 1	2561 1		
81		2411 1	2561 1		
82		2411 1	2561 1		
83		2411 1	2561 1		
84		2411 1	2561 1		
85		2411 1	2561 1		

FLUE NO.	CROSSWALL NO. 82-73	83-73	3-11	11-7
1	2250	SC		
2	SC	SC		
3	2400	SC		
4	2440	2410		
5	2410	2420		
6	2450	2390		
7	2470	SC		
8	2440	2420		
9	2490	2400		
10	2480	2370		
11	2490	2420		
12	2480	2400		
13	2470	2420		
14	2490	2390		
15	2490	2390		
16	2490	2430		
13	2470	2440		
12	2510	2450		
11	2520	2460		
10	2490	2490		
9	2480	2520		
8	2520	2500		
7	2510	2510		
6	2540	SC		
5	2520	2460		
4	2510	2500		
3	2500	2510		
2	2510	2470		
1	—	2290		

REMARKS: Aug 2555

SPan 12-5

PiNS 56-59

C/W 82-83

7-3 ~~Cl. Assistant~~ Pays 3-11 _____ 11-7 _____

...ATURES — NO. 3 BLOCK

DATE 11-12-80

WALL	ZONE 2 FLUE 10	ZONE 3 FLUE 10	ZONE 4 FLUE 5
1			2491
2			2511
3			2551
4			2551
5			2551
6			2551
7			2551
8			2551
9			2558
11			2558
12			2558
13			2558
14			2558
15			2558
16			2558
17			2568
18			2577
19			2577
21			2577
22			2577
23			2577
24			2577
25			2567
26			2567
27			2573
28			2573
29			2573
31			2573
32			2573
33			2573
34			2573
35			2573
36			2573
37			2570
38			2380
39			2580
41			2580
42			2580
43			2580
44			2580
45			2580
46			2577
47			2577
48			2577
49			2577
51			2577
52			2577
53			2577
54			2487
55			2543
56			2543
57			2543
58			2463
59			2463
61			2463
62			2463
63			2463
64			2520
65			2520
66			2520
67			2520
68			2470
69			2500
71			2500
72			2500
73			2500
74			2755
75			2755
76			2755
77			2755
78			2755
79			2755
81			2471
82			2471
83			2471
84			2471
85			2471
86			2471

FLUE NO.	CROSSWALL NO. 7-3	7-3	3-11	11-7
1	2260	2240		
2	2350	2310		
3	2390	2320		
4	2400	2260		
5	2350	2290		
6	2350	2340		
7	2390	2350		
8	2400	2320		
9	2400	2310		
10	2350	2370		
11	2480	2370		
12	2430	2410		
13	2410	2400		
14	2380	2400		
15	2420	2440		
16	2490	2450		
13	2410	2410		
12	2070	2460		
11	2420	2460		
10	2400	2420		
9	2410	2460		
8	2490	2470		
7	2480	2480		
6	2510	2500		
5	2520	2500		
4	2530	2500		
3	2540	2510		
2	2500	2480		
1	2370	—		

REMARKS: Aug 2521

Span 5-12

PINS 69-73

CLW 3-4

7-3 P.O. 3-11 11-7

FLUE TEMPERATURES — No. 3 BLOCK

ASHLAND PLANT

DATE 11-13-80

WALL NO.	PUSHER SIDE ZONE 1 FLUE 5	PUSHER SIDE ZONE 2 FLUE 10	COKE SIDE ZONE 3 FLUE 10	COKE SIDE ZONE 4 FLUE 5
1		2311		2311
2		2311		2318
3		2316		2316
4		2313	2315	2316
5		2311		2317
6		2316		2319
7		2316		2316
8		2316		2311
9		2313		2317
11		2312		2316
12		2314		2310
13		2312	2303	2315
14		2313		2317
15		2310		2318
16		2311		2317
17		2312		2315
18		2312		2313
19		2312		2313
21		2313		2312
22		2313	2351	2313
23		2312		2314
24		2317		2316
25		2318		2317
26		2312		2313
27		2316		2313
28		2318		2319
29		2313		2316
31		2313	2344	2314
32		2314		2317
33		2318		2313
34		2313		2313
35		2318		2318
36		2316		2316
37		2319		2318
38		2319		2317
39		2315	2314	2314
41		2314		2313
42		2315		2319
43		2314		2314
44		2313		2316
45		2313		2311
46		2315		2311
47		2317		2313
48		2317	2316	2316
49		2317		2314
51		2319		2315
52		2310		2310
53		2311		2319
54		2313		2314
55		2313		2314
56		2319		2319
57		2318		2314
58		2319	2318	2318
59		2316		2318
61		2313	2313	2317
62		2313		2313
63		2316		2318
64		2319		2318
65		2314		2315
66		2319	2314	2317
67		2316		2317
68		2310	2313	2318
69		2317		2310
71		2315		2314
72		2316		2314
73		2319		2317
74		2319	2316	2318
75		2317		2318
76		2316		2320
77		2318	2317	2316
78		2319		2316
79		2317		2312
81		2317		2317
82		2320		2317
83		2316		2312
84		2316	2311	2312
85		2311		2317

FLUE NO.	CROSSWALL NO. 7-3	7-3	3-11	11-7
1	SC	SC		
2	2280	SC		
3	2290	2360		
4	2280	2350		
5	2340	2400		
6	2300	2410		
7	SC	2420		
8	SC	2450		
9	2360	2450		
10	2420	2460		
11	2530	2420		
12	2460	2440		
13	2470	2410		
14	2460	2480		
15	2490	2490		
16	2500	2480		
13	2510	2500		
12	2550	2530		
11	2540	2550		
10	2530	2550		
9	2550	2550		
8	2560	2570		
7	2510	2560		
6	2470	2500		
5	2460	2520		
4	2450	2560		
3	2450	2580		
2	2440	2520		
1	2250	—		

REMARKS: Avg 2529

Span 12-5

PINS 82-85

C/W 9-11

7-3 Phyllis Price 3-11 11-7

IV. PROCESS INFORMATION (continued)

C) Coke Oven Gas BTU Value

Date	Calorimeter Value	Calculated Value*
11/11/80	524	521
11/12/80	535	534
11/13/80	515	522
Average	525	526

*Calculated from coke oven gas component analysis

SULFIBAN LABORATORY RESULTS

DATE: 11-11-80

Stream	Substance	Range	Result
Reflux P-104	NH_3	< 0.2 wt%	.22
P-107	NH_3	< 0.2 wt%	
Lean MEA P-103	MEA	13-16 wt%	14.8
	H_2S	< 500 ppm	392
	Petromeen	500-1000 ppm	743
Rich MEA P-101	H_2S	< 5000 ppm	2641
P-102	H_2S	< 5000 ppm	3373
Sour COG	H_2S	150-350 gr/100 SCF	300
	HCN		51.7
Sweet COG	H_2S	< 10 gr/100 SCF	44
	HCN		11.7
Acid Gas To	H_2S	18-35 vol %	29.3
	HCN	< 5% vol	2.8
Acid Gas From	H_2S	18-35 vol %	24.8
	HCN	< 0.5 vol %	.75
Reclaimer	MEA		
	Petromeen		
Sulfur	% Sulfur		
	% Ash		
Tail Gas	ml 0.1N I_2		1.2
11:00 am	ml 0.1N NaOH		1.6
	H_2S + SO_2		.29
	Ratio		1.8

COMMENTS: GAS ANALYSIS
CO_2 .7%
C_2H_4 2.3
H_2 56.7
O_2 .4
N_2 5.2

BTU = 524
Calculated BTU = 521
SG = .365
BP = 29.79
Combustibles = 91.7

cc: WASHBURN
GEYER
MOORE
DAVIDSON
NEWMAN
Pettrey
VANDERZALM
MAJUMDAR

	Test	Range	Result
	pH	7.2 - 8.5	
	Conductivity	< 1000 u mhos	860
	Chlorides	< 100 ppm	78
Cooling Tower	T. Hardness		
	Ca Hardness		
	p Alkalinity		
	m Alkalinity		
	Ammonia		
	O-PO_4	< 5 ppm	5
	TIP	6-10 ppm	16
	T-PO_4	8-14 ppm	16
Make-up Water	pH		
	Conductivity		5.2
	m Alkalinity		
	Ca Hardness		
	Chlorides		51
Boiler	pH		6.3
	Conductivity	< 500 u mhos	7
	p Alkalinity		0
	Sulfites		2
	O-PO_4		1
Condensate	Conductivity		3.4
Sulfur Condensors	Conductivity		
	1)		220
	2)	300 -	15
	3)	500	160
	4)	u mhos	76

SULFIDAN LABORATORY RESULTS

Stream	Substance	Range	Result
Reflux P-104	NH_3	< 0.2 wt%	.28
P-107	NH_3	< 0.2 wt%	—
Lean MEA P-103	MEA	13-16 wt%	16.0
	H_2S	< 500 ppm	443
	Petromeen	500-1000 ppm	646
Rich MEA P-101	H_2S	< 5000 ppm	1806
P-102	H_2S	< 5000 ppm	2368
Sour COG	H_2S	150-350 gr/100 SCF	220
	HCN		174
Sweet COG	H_2S	< 10 gr/100 SCF	18.8
	HCN		54.6
Acid Gas To	H_2S	18-35 vol %	28.0
	HCN	< 5% vol	1.9
Acid Gas From	H_2S	18-35 vol %	21.6
	HCN	< 0.5 vol %	.92
Reclaimer	MEA		5.2
	Petromeen		
Sulfur	% Sulfur		—
	% Ash		—
Tail Gas	ml 0.1N I_2		4.9
11:00 am	ml 0.1N NaOH		4.5
	H_2S + SO_2		1.2
	Ratio		16

COMMENTS:

Gas Analysis

CO_2 = 0.5 BTU = 535
C_2H_4 = 2.1 Comb. = 94.4
H_2 = 58.4 Sp. Grav. = .358
O_2 = 0.3 Bar. Pres. = 29.91
N_2 = 2.6 Cal. BTU = 534
CH_4 = 28.7
CO = 5.2

cc: Washburn
Carver
Moore
Davidson
Newman
Pettrey
Vanderzalm
Magumbar

	Test	Range	Result
Cooling Tower	pH	7.2 - 8.5	7.4
	Conductivity	< 1000 u mhos	1,000
	Chlorides	< 100 ppm	89
	T. Hardness		340
	Ca Hardness		242
	p Alkalinity		0
	m Alkalinity		82
	Ammonia		.5
	O-PO_4	< 5 ppm	6
	TIP	6-10 ppm	9
	T-PO_4	8-14 ppm	11
Make-up Water	pH		7.5
	Conductivity		560
	m Alkalinity		62
	Ca Hardness		140
	Chlorides		50
Boiler	pH		8.8
	Conductivity	< 500 u mhos	1,000
	p Alkalinity		10
	Sulfites		156
	O-PO_4		4
Condensate	Conductivity		5.1
Sulfur Condensors	Conductivity		
1)			580
2)		300 -	400
3)		500	330
4)			210
		u mhos	180

DATE: 11-13-80

SULFIBAN LABORATORY RESULTS

Stream	Substance	Range	Result
Reflux P-104	NH_3	< 0.2 wt%	.18
P-107	NH_3	< 0.2 wt%	—
Lean MEA P-103	MEA	13-16 wt%	14.2
	H_2S	< 500 ppm	395
	Petromeen	500-1000 ppm	808
Rich MEA P-101	H_2S	< 5000 ppm	2658
P-102	H_2S	< 5000 ppm	3339
Sour COG	H_2S	150-350 gr/100 SCF	291
	HCN		43.3
Sweet COG	H_2S	< 10 gr/100 SCF	25.10
	HCN		9.6
Acid Gas To	H_2S	18-35 vol %	28.3
	HCN	< 5% vol	1.7
Acid Gas From	H_2S	18-35 vol %	26.5
	HCN	< 0.5 vol %	.66
Reclaimer	MEA		5.2
	Petromeen		
Sulfur	% Sulfur		—
	% Ash		—
Tail Gas	ml 0.1N I_2		4.9
11:00 am	ml 0.1N NaOH		4.9
	H_2S + SO_2		1.2
	Ratio		-14.9

COMMENTS: GAS ANALYSIS
CO_2 0.5
C_2H_4 2.0
H_2 58.4
O_2 0.3
N_2 3.2
CH_4 27.2

BTU = 515
SG = .344
BP = 29.60
Combustibles = 93.8
Calculated BTU = 522

cc: WASHBURN
GEYER
MOORE
~~DAVISSON~~
NEWMAN
Pettrey
VANDERZALM
MAJUMDAR

	Test	Range	Result
	pH	7.2 - 8.5	
	Conductivity	< 1000 u mhos	120
	Chlorides	< 100 ppm	11
	T. Hardness		
Cooling Tower	Ca Hardness		
	p Alkalinity		
	m Alkalinity		
	Ammonia		
	O-PO_4	< 5 ppm	6
	TIP	6-10 ppm	8
	T-PO_4	8-14 ppm	10
	pH		
	Conductivity		50
Make-up Water	m Alkalinity		
	Ca Hardness		
	Chlorides		4
	pH		9
Boiler	Conductivity	< 500 u mhos	1,00
	p Alkalinity		
	Sulfites		16
	O-PO_4		
Condensate	Conductivity		6
Sulfur Condensors	Conductivity		
1)			60
2)		300 -	42
3)		500	34
4)		u mhos	19

IV. PROCESS INFORMATION (continued)

D) Coal Quality

	Date Charged		
	11/11/80	11/12/80	11/13/80
% H_2O	5.4	6.2	5.4
% Volatiles	30.51	28.82	27.92
% Fixed Carbon	63.44	64.65	66.63
% Ash	6.05	6.53	5.45
% Sulfur	0.78	0.77	0.81
% Passing 1/4" Screen	95	91	93
% Passing 1/8" Screen	82	72	80
Free Swelling Index	DE	DE	D

IV. PROCESS INFORMATION (continued)

E) Coke Quality

	DATE		
	11/11/80	11/12/80	11/13/80
% H_2O	1.04	3.96	8.92
% Volatiles	0.12	0.23	0.23
% Fixed Carbon	92.05	92.34	91.79
% Ash	7.83	7.43	7.98
% Sulfur	0.60	0.60	0.63

LABORATORY REPORT

DATE November 12 19

WEAK AMMONIA LIQUOR 11

SOURCE	Total	Free	Fixed
Primary			
Secondary			
F. L.			
B. H.			
To AC	10.81	8.84	1.97
No 1 Stg	10.34	8.57	1.77
2			
3			
4			
5			

D. S. WASTE 11

Shift	No. 1 NH3	No. 1 CaO	No. 2 NH3	No. 2 CaO
7 - 3				
3 - 11				
11 - 7				

CONC. AMMONIA LIQUOR 12

SOURCE	GPL	%	Color	O.T.
No. 1 Stg		31.45		
No 2 Stg		30.25		
No. 3 Stg		N/S		
AB 1		29.80		
AB 2		33.00		

SPG OPERATION

10 GPL NH_3 BASIS

Liquor	NH_3	H_2S	CO_2	Org
To AC				
FR #1				
FR #2				

AMMONIA CARS LOADED

CAR	Grade	%	Color	OT

LBS (NH_4SO_4) Equiv. IN GAS

AFT LGA'S - 110,000

LGA TOP - gpl

11.8 COAL TO OVENS

%	3BIK	4BIK	Ind	Reg-Fce
H_2O	5.0	5.3		
Vol.	30.20	29.07		
F. C.	64.02	65.36		
Ash	5.78	5.57		
Sul.	0.78	0.80		
½" Scr.	93	93		
⅛" Scr.	76	81		
F.G.I.	D	D		

11.10 COKE PRODUCED

%	3BIK	Fdry	Ind	Reg-Fce
H_2O	7.52			
Vol.	0.21			
F. C.	92.53			
Ash	7.26			
Sul.	0.66			
Shatter	N/S			
Tr. Gr.	1.923			
App. Gr.	0.957			
Poros.	50.2			
Stab	64.0			
Hard.	71.5			

TAR ACID REMOVAL 11

SOURCE	Phenol
Raw Liquor	0.88
Deph. Liquor	0.09
Phenolated L.O.	
L.O. Aft Pri Loc	
Deph L. O.	
Primary Carb	
Sec. Carb	
D. S. Waste	
% Elim	89.8
Abs Pri LOC	

W.L. FR. WLLO'S

GPL Phenol No. 1		.10
GPL Phenol No. 2		.35
GPL Phenol No. 3		.64
GPL	% Wet	% Dry
NAOH	T. A.	T. A.
GPL H_2S Bef. Scrub		
GPL H_2S Aft Scrub		
% H_2S Removal		

COAL UNLOADED

Kind	Car Number	H_2O	Vol.	F. C.	Ash

CIRCULATION OIL

SOURCE	#1 DSH		#2 DSH	
Distilled To	170°C	200°C	170°C	200°C
% L. O. To DSH				
% L. O. Fr DSH				
% L.O. SPG LGI				
Gals L. O. /10M Cu. Ft. Gas – Rich Gas				
– Leah Gas				

TAR

SOURCE	Temp. °C	H_2O %
No. 1		
No. 2		
No. 3		
No. 4		
No. 5		

L. O. CARS

CAR	Sp Gr. @ 60°F	% @ 100°C

GAS ANALYSIS

Kind	
CO_2	
ILL	
O_2	
CO	
H_2	
CH_4	
C_2H_6	
N_2	
Comb.	
B.T.U.	
Sp. Gr.	
Barometer	

% COMBUSTIBL IN BOILER ASH

FR BREEZE	
FR COAL	

Coal Pulv. on 11-11-80

	3BIK	4BIK
1/4"	91	–
1/8"	72	79

#1 T.A. Sp GR. 7:00 Am 11-12-80 R/0.74

A C 78 11-5-78

Sp. Gravity 1.209

% H2O 3.6

% Cl 4.1

LABORATORY REPORT

DATE November 13 1980

WEAK AMMONIA LIQUOR 12

SOURCE	Total	Free	Fixed
Primary	9.52	7.00	2.52
Secondary	9.38	8.16	1.22
F. L.	9.11		
B. H.	5.64	1.70	3.94
To AC	10.00	8.23	1.77
No. 1 Stg	9.93		
2	10.00		
3	N/S		
4	10.27		
5	10.47		

D. S. WASTE 12

Shift	No. 1 NH_3	No. 1 CaO	No. 2 NH_3	No. 2 CaO
7 - 3	.01		.06	
3 - 11	.01		.01	
11 - 7	.01		.10	

CONC. AMMONIA LIQUOR 13

SOURCE	H_2S	%	Color	O.T.
No. 1 Stg	ZERO	31.35	.026	71
No. 2 Stg	ZERO	30.25	.050	128
No. 3 Stg		N/S		
AB 1	HUY	31.10	.026	74
AB 2	Trace	32.25	.030	92

SPG OPERATION

10 GPL NH_3 BASIS

Liquor	NH_3	H_2S	CO_2	Org
To AC				
FR #1				
FR #2				

11-11-80 AMMONIA CARS LOADED

CAR	H_2S	%	Color	OT
ACDX 53203	ZERO	31.30	.030	61

LBS (NH_4SO_4) Equiv. IN GAS

AFT LGA'S - /10,000

LGA TOP - 1.53 gpl

11-9 COAL TO OVENS

%	3BIK	Fdry	Ind	Reg-Fce
H_2O	4.8			
Vol.	29.93			
F. C.	64.25			
Ash	5.82			
Sul.	0.72			
½" Scr.	91			
⅛" Scr.	72			
F.S.I.	E			

11-11 COKE PRODUCED

%	3BIK	Fdry	Ind	Reg-Fce
H_2O	1.04			
Vol.	0.12			
F. C.	92.05			
Ash	7.83			
Sul.	0.60			
Shatter	73-87			
Tr. Gr.	1.950			
App. Gr.	0.959			
Poros.	50.3			
Stab	58.3			
Hard.	70.2			

TAR ACID REMOVAL 12

SOURCE	Phenol
Raw Liquor	0.82
Deph. Liquor	0.09
Phenolated L.O.	1.25
L.O. Aft Pri Loc	1.00
Deph L. O.	0.46
Primary Carb	215.8
Sec. Carb	54.6
D. S. Waste	-
% Elim	89.0
Abs Pri LOC	31.6

W.L. FR. WLLO'S

GPL Phenol No. 1		
GPL Phenol No. 2		
GPL Phenol No. 3		
GPL	% Wet	% Dry
NAOH	T. A.	T. A.
GPL H_2S Bef. Scrub		
GPL H_2S Aft Scrub		
% H_2S Removal		

Coal Pulv. ON 11-12-80

	3BIK	4BIK
1/4"	-	93
1/8"	73	80

COAL UNLOADED

Kind	Car Number	H_2O	Vol.	F. C.	Ash	S

11-12-80 CIRCULATION OIL

SOURCE	#1 DSH		#2 DSH	
Distilled To	170°C	200°C	170°C	200°C
% L. O. To DSH	1.45	1.55		
% L. O. Fr DSH	0.10	0.13	0.34	0.39
% L.O. SPG LGI				
Gals L. O. /10M Cu. Ft. Gas - Rich Gas				
- Leah Gas				

GAS ANALYSIS

Kind	
CO_2	
ILL	
O_2	
CO	
H_2	
CH_4	
C_2H_6	
N_2	
Comb.	
B.T.U.	
Sp Gr.	
Barometer	

TAR

SOURCE	Temp. °C	H_2O %
No. 1		
No. 2		
No. 3		
No. 4		
No. 5		

11-11-80 L. O. CARS

CAR	Sp. Gr. @ 60°F	% @ 100°C
Truck	0.887	85.0

% COMBUSTIBLE IN BOILER ASH

FR BREEZE	
FR COAL	

#1 SPGR 7:00 AM 11-13-80 R/O 1.5

#2 SPGR 7:00 AM 11-13-80 R/O 0.22

LABORATORY REPORT

DATE November 14 19 8

WEAK AMMONIA LIQUOR 13

SOURCE	Total	Free	Fixed
Primary			
Secondary			
F. L.			
B. H.			
To AC	11.22	8.36	2.86
No. 1 Stg	10.88	8.02	2.86
2			
3			
4			
5			

D. S. WASTE 13

Shift	No. 1 NH3	No. 1 CaO	No. 2 NH3	No. 2 CaO
7 - 3	0.00		.09	
3 - 11	0.01		.20	
11 - 7	0.00		.16	

CONC. AMMONIA LIQUOR 14

SOURCE	GPL	%	Color	O.T.
No. 1 Stg		31.25		
No. 2 Stg		30.20		
No. 3 Stg		N/S		
AB 1		28.60		
AB 2		31.50		

SPG OPERATION

10 GPL NH_3 BASIS

Liquor	NH_3	H_2S	CO_2	Org
To AC				
FR #1				
FR #2				

AMMONIA CARS LOADED

CAR	Grade	%	Color	OT

LBS (NH_4SO_4) Equiv. IN GAS

AFT LGA'S - 110,000

LGA TOP - gpl

11·10 COAL TO OVENS

%	4B1K	Fdry	Ind	Reg-Fce
H_2O	5.4			
Vol.	30.51			
F. C.	63.44			
Ash	6.05			
Sul.	0.78			
½" Scr.	95			
¼" Scr.	82			
F.D.S.I.	DE			

11·12 COKE PRODUCED

%	4B1K	Fdry	Ind	Reg-Fce
H_2O	3.96			
Vol.	0.23			
F. C.	92.34			
Ash	7.43			
Sul.	0.60			
Shatter	70-87			
Tr. Gr.	1.919			
App. Gr.	0.905			
Poros.	52.8			
Stab	63.5			
Hard.	70.4			

TAR ACID REMOVAL 13

SOURCE	Phenol
Raw Liquor	0.43
Deph. Liquor	0.03
Phenolated L.O.	
L.O. Aft Pri Loc	
Deph L. O.	
Primary Carb	
Sec. Carb	
D. S. Waste	
% Elim	93.0
Abs Pri LOC	

W.L. FR. WLLO'S

GPL Phenol No. 1		0.02
GPL Phenol No. 2		0.07
GPL Phenol No. 3		0.10
GPL NAOH	% Wet T. A.	% Dry T. A.
GPL H_2S Bef. Scrub		
GPL H_2S Aft Scrub		
% H_2S Removal		

COAL UNLOADED

Kind	Car Number	H_2O	Vol.	F. C.	Ash

CIRCULATION OIL

SOURCE	#1 DSH		#2 DSH	
Distilled To	170°C	200°C	170°C	200°C
% L. O. To DSH				
% L. O. Fr DSH				
% L.O. SPG LG				
Gals L. O. /10M Cu. Ft. Gas – Rich Gas				
– Leah Gas				

TAR

SOURCE	Temp. °C	H_2O %
No. 1		
No. 2		
No. 3		
No. 4		
No. 5		

11-12-80 L. O. CARS

CAR	Sp. Gr. @ 60°F	% @ 100°C
Truck	0.887	86.0

GAS ANALYSIS

Kind	
CO_2	
ILL	
O_2	
CO	
H_2	
CH_4	
C_2H_6	
N_2	
Comb.	
B.T.U.	
Sp. Gr.	
Barometer	

% COMBUSTIBLE IN BOILER ASH

FR BREEZE	
FR COAL	

Cool Pulv. on 11-13-80.

	3B1K	4B1K
1/4"	91	–
1/8"	71	83
	73	73

November 14, 1980
2 T.A. SPGR
R/O 0.73

LABORATORY REPORT

DATE November 15

WEAK AMMONIA LIQUOR 14

SOURCE	Total	Free	Fixed
Primary			
Secondary			
F. L.			
B. H.			
To AC	8.84	7.48	1.36
No. 1 Stg	9.79	7.96	1.83
2			
3			
4			
5			

D. S. WASTE 14

Shift	No. 1 NH_3	No. 1 CaO	No. 2 NH_3	No. 2 CaO
7 - 3	.16		.03	
3 - 11	.01		.09	
11 - 7	.01		.07	

CONC. AMMONIA LIQUOR 15

SOURCE	H_2S	%	Color	O.T.
No. 1 Stg	Zero	31.25	.040	
No. 2 Stg	Zero	30.25	.050	
No. 3 Stg		N/S		
AB 1	Hvy	28.80	.035	
AB 2	Trace	31.00	.030	

SPG OPERATION

10 GPL NH_3 BASIS

Liquor	NH_3	H_2S	CO_2	Org
To AC				
FR #1				
FR #2				

AMMONIA CARS LOADED

CAR	Grade	%	Color	OT

LBS (NH_4SO_4) Equiv. IN GAS

AFT LGA'S - /10,000

LGA TOP - gpl

11·11 COAL TO OVENS

%	3 Blk	Fdry	Ind	Reg-Fce
H_2O	6.2			
Vol.	28.82			
F. C.	64.65			
Ash	6.53			
Sul.	0.77			
¼" Scr.	91			
⅛" Scr.	72			
F.D.I.	DE			

11·13 COKE PRODUCED

%	3 Blk	Fdry	Ind	Reg-Fce
H_2O	8.92			
Vol.	0.23			
F. C.	91.79			
Ash	7.98			
Sul.	0.63			
Shatter	73-87			
Tr. Gr.	1.969			
App. Gr.	N/S			
Poros.	N/S			
Stab	53.8			
Hard.	68.8			

TAR ACID REMOVAL 14

SOURCE	Phenol
Raw Liquor	0.40
Deph. Liquor	0.02
Phenolated L.O.	
L.O. Aft Pri Loc	
Deph L. O.	
Primary Carb	
Sec. Carb	
D. S. Waste	
% Elim	95.0
Abs Pri LOC	

W.L. FR. WLLO'S

GPL Phenol No. 1		
GPL Phenol No. 2		
GPL Phenol No. 3		
GPL	% Wet	% Dry
NAOH	T. A.	T. A.
GPL H_2S Bef. Scrub		
GPL H_2S Aft Scrub		
% H_2S Removal		

COAL UNLOADED

Kind	Car Number	H_2O	Vol.	F. C.	Ash

CIRCULATION OIL

SOURCE	#1 DSH		#2 DSH	
Distilled To	170°C	200°C	170°C	200°C
% L. O. To DSH				
% L. O. Fr DSH				
% L.O. SPG LGI				
Gals L. O. /10M Cu. Ft. Gas – Rich Gas				
– Leah Gas				

TAR

SOURCE	Temp. °C	H_2O %
No. 1		
No. 2		
No. 3		
No. 4		
No. 5		

11·13·80 L. O. CARS

CAR	Sp. Gr. @ 60°F	% @ 100°C
Truck	0.887	84.0

GAS ANALYSIS

Kind	
CO_2	
ILL	
O_2	
CO	
H_2	
CH_4	
C_2H_6	
N_2	
Comb.	
B.T.U.	
Sp. Gr.	
Barometer	

% COMBUSTIBLE IN BOILER ASH

FR BREEZE	
FR COAL	

Coal Pulv. on 11-14-80

	3 Blk	4 Blk
1/4"	N/S	86
1/8"	N/S	68

LABORATORY REPORT

DATE November 16 19 8

WEAK AMMONIA LIQUOR 15

SOURCE	Total	Free	Fixed
Primary			
Secondary			
F. L.			
B. H.			
To AC	9.18	7.28	1.90
No. 1 Stg	9.32	7.14	2.18
2			
3			
4			
5			

D. S. WASTE 15

Shift	No. 1 NH3	No. 1 CaO	No. 2 NH3	No. 2 CaO
7 - 3	.12		.00	
3 - 11	.00		.05	
11 - 7	.00		.04	

CONC. AMMONIA LIQUOR 16

SOURCE	H2S	%	Color	O.T.
No. 1 Stg	Trace	31.20	.040	
No. 2 Stg	Zero	30.25	.050+	
No. 3 Stg		N/S		
AB 1	HVY	29.60	.040	
AB 2	HVY	31.60	.035	

SPG OPERATION

10 GPL NH_3 BASIS

Liquor	NH_3	H_2S	CO_2	Org
To AC				
FR #1				
FR #2				

AMMONIA CARS LOADED

CAR	Grade	%	Color	OT

LBS (NH_4SO_4) Equiv. IN GAS

AFT LGA'S - /10,000

LGA TOP - gpl

11.12 COAL TO OVENS

%	4BIK	Fdry	Ind	Reg-Fce
H_2O	5.4			
Vol.	27.92			
F. C.	66.63			
Ash	5.45			
Sul.	0.81			
½" Scr.	93			
⅛" Scr.	80			
F.S.I.	D			

11.14 COKE PRODUCED

%	4BIK	Fdry	Ind	Reg-Fce
H_2O	9.06			
Vol.	0.11			
F. C.	92.53			
Ash	7.36			
Sul.	0.64			
Shattor	N/S			
Tr. Gr.	N/S			
App. Gr.	N/S			
Poros.	N/S			
Stab	62.2			
Hard.	72.8			

TAR ACID REMOVAL 15

SOURCE	Phenol
Raw Liquor	0.42
Deph. Liquor	0.02
Phenolated L.O.	
L.O. Aft Pri Loc	
Deph L. O.	
Primary Carb	
Sec. Carb	
D. S. Waste	
% Elim	95.2
Abs Pri LOC	

W.L. FR. WLLO'S

GPL Phenol No. 1		
GPL Phenol No. 2		
GPL Phenol No. 3		
GPL	% Wet	% Dry
NAOH	T. A.	T. A.
GPL H_2S Bef. Scrub		
GPL H_2S Aft Scrub		
% H_2S Removal		

COAL UNLOADED

Kind	Car Number	H_2O	Vol.	F. C.	Ash

CIRCULATION OIL

SOURCE	#1 DSH		#2 DSH	
Distilled To	170°C	200°C	170°C	200°C
% L. O. To DSH				
% L. O. Fr DSH				
% L.O. SPG LGI				
Gals L. O. /10M Cu. Ft. Gas – Rich Gas				
– Leah Gas				

TAR

SOURCE	Temp. °C	H_2O %
No. 1		
No. 2		
No. 3		
No. 4		
No. 5		

11.14.80 L. O. CARS

CAR	Sp. Gr. @ 60°F.	% @ 100°C
Truck	0.888	85.0

GAS ANALYSIS

Kind	
CO_2	
ILL	
O_2	
CO	
H_2	
CH_4	
C_2H_6	
N_2	
Comb.	
B.T.U.	
Sp. Gr.	
Barometer	

% COMBUSTIBLE IN BOILER ASH

FR BREEZE	
FR COAL	

Coal Pulv. ON 11.15.80

	3BIK	4BIK
1/4"	93	–
1/8"	76	86
	7.3	

LABORATORY REPORT

DATE November 17

WEAK AMMONIA LIQUOR 16

SOURCE	Total	Free	Fixed
Primary			
Secondary			
F. L.			
B. H.			
To AC	8.91	7.14	1.77
No. 1 Stg	9.25	7.28	1.97
2			
3			
4			
5			

D. S. WASTE 16

Shift	No. 1 NH3	No. 1 CaO	No. 2 NH3	No. 2 CaO
7-3	.10		.03	
3-11	.00		.05	
11-7	.00		.05	

CONC. AMMONIA LIQUOR 17

SOURCE	1126	%	Color	O.T.
No. 1 Stg	ZERO	31.20	.045	
No. 2 Stg	ZERO	30.20	.050	
No. 3 Stg		N/S		
AB 1	ZERO	31.60	.035	
AB 2	ZERO	31.90	.040	

SPG OPERATION

10 GPL NH_3 BASIS

Liquor	NH_3	H_2S	CO_2	Org
To AC				
FR #1				
FR #2				

AMMONIA CARS LOADED

CAR	Grade	%	Color	OT

LBS $(NH_4)_2SO_4$ Equiv. IN GAS

AFT LGA'S - /10,000

LGA TOP - gpl

11-13 COAL TO OVENS

%	3BIK	Fdry	Ind	Reg-Fce
H_2O	6.3			
Vol.	30.33			
F. C.	63.41			
Ash	5.76			
Sul.	0.82			
¼" Scr.	91			
⅛" Scr.	71			
B.B.I.	EF			

11-15 COKE PRODUCED

%	3BIK	Fdry	Ind	Reg-Fce
H_2O	4.29			
Vol.	0.39			
F. C.	91.81			
Ash.	7.80			
Sul.	0.63			
Shatter	N/S			
Tr. Gr.	1.968			
App. Gr.	N/S			
Poros.	N/S			
Stab.	50.2			
Hard.	68.8			

COAL UNLOADED

Kind	Car Number	H_2O	Vol.	F. C.

CIRCULATION OIL

SOURCE	#1 DSH		#2 DSH	
Distilled To	170°C	200°C	170°C	200°C
% L. O. To DSH				
% L. O. Fr DSH				
% L.O. SPG LG				
Gals L. O. /10M Cu. Ft. Gas → Rich Gas				
→ Lean Gas				

GAS ANALYSIS

Kind	
CO_2	
ILL	
O_2	
CO	
H_2	
CH_4	
C_2H_6	
N_2	
Comb.	
B.T.U.	
Sp. Gr.	
Barometer	

TAR ACID REMOVAL 16

SOURCE	Phenol
Raw Liquor	0.37
Deph. Liquor	0.02
Phenolated L.O.	
L.O. Aft Pri Loc	
Deph L. O.	
Primary Carb	
Sec. Carb	
D. S. Waste	
% Elim	94.6
Abs Pri LOC	

W.L. FR. WLLO'S

GPL Phenol No. 1		
GPL Phenol No. 2		
GPL Phenol No. 3		
GPL	% Wet	% Dry
NAOH	T. A.	T. A.
GPL H_2S Bef. Scrub		
GPL H_2S Aft Scrub		
% H_2S Removal		

TAR

SOURCE	Temp. °C	H_2O %
No. 1		
No. 2		
No. 3		
No. 4		
No. 5		

L. O. CARS

CAR	Sp. Gr. @ 60°F	% @ 100°C

% COMBUSTIBLE IN BOILER ASH

FR BREEZE	
FR COAL	

Coal Pulv. ON 11-16-80.

	3BIK	4BIK
1/4"	N/S	92 -
1/8"	N/S	74 86

IV. PROCESS INFORMATION (continued)

F) Coke Oven Gas Consumption by Number Three Battery Flues

Date	Coke Oven Gas Consumed Millions Cubic Feet
11/11/80	6.34
11/12/80	6.00
11/13/80	6.00
Average	6.11

GAS PRODUCTION AND DISTRIBUTION

DATE	11-11-80			
FLUES No. 3	6340,000			
No. 4	9042			
TOTAL FLUES	15382			
CONSUMED:				
Clark Compressors	672			
Laboratory				
Coke Handling	50			
Coal Handling	100			
SULFA-BAN	560			
TOTAL MISC.	1382			
BOILERS	10235			
TOTAL CONSUMED	11617			
SALES:				
Armco	3442			
Spec. Chem. Boilers				
TOTAL SOLD	3442			
BLED	4000			
IDLE OVENS				
TOTAL PRODUCED	34441			
B. T. U.	534			
	3648			
	3720	144	0	53,768 0 864
ARMCO B.T.U.				
DRY COAL	3227			
	.350			
	29.69			
	541			

GAS PRODUCTION AND DISTRIBUTION

DATE	11-12-80			
FLUES No. 3	6,000,000			
No. 4	8640			
TOTAL FLUES	14640			
CONSUMED:				
Clark Compressors	672			
Laboratory				
Coke Handling	50			
Coal Handling	50			
SULFA-RAN	560			
TOTAL MISC.	1332			
BOILERS	10440			
TOTAL CONSUMED	11772			
SALES:				
Armco	4380			
Spec. Chem. Boilers				
TOTAL SOLD	4380			
BLED	2000			
IDLE OVENS				
TOTAL PRODUCED	32792			
B. T. U.	530			

3840 70 30 52,744 0 840

ARMCO B.T.U.				
DRY COAL	3153			

.351
29.74
531

GAS PRODUCTION AND DISTRIBUTION

DATE	11-13-80			
FLUES No. 3	6000,000			
No. 4	8640			
TOTAL FLUES	14640			
CONSUMED:				
Clark Compressors	672			
Laboratory RD	25			
Coke Handling	50			
Coal Handling	50			
SULFA-BAN	560			
TOTAL MISC.	1357			
BOILERS	11126			
TOTAL CONSUMED	12483			
SALES:				
Armco	4395			
Spec. Chem. Boilers				
TOTAL SOLD	4395			
BLED	3000			
IDLE OVENS				
TOTAL PRODUCED	34518			
B. T. U.	525			

3595 120 20 51, 660 0 768

ARMCO B.T.U.				
DRY COAL	3288			

.354
29.60
530

IV. PROCESS INFORMATION (continued)

G) Ovens Push and Charge Schedule

- SEE ATTACHED SHEETS -

OVENS PUSHED

BLOCK NO. 3

DATE 11/11/80 19

SHIFT NO. 1

	OVEN NO.	SCHEDULE	TIME PUSHED	TIME LEVELED	COKING TIME	AMPS. TO PUSH	KIND OF COAL	KIND OF COKE
1	24	210	728	740				
2	14		35	48				
3	4		44	802				
4	82		56	15				
5	72	802	810	28				
6	62		24	43				
7	52		33	900				
8	42		41	09				
9	32		905	16				
10	22	907	12	29				
11	12		22	36				
12	2		32	46				
13	69		41	54				
14	59	1030	1037	1059				
15	49		43	58				
16	39	1104	53	1105				
17	29		1130	42				
18	19		1208	1221				
19	9		1138	1149				
20	77	1212	59	1211				
21	57		1234	1245				
22	47		40	55				
23	37	103	106	114				
24	27		19	24				
25	17		50	202				
26	7		58	10				
27	75	206	206	20				
28	65		17	27				
29	55	230	29	32				
30								
31								
32								
33								
34								
35								
36								
37								
38								
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HARRIS / HALEY

STARR - ET. AL

OPERATOR McConnell

OVENS PUSHED 29 ✓ COAL CH'G'D (GROSS WET TONS)

OVENS CHARGED 29 ✓ SPILLAGE

PER CH'G'D OVEN (NET WET) COAL CH'G'D (NET WET)

SHIFT NO. 2

	OVEN NO.	SCHEDULE	TIME PUSHED	TIME LEVELED	COKING TIME	AMPS. TO PUSH	KIND OF COAL	KIND OF COKE
1	45	310	328	342				
2	35		34	50				
3	25		39	54				
4	15		46	404				
5	5	402	54	37				
6	67		430	46				
7	83		37	54				
8	73		44	506				
9	63		51	08				
10	53	507	58	13				
11	43		505	19				
12	33		31	41				
13	23		36	47				
14	13	630	645	710				
15	3		700	18				
16	81	704	7	25				
17	71		15	31				
18	61		22	39				
19	51		810	820				
20	41	812	17	42				
21	31		25	50				
22	21		40	902				
23	11	903	7	10				
24	1		900	16				
25	78		945	1002				
26	76		52	01				
27	68	1006	57	13				
28	58		1006	24				
29	48	1030	15	31				
30								
31								
32								
33								
34								
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43								
44		Spencer						
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OPERATOR Barton

OVENS PUSHED 29 ✓ COAL CH'G'D (GROSS WET TONS)

OVENS CHARGED 29 ✓ SPILLAGE

PER CH'G'D OVEN (NET WET) COAL CH'G'D (NET WET)

SHIFT NO. 3

	OVEN NO.	SCHEDULE	TIME PUSHED	TIME LEVELED	COKING TIME	AMPS. TO PUSH	KIND OF COAL	KIND OF COKE
1	38	1110	1120	1142				
2	28		30	50				
3	18		36	1200				
4	8		45	12				
5	66	1202	52	22				
6	56		1210	30				
7	46		19	38				
8	36		27	100				
9	26		STUCK					
10	76	107	2115	241				
11	6		31	50				
12	79		39	302				
13	54		48	09				
14	74	230	300	319				
15	64		07	25				
16	54	304	17	32				
17	44		23	41				
18	34		30	50				
19	24		40	55				
20	14	402	48	400		Push	[illegible]	Sample Stuck
21	4		405	15				
22	82		18	28				
23	72	503	25	37				
24	62		35	42				
25	52		410	49				
26	42		535	52				
27	32	606	48	600				
28	22		610	17				
29	12	630	15	25				
30								
31								
32								
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Fin L

OPERATOR Blanco

OVENS PUSHED 28 ✓ COAL CH'G'D (GROSS WET TONS)

OVENS CHARGED 28 ✓ SPILLAGE

PER CH'G'D OVEN (NET WET) COAL CH'G'D (NET WET)

TOTALS

OVENS OFF	TIME PUSHED OUT

COAL CHARGED (NET WET TONS)

1

2

3

TOTAL CHARGED PER OVEN (NET WET TONS)

% H_2O IN COAL

TOTAL COAL CHARGED (DRY TONS)

86 ✓

86 ✓

OVENS PUSHED

BLOCK NO. 3

DATE 11/12/80 19

SHIFT NO. 1

	OVEN NO.	SCHE-DULE	TIME PUSHED	TIME LEVELED	COKING TIME	AMPS. TO PUSH	KIND OF COAL	KIND OF COKE
1	2	210	222	240				
2	69		37	48				
3	56		41	57				
4	49		53	804				
5	39	802	805	18				
6	29		15	25				
7	19		38	45				
8	9		41	58				
9	77		53	906				
10	57	907	915	26				
11	47		22	35				
12	37		32	42				
13	27		1042	1052				
14	17	1030	47	1101				
15	7		55	10				
16	75	1104	1105	18				
17	65		30	40				
18	55		35	47				
19	45		52	1210				
20	35	1212	1224	37				
21	25		32	130				
22	15		918	926	pm	stie	er	✓
23	5	103	125	138				
24	(67)		35	46				
25	83		43	54				
26	73		52	203				
27	63	206	210	18				
28	53		15	25				
29	43	230	22	32				
30								
31								
32								
33	Stick er							
34								
35	26	→	926	955	Chg in line		pm	
36								
37								
38								
39								
40								
41								
42								
43								
44								
45								
46								
47								
48			HARRIS					
49								
50								

OPERATOR STEVENS

OVENS PUSHED 28 ✓ COAL CH'G'D (GROSS WET TONS)

OVENS CHARGED 28 ✓ SPILLAGE

PER CH'G'D OVEN (NET WET) COAL CH'G'D (NET WET)

SHIFT NO. 2

	OVEN NO.	SCHE-DULE	TIME PUSHED	TIME LEVELED	COKING TIME	AMPS. TO PUSH	KIND OF COAL	KIND OF COKE
1	33	310	405	422	Blown Fuse 110			
2	23		12	29	Trip		Bam	
3	13		19	36				
4	3		26	43				
5	81	402	33	50				
6	71		40	57				
7	61		47	503				
8	51		54	10				
9	41		501	18				
10	31	507	508	25				
11	21		15	32				
12	11		21	39				
13	1		28	45	SCOOP STICKER			
14	78	630	35	50				
15	68		42	56				
16	58	704	720	735				
17	48		32	46				
18	(76)		39	53				
19	38		46	59				
20	28	812	55	811				
21	18		815	39				
22	8		25	32				
23	66	903	912	935				
24	56		25	41				
25	46		32	53				
26	36		41	1003				
27	16	1006	50	04				
28	6		1000	18				
29	84	1030	15	24				
30								
31								
32								
33								
34								
35								
36								
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50								

OPERATOR

OVENS PUSHED 31 ✓ COAL CH'G'D (GROSS WET TONS)

OVENS CHARGED 31 ✓ SPILLAGE

PER CH'G'D OVEN (NET WET) COAL CH'G'D (NET WET)

SHIFT NO. 3

	OVEN NO.	SCHE-DULE	TIME PUSHED	TIME LEVELED	COKING TIME	AMPS. TO PUSH	KIND OF COAL	KIND OF COKE
1	74	1110	1120	1134				
2	64		30	57				
3	54		43	1202				
4	44		50	09				
5	34	1202	57	19				
6	24		1203	33				
7	14		15	34				
8	4		22	41				
9	82		32	48				
10	(79)	107	1:15	1:32				
11	72		24	43				
12	62		30	50				
13	52		40	56				
14	42	230	230	308				
15	32		54	21				
16	22	304	306	33				
17	12		18	40				
18	2		30	47				
19	69		4:10	4:32				
20	59	412	18	39				
21	49		30	50				
22	39		45	502				
23	29	503	528	36				
24	19		34	44				
25	9							
26	77							
27	57	606						
28	47							
29	37	630						
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								
41								
42								
43								
44			Fish					
45								
46								
47								
48								
49								
50								

OPERATOR BLEVINS

OVENS PUSHED 24 ✓ COAL CH'G'D (GROSS WET TONS)

OVENS CHARGED 24 ✓ SPILLAGE

PER CH'G'D OVEN (NET WET) COAL CH'G'D (NET WET)

TOTALS

OVENS OFF	TIME PUSHED OUT

COAL CHARGED (NET WET TONS)

1

2

3

TOTAL CHARGED PER OVEN (NET WET TONS)

% H_2O IN COAL

TOTAL COAL CHARGED (DRY TONS)

83

83

OVENS PUSHED

BLOCK NO. 3

DATE 11/13/80 19

SHIFT NO. 1

	OVEN NO.	SCHEDULE	TIME PUSHED	TIME LEVELED	COKING TIME	AMPS. TO PUSH	KIND OF COAL	KIND OF COKE
1	9	210	722	736				
2	22		30	55				
3	57		41	104				
4	47		55	13				
5	32	802	608	21				
6	12		35	49				
7	2		45	202				
8	25		58	10				
9	65		502	18				
10	37	902	16	24				
11	45		1146	1156				
12	35		238	551				
13	(27)		47	55				
14	5	1030	1051	1102				
15	(67)		59	15				
16	83	1104	1112	25				
17	73		21	35				
18	63		32	42				
19	53		35	45				
20	43	1212	1232	1234				
21	(25)		10	51				
22	33		55	110				
23	23	103	103	35				
24	13		31	44				
25	3		35	238				
26	81		215	44				
27	71	206	10	51				
28	61		47	57				
29	51	230	245	1259				
30								
31								
32								
33								
34								
35								
36								
37								
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49								
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OPERATOR J. McCornell

OVENS PUSHED 29 ✓ COAL CH'G'D (GROSS WET TONS)

OVENS CHARGED 29 ✓ SPILLAGE

PER CH'G'D OVEN (NET WET) COAL CH'G'D (NET WET)

SHIFT NO. 2

	OVEN NO.	SCHEDULE	TIME PUSHED	TIME LEVELED	COKING TIME	AMPS. TO PUSH	KIND OF COAL	KIND OF COKE
1	41	310	3:30	3:42	*	COKE	HANDLE	
2	31		45	54				
3	21		48	4:06				
4	11		51	06				
5	1	402	57	12				
6	28		4:02	18				
7	68		08	25				
8	58		12	28				
9	48		15	38		Chest		
10	38	507	19	5:03		X-RAYS		
11	28		54	08				
12	18		57	13				
13	8		505	18				
14	76	630	645	703				
15	66		50	10				
16	(15)	704	58	17				
17	56		707	23				
18	46		23	35				
19	36		23	41				
20	26	812	815	829				
21	16		20	36				
22	6		26	46				
23	84	903	52	59				
24	74		58	9:01				
25	64		0:12	50				
26	54		16	57				
27	44	1006	53	1002				
28	34		29	16				
29	24	1030	14	21				
30								
31								
32								
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OPERATOR Miller

OVENS PUSHED 29 ✓ COAL CH'G'D (GROSS WET TONS)

OVENS CHARGED 29 ✓ SPILLAGE

PER CH'G'D OVEN (NET WET) COAL CH'G'D (NET WET)

SHIFT NO. 3

	OVEN NO.	SCHEDULE	TIME PUSHED	TIME LEVELED	COKING TIME	AMPS. TO PUSH	KIND OF COAL	KIND OF COKE
1	14	1110	1120	1139				
2	4		28	50				
3	82		37	59				
4	72		48	1212				
5	62	1202	57	18				
6	52		1210	25				
7	(29)		16	32				
8	42		22	40				
9	32		105	126				
10	22	107	13	36				
11	12		21	47				
12	2		31	54				
13	69		45	203				
14	59	230	245	304				
15	49		52	12				
16	39	304	302	21				
17	29		10	28				
18	19		18	36				
19	9		405	415				
20	77	412	12	23				
21	57		20	30				
22	47		35	47				
23	37	503	45	54				
24	17		503	510				
25	7		39	44				
26	75		42	54				
27	65	606	53	600				
28	55		602	10				
29	(27)	630	09	18		Chest	X-Rays	
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								
41								
42								
43								
44								
45								
46								
47								
48								
49								
50								

OPERATOR B. Clair

OVENS PUSHED 29 ✓ COAL CH'G'D (GROSS WET TONS)

OVENS CHARGED 29 ✓ SPILLAGE

PER CH'G'D OVEN (NET WET) COAL CH'G'D (NET WET)

TOTALS

OVENS OFF	TIME PUSHED OUT

COAL CHARGED (NET WET TONS)

1.

2.

3.

TOTAL CHARGED PER OVEN (NET WET TONS)

% H_2O IN COAL

TOTAL COAL CHARGED (DRY TONS)

87

IV. PROCESS INFORMATION (continued)

H) Tons of Coal Charged Per Oven

DATE	AVERAGE TONS CHARGED OVEN "TONS"
11/11/80	15.86
11/12/80	15.73
11/13/80	15.73
Average	15.77

1st day Tap

DATE 11-10-80

TO: J.=GEYER G. Hunt
B.=BARKER D. Greene
J.=BOWLING J. Geyer
COAL HANDLING FOREMAN
T. Stewart

NUMBER 3 BATTERY

	7 - 3 SHIFT	3 - 11 SHIFT	11 - 7 SHIFT	AVERAGE
NUMBER OF WEIGHTS AND OVENS CHARGED	16 OF 29	15 OF 29	29 OF 29	60 OF 87
AVERAGE PER OVEN - POUNDS	31743	31396	31992	31710
AVERAGE PER OVEN - TONS	15.87	15.70	16.00	15.86
OVEN FOREMAN	Hamb	Spence	Berry	

NUMBER 4 BATTERY

	7 - 3 SHIFT	3 - 11 SHIFT	11 - 7 SHIFT	AVERAGE
NUMBER OF WEIGHTS AND OVENS CHARGED	23 OF 25	0 OF 25	18 OF 25	41 OF 75
AVERAGE PER OVEN - POUNDS	55789	710	56936	56363
AVERAGE PER OVEN - TONS	27.89	Tape	28.47	28.18
OVEN FOREMAN	Merrifield	Strassburg	Allen	

2nd day 1981

DATE 11-11-80

TO: J.=GEYER G. Hunt
D.=BARKER D. Greene
~~J.=DOWLING~~ J. Geyer
~~COAL HANDLING FOREMAN~~
T. Stewart

NUMBER 3 BATTERY

	7 - 3 SHIFT	3 - 11 SHIFT	11 - 7 SHIFT	AVERAGE
NUMBER OF WEIGHTS AND OVENS CHARGED	28 OF 29	28 OF 29	28 OF 28	84 OF 86
AVERAGE PER OVEN - POUNDS	29206	30310	30405	29974
AVERAGE PER OVEN - TONS	14.60	15.16	15.20	Tons 14.99
OVEN FOREMAN	Harris/Haney Stark	Spence	Fish	→ 15.173 AVG EST 11 days

NUMBER 4 BATTERY

	7 - 3 SHIFT	3 - 11 SHIFT	11 - 7 SHIFT	AVERAGE
NUMBER OF WEIGHTS AND OVENS CHARGED	21 OF 25	14 OF 25	24 OF 25	59 OF 75
AVERAGE PER OVEN - POUNDS	54826	53771	55502	54700
AVERAGE PER OVEN - TONS	27.41	26.89	27.75	27.35
OVEN FOREMAN	Merrifield	Strassburg	Rabbey	

3rd day Trial

DATE 11-12-80

TO: ~~J.~~ GEYER G. Hunt
~~D.~~ BARKER D. Greene
~~J.~~ BOWLING J. Geyer
~~COAL HANDLING FOREMAN~~
T. Stewart

NUMBER 3 BATTERY

	7 - 3 SHIFT	3 - 11 SHIFT	11 - 7 SHIFT	AVERAGE
NUMBER OF WEIGHTS AND OVENS CHARGED	28 OF 28	27 OF 31	24 OF 24	79 OF 83
AVERAGE PER OVEN - POUNDS	29027	30480	30407	29971
AVERAGE PER OVEN - TONS	14.51	15.24	15.20	Too low ~~14.99~~
OVEN FOREMAN	Harris	?	Fisher	15.73 ES AVG. for 11 da

NUMBER 4 BATTERY

	7 - 3 SHIFT	3 - 11 SHIFT	11 - 7 SHIFT	AVERAGE
NUMBER OF WEIGHTS AND OVENS CHARGED	24 OF 25	23 OF 25	24 OF 24	71 OF 74
AVERAGE PER OVEN - POUNDS	54552	55015	55207	54923
AVERAGE PER OVEN - TONS	27.27	27.51	27.60	27.46
OVEN FOREMAN	Merrifield	Strawbridge	Rodeffer	

V. SAMPLING PROCEDURES

A) Sampling Location (See Figure 1)

The outlet sampling point is located near the top of the scrubber outlet stack. The ports are approximately ninety (90) feet down stream from the nearest flow disturbance ($\simeq$ 9 diameters) and approximately twenty-two (22) feet from the top of the stack (>2 diameters). Each of the square ports is 5.0" x 5.25" I. d. and they are located on 90° (perpendicular) diameters. Each port had a twelve (12) point traverse with each traverse point encompassing one oven pushed. (See figure 2).

The duct cross-sectional area was figured as follows:

$$As = \pi r^2$$
$$As = \pi(5')^2$$
$$As = \pi(25) = 78.5398 \sim \underline{78.54\ ft.^2}$$

The traverse points 1 - 12 (same for each port) were calculated as per EPA Method #1 as shown in Table 6.

TABLE 6

TRAVERSE POINT LOCATIONS

Traverse Point	% of Diameter	Duct Diameter (inches)	Location of Traverse Point from Inside Wall of Stack (inches)
1	2.1	120	2.52
2	6.7	120	8.04
3	11.8	120	14.16
4	17.7	120	21.24
5	25.0	120	30.00
6	34.6	120	42.72
7	64.4	120	77.28
8	75.0	120	90.00
9	82.3	120	98.76
10	88.2	120	105.84
11	93.3	120	111.96
12	97.9	120	117.48

FIGURE 1

MINISTER STEIN

SCRUBBER OUTLET

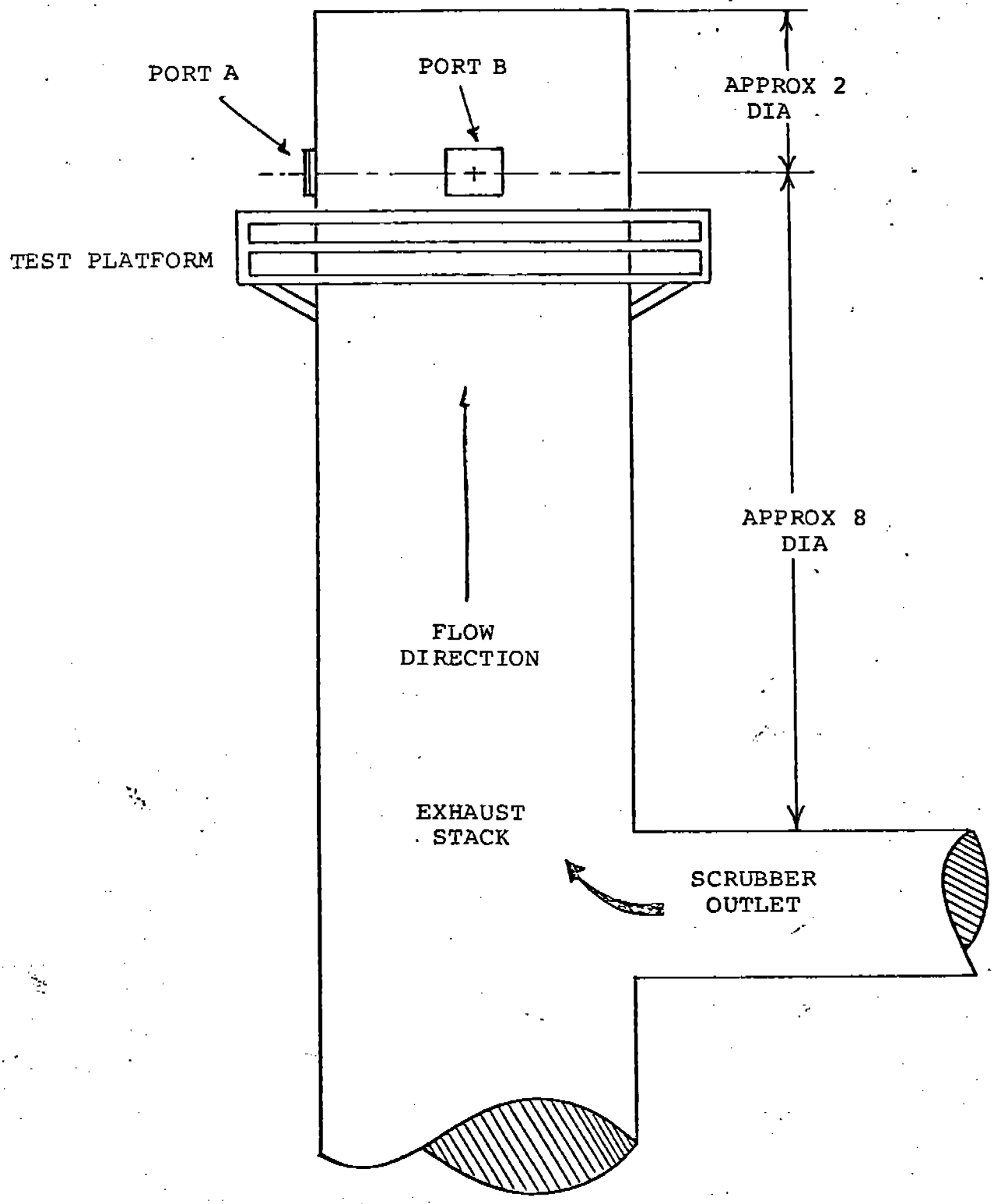
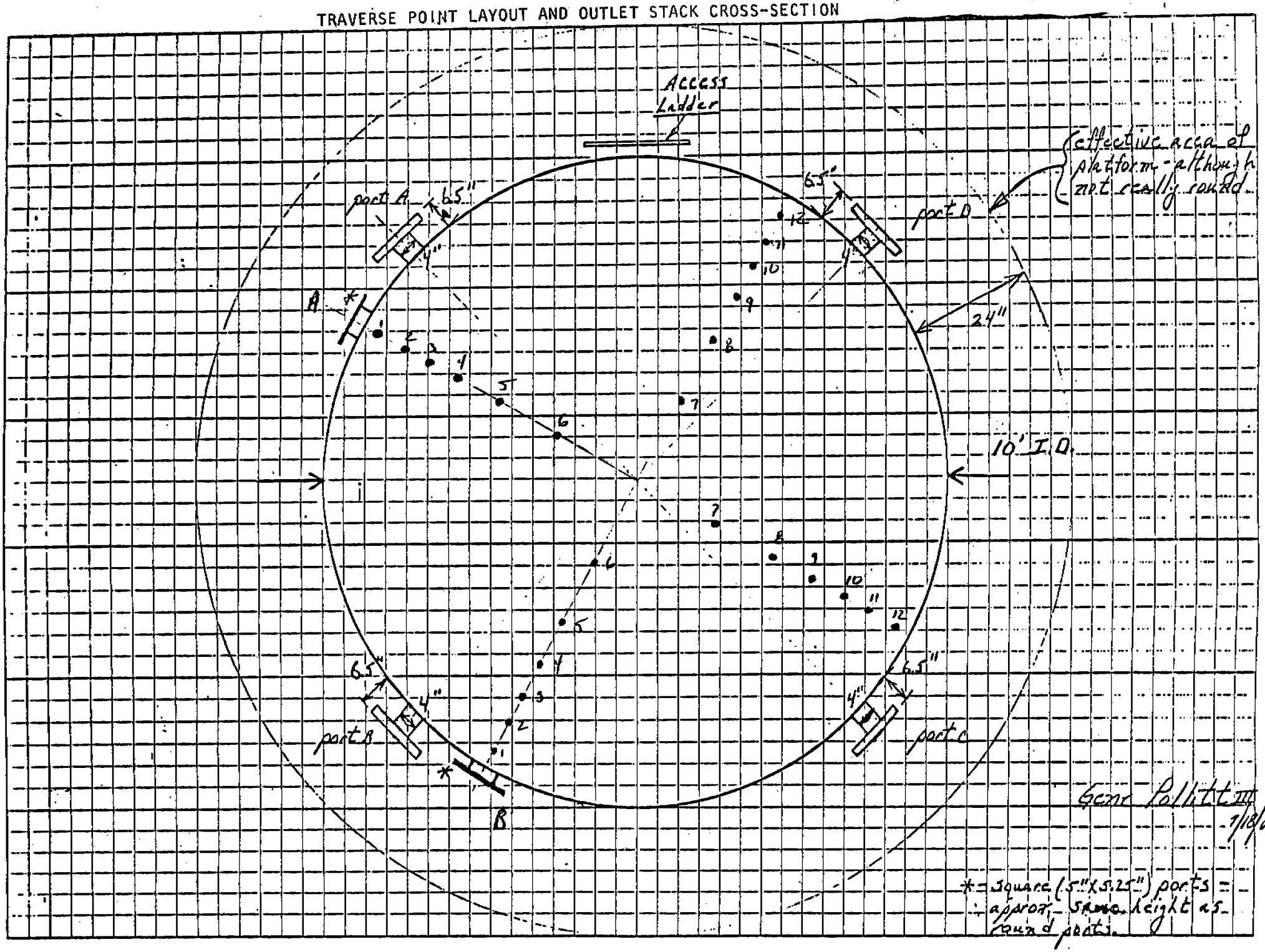


FIGURE 2

TRAVERSE POINT LAYOUT AND OUTLET STACK CROSS-SECTION



V. SAMPLING (continued)

B) Sampling Train

The sampling train used was an Aerotherm High Volume Stack Sampling Unit (see Figure 3). The sampling train was set up to conform to EPA Method 5 parameters.

C) Testing Procedures

All testing was done in accordance with EPA Methods 1, 2, 3, 4, and modified method 5. The modification being (due to the nature of the process) that the sample was collected during the oven pushing cycle. The pushing cycle is defined as: the time when coke enters the quench car until the quench car pulls out from under the hood. Coordinating of the start and stop of the sampling period were performed via observers using sound power communications.

D) Analytical Procedures

All analytical work, beginning with the impinger train clean up (sample recovery), thru the final calculations, were conducted in accordance with EPA Method 5. Sample chain of custody was maintained.

All procedures, including analytical source testing and calibrations, were carried out in accordance with the EPA Source Sampling Methods (40CFR, Part 60, Appendix A, Methods 1 thru 5). See Appendix Two.

E) Leak Checks (See Table 7)

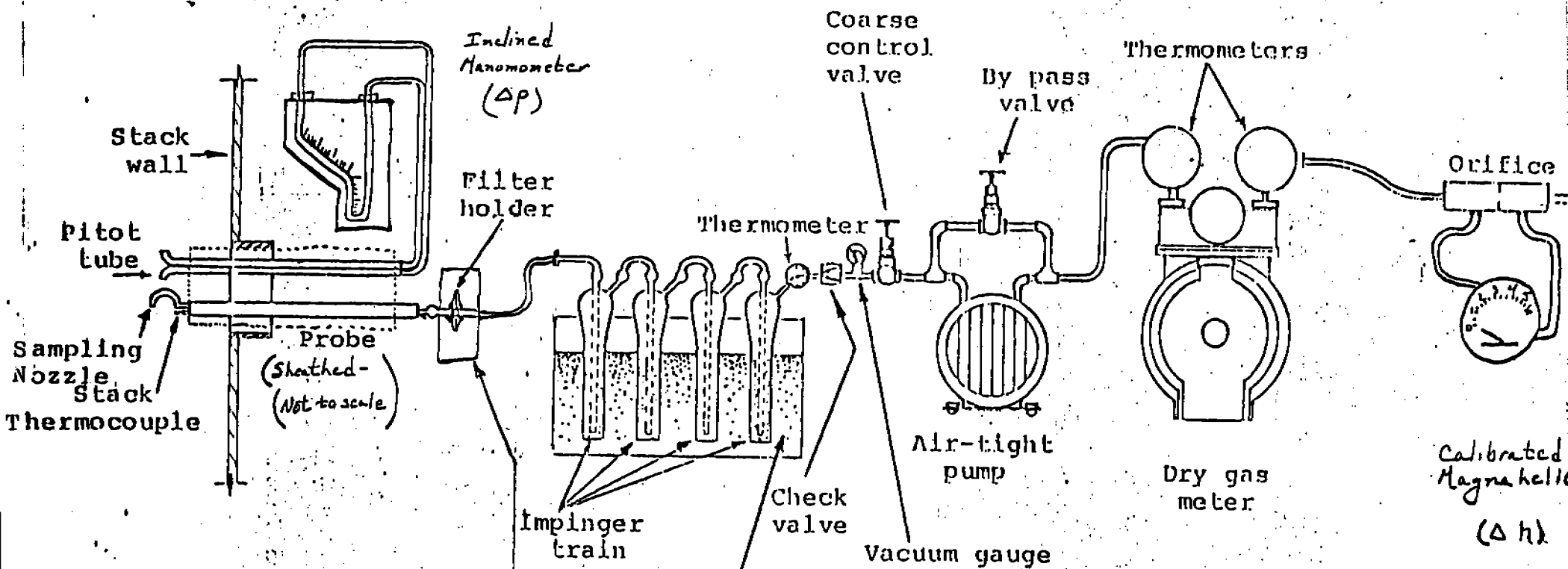
Leak checks were performed on the sampling train before and after every test and on the manometer and pitot tube after every test. These leak checks were witnessed and supervised by Mr. John Jayne, Environmental Specialist, KDAPC. All leak checks conformed to the EPA regulations - Appendix Two, Section 4.1.4.1. page 111.

TABLE 7

	11/11/80	11/12/80	11/13/80
Meter box (pre-test)	Vacuum to +20"Hg-good	Vacuum to +18" Hg-good	Vacuum to +19"Hg-good
Meter box (post-test)	Vacuum to +17"Hg (.005 cfm leakage)	Vacuum to +19.5" Hg-good	Vacuum to +23"Hg (.01 cfm leakage)
Pitot and Manometer	Good @+3" H_2O	Good @+3" H_2O	Positive - good @3.5" H_2O Negative - good @ 5" H_2O

FIGURE 3

MINISTER STEIN OUTLET
SAMPLING TRAIN CONFIGURATION
(Not to scale)



Digital Thermometer Inputs
(not shown)

1) Stack
2) Probe
3) Cyclone
4) Cyclone-filter umbilical
5) Filter case
6) Impinger outlet
7) Gas meter inlet
8) Gas meter outlet

VI. RESULTS

A) Flow Direction Analysis and Preliminary Velocity Traverse

The dimensions of the outlet stack conform to the required "8 and 2" diameter criteria. The air flow was proven to be laminar by the null method as given in the EPA Methods 1-5.

The preliminary velocity and temperature data is given in RAW FIELD DATA (Section VII).

B) Emission Results and Calculations

1) Moisture Test - A preliminary moisture test was conducted on 10/23/80 - see Appendix Two, Method #4. A moisture of approximately 2.0% was found in the stack gas and this moisture content was used to set up the nomograph.

2) Test Run #1 - Calculations (See Attached)

3) Test Run #2 - Calculations (See Attached)

4) Test Run #3 - Calculations (See Attached)

5) Evaluation of Results

The results of these tests are considered valid, with all testing being done in accordance with the appropriate EPA Methods, all test ran being between 100% and 104% isokinetic, and all laboratory results meeting the quality control criteria.

C) Clarifier Overflow Water Analysis

The Minister-Stein scrubber water is processed through a clarifer. This clarifier's overflow was sampled every hour during the stack testing. The analysis of these samples was conducted for total suspended solids and dissolved solids in accordance with the appropriate methods as given in EPA-600/4-79-020, March, 1979. - Methods for Chemical Analysis of Water and Wastes. (See Raw Data and Table 4).

2) TEST RUN #1

Calculations - #3 Battery Minister-Stein

Outlet Stack - Front Half Particulate

Ashland
Minister-Stein Method 5 Particulate Test # 1 Outlet

Calculation Form:

I. Necessary Data

A. No. of Traverse Points 24

B. Total Test Time (θ) 31.375 minutes (1.3072 min/push)

C. Water Collected

1. Impinger H_2O — ml

2. Silica Gel 15 gm

D. Particulate Weight ($^m n$) .0194 gm (front half)

E. Volume Metered

V_m = 58.26 CF X DGMCF (.998) = 58.144 CF

F. Average $\sqrt{\Delta P}$ .415 in H_2O

G. Average ΔH 2.053 in H_2O

H. Average Meter Temperature T_m 53.25 °F + 460 = 513.25 °R

I. Average Stack Temperature T_s 92.02 °F + 460 = 552.02 °R

J. Stack Absolute Pressure $P_{s(abs)} = \left(P_s + \frac{P_{static}}{13.6}\right)$ = 29.29 in. Hg

K. Barometric Pressure 29.78 in. Hg

L. %CO_2 0.4 ; %O_2 19.2 ; %CO 0 ; %N_2 80.4 ;

M. Area of Stack 78.54 ft.^{2}

N. Area of Nozzle .001364 ft.^{2}

11/11/80

Test #1

Coke = 12.32 $\frac{\text{tons}}{\text{oven}}$

pounds emissions per ton of coke = $\frac{\text{lb}}{\text{dscf}} \times \frac{\text{dscf}}{\text{oven}} \div \frac{\text{tons}}{\text{oven}}$

front half - $\frac{\text{lbs.}}{\text{dscf}} \times \frac{\text{dscf}}{\text{oven}} \times \frac{1}{12.32 \frac{\text{tons}}{\text{oven}}} = \frac{\text{lbs.}}{\text{ton}}$ emissions

$= .000000714 \frac{\text{lbs.}}{\text{dscf}} \times 138800.6 \frac{\text{dscf}}{\text{oven}} \times .08116883 \left(\frac{\text{tons}}{\text{oven}}\right)^{-1} = .00804 \frac{\text{lbs.}}{\text{ton}}$

II. Calculations

A. Standard Volume Metered

Y= Dry Gas meter calibration factor

$$V_{m(std)} = V_m Y \frac{T_{std}}{P_{std}} \frac{P_b + \frac{\Delta H}{13.6}}{T_m}$$

$$V_{m(std)} = (58.144 \text{ CF}) \left(\frac{528°R}{29.92 \text{ in.Hg}} \right) \left(\frac{29.93 \text{ in.Hg}}{513.25 \text{ °R}} \right) = 59.835 \text{ dscf}$$

B. Moisture Content of Stack Gas

1. H_2O collected in impingers in standard cubic feet

$$V_{wc(std)} = K (V_f - V_i)$$

$$V_{wc(std)} = 0.04707 \text{ ft.}^3\text{/ml } (____ \text{ ml}) = ____ \text{ scf}$$

2. H_2O collected in Silica Gel in standard cubic feet

$$V_{wsg(std)} = K (W_f - W_i)$$

$$V_{wsg(std)} = 0.04715 \text{ ft.}^3\text{/gm. } (15 \text{ gm}) = .707 \text{ scf}$$

3. Moisture Content of Stack Gas (B_{ws})

$$B_{ws} = \frac{V_{wc(std)} + V_{wsg(std)}}{V_{wc(std)} + V_{wsg(std)} + V_{m(std)}}$$

$$B_{ws} = \frac{(0 \text{ scf}) + (.707 \text{ scf})}{(0 \text{ scf}) + (.707 \text{ scf}) + (59.835 \text{ scf})} = .0117$$

C. Molecular Weight of Stack Gas (lB/lB-mole)

1. M_d (Dry Molecular Weight) = $\Sigma M_x B_x$ (= 28.8 IF AIR ASSUMED)

$$M_d = (44) .4 \%CO_2 + (32) 19.2 \%O_2 + (28) 0 \%CO + (28) 80.4 \%N_2 = 28.832 \text{ lB/lB-mole}$$

2. M_s (Wet Molecular Weight) = $M_d (1-B_{ws}) + 18 B_{ws}$

$$M_s = 28.832 (1 - .0117) + 18(.0117) = 28.70 \text{ lB/lB-mole}$$

#1

D. Average Stack Gas Velocity

$$\bar{V}_s = K_p C_p \left[\frac{T_s}{P_s M_s}\right]^{1/2} \left[\frac{\quad}{\Delta P}\right]$$

$$\bar{V}_s = 85.48 \text{ ft./sec.} \left[\frac{\text{lb/lb-mole(in.Hg)}}{°R(\text{in.}H_2O)}\right]^{1/2} \underline{.84} \left[\frac{(552.02)°R}{(\underline{29.79}\text{ in.Hg})(\underline{28.70}\text{ lb/lb-mole})}\right]^{1/2}$$

$$\left[\underline{.415}\text{ in. }H_2O\right] = \underline{23.944}\text{ ft./sec}$$

E. Average Stack Gas Volumetric Flow Rate

$$\bar{Q}_s = \left(\frac{\text{min}}{\text{push}} \times \frac{\text{sec}}{\text{min}}\right)(\bar{V}_s)(A_s)(1-B_{ws}) \frac{T_{std}}{P_{std}} \frac{P_s}{T_s}$$

$$\bar{Q}_s = (1.307 \times 60)(\underline{23.944}\text{ft./sec})(\underline{78.54}\text{ft.}^2)(1-\underline{.0117}) \frac{528°R}{29.92\text{in.Hg}}$$

$$\left[\frac{\underline{29.79}\text{ in.Hg}}{\underline{552.02}°R}\right] = \underline{138800.6}\text{ dscf/over}$$

F. Pollutant Mass

$$\frac{.0194g}{454g/lb} \times \frac{1}{59.835\text{ dscf}} = \underline{.000000714\text{ lb/dscf}}$$

G. % Isokinetic Variation (Intermediate Data)

$$\%I = \frac{T_s V_{m(std)} P_{std} \; 100}{\theta \bar{V}_s A_n P_s T_{std}(60)(1-B_{ws})}$$

$$\%I = \frac{(\underline{552.02}°R)(\underline{59.835}\text{ dscf})(29.92\text{ in.Hg}) \times 100\%}{(\underline{.00136}\text{ft}^2)(\underline{31.375}\text{ min.})(\underline{23.944}\text{ ft./sec.})(\underline{29.79}\text{ in.Hg})(528°R)(60\text{ sec./min.})(1-\underline{.0117})}$$

$$\%I = \underline{103.4}$$

3) TEST RUN #2

Calculations - #3 Battery Minister-Stein

Outlet Stack - Front Half Particulate

Ashland Minister-Stein Method 5 Particulate Test # 2 Outlet

Calculation Form:

I. Necessary Data

A. No. of Traverse Points 24

B. Total Test Time (θ) 36.71 minutes (1.52958 min/push)

C. Water Collected

1. Impinger H_2O 6.5 ml

2. Silica Gel 19.0 gm

D. Particulate Weight ($^m n$) .0321 gm (front half)

E. Volume Metered

V_m = 66.255 CF X DGMCF (.998) = 66.123 CF

F. Average $\sqrt{\Delta P}$ .414 in H_2O

G. Average ΔH 1.996 in H_2O

H. Average Meter Temperature T_m 49.56 °F + 460 = 509.56 °R

I. Average Stack Temperature T_s 93.56 °F + 460 = 553.56 °R

J. Stack Absolute Pressure $P_{s(abs)} = \left(P_s + \frac{P_{static}}{13.6}\right)$ = 29.90 in. Hg

K. Barometric Pressure 29.89 in. Hg

L. $\%CO_2$ 0.8 ; $\%O_2$ 19.0 ; %CO 0.0 ; $\%N_2$ 80.2 ;

M. Area of Stack 78.54 ft.^{2}

N. Area of Nozzle .001364 ft.^{2}

11/12/80

Test #2

Coke = 12.27 tons/oven

Pounds emissions per ton of coke = $\frac{lb}{dscf} \times \frac{dscf}{oven} \div \frac{tons}{oven}$

$= .000001028 \frac{lbs}{dscf} \times 161256.4 \frac{dscf}{oven} \times .08149959 \left(\frac{tons}{oven}\right)^{-1} = .01342 \frac{lbs}{ton}$

II. Calculations

A. Standard Volume Metered

Y = Dry Gas meter calibration factor

$$V_{m(std)} = V_m Y \frac{T_{std}}{P_{std}} \frac{P_b + \frac{\Delta H}{13.6}}{T_m}$$

$$V_{m(std)} = (66.123 \text{ CF}) \left(\frac{528°R}{29.92 \text{ in.Hg}} \right) \left(\frac{30.04 \text{ in.Hg}}{509.56 °R} \right) = 68.7908 \text{ dscf}$$

B. Moisture Content of Stack Gas

1. H_2O collected in impingers in standard cubic feet

$$V_{wc(std)} = K (V_f - V_i)$$

$$V_{wc(std)} = 0.04707 \text{ ft.}^3\text{/ml } (6.5 \text{ ml}) = .305955 \text{ scf}$$

2. H_2O collected in Silica Gel in standard cubic feet

$$V_{wsg(std)} = K (W_f - W_i)$$

$$V_{wsg(std)} = 0.04715 \text{ ft.}^3\text{/gm. } (19 \text{ gm}) = .89585 \text{ scf}$$

3. Moisture Content of Stack Gas (B_{ws})

$$B_{ws} = \frac{V_{wc(std)} + V_{wsg(std)}}{V_{wc(std)} + V_{wsg(std)} + V_{m(std)}}$$

$$B_{ws} = \frac{(.305955 \text{ scf}) + (.89585 \text{ scf})}{(.305955 \text{ scf}) + (.89585 \text{ scf}) + (68.7908 \text{ scf})} = .01717$$

C. Molecular Weight of Stack Gas (lb/lb-mole)

1. M_d (Dry Molecular Weight) = $\Sigma M_x B_x$ (= 28.8 IF AIR ASSUMED)

$$M_d = (44)\ .8\ \%CO_2 + (32)\ 19.0\ \%O_2 + (28)\ 0\ \%CO + (28)\ 80.2\ \%N_2 = 28.888 \text{ lb/lb-mole}$$

2. M_s (Wet Molecular Weight) = $M_d (1-B_{ws}) + 18 B_{ws}$

$$M_s = 28.888\ (1 - .01717) + 18(.01717) = 28.701 \text{ lb/lb-mole}$$

#2

D. Average Stack Gas Velocity

$$\bar{V}_s = K_p C_p \left[\frac{T_s}{P_s M_s}\right]^{1/2} \left[\overline{\Delta P}\right]$$

$$\bar{V}_s = 85.48 \text{ ft./sec.} \left[\frac{\text{lb/lb-mole(in.Hg)}}{°R(\text{in.}H_2O)}\right]^{1/2} \frac{.84}{} \left[\frac{(553.56)°R}{(29.9 \text{ in.Hg})(28.701 \text{ lb/lb-mole})}\right]$$

$$\left[.414 \text{ in.}H_2O\right] = 23.875 \text{ ft./sec}$$

E. Average Stack Gas Volumetric Flow Rate

$$\bar{Q}_s = \left(\frac{\text{min}}{\text{hr}} \times \frac{\text{sec.}}{\text{min}}\right)(\bar{V}_s)(A_s)(1-B_{ws}) \frac{T_{sid}}{P_{sid}} \frac{P_s}{T_s}$$

$$\bar{Q}_s = (1.52958 \times 60)(23.875 \text{ ft./sec})(78.54 \text{ ft.}^2)(1-.01717) \frac{528°R}{29.92 \text{ in.Hg}}$$

$$\left[\frac{29.90 \text{ in.Hg}}{553.56°R}\right] = 161218.87 \text{ dscf/HREN}$$

F. Pollutant Mass

$$\frac{.0321 g}{454 g/lb} \times \frac{1}{68.7908 \text{ dscf}} = .000001028 \frac{lb}{dscf}$$

G. % Isokinetic Variation (Intermediate Data)

$$\%I = \frac{T_s V_{m(sid)} P_{sid} \; 100}{\theta \bar{V}_s A_n P_s T_{sid}(60)(1-B_{ws})}$$

$$= \frac{(553.56°R)(68.7908 \text{ dscf})(29.92 \text{ in.Hg}) \times 100\%}{(.00136 \text{ ft}^2)(36.71 \text{ min.})(23.875 \text{ ft./sec.})(29.9 \text{ in.Hg})(528°R)(60 \text{ sec./min.})(1-.01717)}$$

$$\%I = 102.4$$

4) TEST RUN #3

Calculations - #3 Battery Minister-Stein

Outlet Stack - Front Half Particulate

Ashland
Minister-Stein Method 5 Particulate Test # 3 Outlet

Calculation Form:

I. Necessary Data

A. No. of Traverse Points 24

B. Total Test Time (θ) 44.14 minutes (1.83916 min/pnt)

C. Water Collected

1. Impinger H_2O 26 ml

2. Silica Gel 10 gm

D. Particulate Weight ($^m n$) .0118 gm (front half)

E. Volume Metered

V_m = 82.305 CF X DGMCF (.998) = 82.140 CF

F. Average $\sqrt{\Delta P}$ .428 in H_2O

G. Average ΔH 2.099 in H_2O

H. Average Meter Temperature T_m 52.0°F + 460 = 512.0 °R

I. Average Stack Temperature T_s 99.7 °F + 460 = 559.7 °R

J. Stack Absolute Pressure $P_{s(abs)} = \left(P_s + \frac{P_{static}}{13.6}\right)$ = 29.57 in. Hg

K. Barometric Pressure 29.56 in. Hg

L. $\%CO_2$ .2 ; $\%O_2$ 18.8 ; %CO .2 ; $\%N_2$ 79.8 ;

M. Area of Stack 78.54 $ft.^2$

N. Area of Nozzle .001364 $ft.^2$

11/13/80

Test #3

Coke = 12.27 tons/oven

Pounds emissions per ton of coke = $\frac{lb}{dscf} \times \frac{dscf}{oven} \div \frac{tons}{oven}$

$= .000000309 \frac{lbs}{dscf} \times 199078.4 \frac{dscf}{oven} \times .08149959 \left(\frac{tons}{oven}\right)^{-1} = \underline{.00501 \frac{lbs}{ton}}$

II. Calculations

A. Standard Volume Metered

Y= Dry Gas meter calibration factor

$$V_{m(std)} = V_m Y \frac{T_{std}}{P_{std}} \frac{P_b + \frac{\Delta H}{13.6}}{T_m}$$

$$V_{m(std)} = (\underline{82.14}\ CF)\left(\frac{528°R}{29.92\ in.Hg}\right)\left(\frac{29.71 + \frac{\Delta H}{13.6}\ in.Hg}{512\ °R}\right) = \underline{84.124}\ dscf$$

B. Moisture Content of Stack Gas

1. H_2O collected in impingers in standard cubic feet

$$V_{wc(std)} = K\ (V_f - V_i)$$

$$V_{wc(std)} = 0.04707\ ft.^3/ml\ (\underline{2.6}\ ml) = \underline{1.224}\ scf$$

2. H_2O collected in Silica Gel in standard cubic feet

$$V_{wsg(std)} = K\ (W_f - W_i)$$

$$V_{wsg(std)} = 0.04715\ ft.^3/gm.\ (\underline{10}\ gm) = \underline{.4715}\ scf$$

3. Moisture Content of Stack Gas (B_{ws})

$$B_{ws} = \frac{V_{wc(std)} + V_{wsg(std)}}{V_{wc(std)} + V_{wsg(std)} + V_{m(std)}}$$

$$B_{ws} = \frac{(\underline{1.224}\ scf) + (\underline{.4715}\ scf)}{(\underline{1.224}\ scf) + (\underline{.4715}\ scf) + (\underline{84.124}\ scf)} = \underline{.019754}$$

C. Molecular Weight of Stack Gas (lb/lb-mole)

1. M_d (Dry Molecular Weight) = $\Sigma\ M_x\ B_x$ (= 28.8 IF AIR ASSUMED)

M_d = (44) .2 %CO_2 + (32) 18.8 %O_2 + (28) .2 %CO + (28) 79.8 %N_2 =

28.504 lb/lb-mole

2. M_s (Wet Molecular Weight) = $M_d\ (1-B_{ws}) + 18\ B_{ws}$

M_s = 28.504 (1- .0198) + 18(.0198) = 28.2960 lb/lb-mole

D. Average Stack Gas Velocity

$$\bar{V}_s = K_p C_p \left[\frac{T_s}{P_s M_s}\right]^{1/2} \left[\overline{\Delta P}\right]$$

$$\bar{V}_s = 85.48 \text{ ft./sec.} \left[\frac{\text{lb/lb-mole(in.Hg)}}{°R(\text{in.}H_2O)}\right]^{1/2} \frac{.84}{} \left[\frac{(559.7)°R}{(29.57 \text{ in.Hg})(28.296 \text{ lb/lb-mole})}\right]$$

$$\left[.428 \text{ in.}H_2O\right] = 25.1349 \text{ ft./sec}$$

E. Average Stack Gas Volumetric Flow Rate

$$\bar{Q}_s = \left(\frac{\text{min}}{\text{push}} \times \frac{\text{sec}}{\text{min}}\right)(\text{[redacted]})(\bar{V}_s)(A_s)(1-B_{ws}) \frac{T_{std}}{P_{std}} \frac{P_s}{T_s}$$

$$\bar{Q}_s = \left(\frac{1.83917 \times 60}{}\right)(\text{[redacted]})(25.1349 \text{ ft./sec})(78.54 \text{ ft.}^2)(1-.0198) \frac{528°R}{29.92 \text{ in.Hg}}$$

$$\left[\frac{29.57 \text{ in.Hg}}{559.7 °R}\right] = 199078.4 \text{ dscf/oven}$$

F. Pollutant Mass

$$\frac{.0118 \text{ g}}{454 \text{ g/lb}} \times \frac{1}{84.124 \text{ dscf}} = .000000309 \text{ lb/dscf}$$

G. % Isokinetic Variation (Intermediate Data)

$$\%I = \frac{T_s V_{m(std)} P_{std} \; 100}{\theta \bar{V}_s A_n P_s T_{std}(60)(1-B_{ws})}$$

$$I = \frac{(559.7°R)(84.124 \text{ dscf})(29.92 \text{ in.Hg}) \times 100\%}{(.00136 \text{ ft}^2)(44.14 \text{ min.})(25.1349 \text{ ft./sec.})(29.57 \text{ in.Hg})(528°R)(60 \text{ sec./min.})(1-.0198)}$$

$$\%I = 101.4$$

VII. RAW FIELD DATA

See Attached Sheets

A) PRELIMINARY VELOCITY TRAVERSE

T_{probe} = 250°F

$T_{filter\ heater}$ = 250°F

PLANT Ashland Coke

DATE 10/7/80

LOCATION Minister-Stein - Outlet #3 battery

STACK I.D. 10'

BAROMETRIC PRESSURE, in. Hg 29.92

STACK GAUGE PRESSURE, in. H_2O

OPERATORS G. Pollitt, C. Holtzapfel

SCHEMATIC OF TRAVERSE POINT LAYOUT

oven number	TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F	ΔG.M. Reading ft³	Imp. Temp. °F	Ø. G.M. Inlet Temp. °F	ΔG.M. outlet Temp. °F
73	12 Ⓐ	.30/.31	88/89	107.40	61	—	
53	11	.28/.29/.28	89/90/91	108.605	61	—	
43	10	.31/.29/.30	91/92/92	110.39	61	—	
33	9	.32/.32/.32	91/91/91	112.04	61	65	64
23	8	.29/.29/.32	92/92/92	113.96	61	66	64
13	7	.29/.30/.39	94	116.00	61	68	67
81	6	.35/.33/.33/.34	89	120.59	62	69	67
71	5	.34/.33/.34/.35	93.5	127.00	62	69	66
61	4	.34/.34/.35	94.75	129.215	63	70	68
57	3	.30/.32/.32	95		63	71	68
41	2	.32/.29/.30/.31	96		63	71	69
31	1	.29/.28/.29	94		62	73	72
1	12 Ⓑ	.30/.29/.31/.29	97		63	76	74
7B	11	.33/.32/.30	95.5		64	76	74
6B	10	.34/.30/.29	93		64	76	75
5B	9	.34/.35/.33/.34	97		65	76	75
4B	8	.35/.34/.30/.35	98.5		70	76	75
3B	7	.35/.33/.32/.31	99		72	76	75
2B	6	.32/.33/.30/.32	101		67	76	75
1B	5	.32/.34/.35	101		65	76	74
B	4	.325/.33/.34/.32	101		64	77	75
	stopped using hood						
				163.10			
	AVERAGE	.319	94.8		AVERAGE	73	71.1

55.7

72°F

B.) NOMOGRAPH DATA

PLANT Ashland Coke

DATE (for) 11/11/80

SAMPLING LOCATION M-5 outlet

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	.328
AVERAGE METER TEMPERATURE (AMBIENT + 20°F), °F	$T_{m_{avg.}}$	~ 75
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B_{wo}	~ 2.5
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	29.85
STATIC PRESSURE IN STACK, in. Hg ($P_m \pm 0.073$ x STACK GAUGE PRESSURE in in. H_2O)	P_s	+.3
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	≃ 1
AVERAGE STACK TEMPERATURE, °F	$T_{s_{avg.}}$	95
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	.30
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	.36
C FACTOR		
CALCULATED NOZZLE DIAMETER, in.	.500"	
ACTUAL NOZZLE DIAMETER, in.	.500"	
REFERENCE Δp, in. H_2O	.162	

Pre Leak check - +20" Hg - good 2nd III

Post L.C. - +17" Hg .005 cft/min Leakage. EWB

Pitot L.C. OK - +5" H2O

FIELD DATA

PLANT Ashland Coke
DATE 11/11/90
SAMPLING LOCATION M-5 outlet
SAMPLE TYPE Part (#5)
RUN NUMBER #1 Compliance
OPERATOR G. Pollitt
AMBIENT TEMPERATURE ~
BAROMETRIC PRESSURE 29.28
STATIC PRESSURE, (P_s) +.2" H2O
FILTER NUMBER (s) #1

PROBE LENGTH AND TYPE 10' heated
NOZZLE I.D. .500"
ASSUMED MOISTURE, % 3%
SAMPLE BOX NUMBER
METER BOX NUMBER Hero-100(
METER $\Delta H_@$ .556
C FACTOR .998
PROBE HEATER SETTING 250°F
HEATER BOX SETTING 250°F
REFERENCE Δp

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY Hish ~~MINUTES~~

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	~~SAMPLE BOX~~ TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
			642.075									
4	1	1.6 7:42	642.075 - 644.875	.15	1.8	1.8	80 84	35	34	3	250	33
82	2	1.0 7:50	644.875 - 646.525	.15	1.8	1.8	80 83	37	37	3	#	34
72	3	1.5 8	646.525 - 649.20	.15	1.6	1.6	85 - 85	40	38	3.5	250	37
62	4	1.3 8:20	649.20 - 651.447	.15	1.8	1.8	85 86	42	40	3.5		38
52	5	1.0	651.447 - 653.020	.15	1.8	1.8	85	45	42	3.5		41
42	6	1.5 8:40	653.020 - 656.080	.23	2.7	2.7	85 86	45	44	3.0		43
32	7	1.2 9:00	656.080 - 658.410	.17	2.0	2.0	94	48	46	3.0	250	46
22	8	1.15 9:10	658.410 - 660.535	.17	2.0	2.0	93 94	50	48	3.0	250	49
12	9	1.3 9:20	660.535 - 662.80	.15	1.76	1.76	96 90	51	49	3.0	250	54
2	10	1.1 9:30	662.80 - 664.735	.15	1.76	1.76	95 96	53	51	3.0	251	55
69	11	1.3 9:42	664.735 - 667.975	.14	1.66	1.66	96 97	54	53	3.0	250	54
49	12	1.25 10:40	667.975 - 669.720	.14	1.66	1.66	91	61	60	3.0	250	57
24	1	1.7 11:28	669.720 - 672.146	.15	1.8	1.8	97 98	58	58	2.5	253	57
19	2	1.4 11:35	672.146 - 674.730	.17	2.0	2.0	95 96	57	58	2.5	250	57.0
77	3	1.3 11:55	674.730 - 677.16	.14	2.13	2.13	89 90	58	58	2.5	250	56
19	4	1.3 12:05	677.160 - 679.65	.18	2.13	2.13	95	58	59	2.5	250	56
57	5	1.1 12:30	679.65 681.79	.19	2.25	2.25	94 95	60	60	2.5	252	56
47	6	1.3 12:40	681.79 - 684.165	.19	2.25	2.25	95 96	61	60	2.5	250	58
37	7	1.2 1:03	684.165 686.492	.19	2.25	2.25	93 94	63	62	2.5	251	59
27	8	1.4 1:13	686.492 689.253	.20	2.38	2.38	97 98	64	63	2.5	250	60
17	9	1.3 1:45	689.253 - 691.841	.20	2.38	2.38	90 91	65	64	2.5	250	55
7	10	1.5 1:55	691.841 694.850	.20	2.38	2.38	95 96	61	65	2.5	250	52
75	11	1.4 2:05	694.850 697.724	.22	2.6	2.6	100 101	58	64	2.5	250	53
65	12	1.3 2:15	697.724	.20	2.38	2.38	100	57	62	2.5	250	50

COMMENTS:

31.375 700.335 58.26 Tap = .4150 2.053 92.02 53.25

Pre-test L.C. - good + 18" Hg.
Post-test L.C. - good + 19.5" Hg
(.02/min)

FIELD DATA

Pitot L.C. → good +3" H_2O

PLANT Ashland
DATE 11/12/80
SAMPLING LOCATION M-3 outlet
SAMPLE TYPE Method 5
RUN NUMBER #2 Compliance
OPERATOR Gene Pollitt (CJH)
AMBIENT TEMPERATURE ~40°F →
BAROMETRIC PRESSURE 29.89
STATIC PRESSURE, (P_s) +.2" H_2O
FILTER NUMBER (s) #4

PROBE LENGTH AND TYPE 10' Heated
NOZZLE I.D. .500"
ASSUMED MOISTURE, % 3%
SAMPLE BOX NUMBER —
METER BOX NUMBER Aero-100
METER $\Delta H_@$ .328
C FACTOR .998
PROBE HEATER SETTING 250°F
HEATER BOX SETTING 250°F
REFERENCE Δp:

.163
.160

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY Push [redacted]

	TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
				704.395									
59	1	1.4	7:43	706.915	.155	1.8	1.8	84	34	36	2.0	250	32
49	2	1.8	7:53	706.915 - 710.242	.18	2.05	2.05	87 89	35	36	2.5	250	34
39	3	1.42	8:04	710.242 - 712.840	.17	1.95	1.95	92	39	38	2.5	250	39
29	4	1.3	8:13	712.840 - 715.330	.20	2.30	2.30	92	41	40	2.5	250	37
19	5	1.4	8:35	715.330 - 717.890	.17	1.95	1.95	91 92	46	44	2.5	251	46
9	6	1.5	8:40	717.890 - 720.492	.15	1.75	1.75	92 93	48	45	2.5	250	49
77	7	1.5	8:50	720.492 - 723.205	.17	1.95	1.95	89, 91	49	46	2.5	249	52
57	8	1.5	9:14	723.205 - 725.924	.16	1.85	1.85	91, 92	50	49	2.5	250	56
47	9	1.7	9:25	725.924 - 728.895	.15	1.75	1.75	98, 99	51	49	2.5	250	60
37	10	1.6	9:30	728.895 - 731.656	.15	1.75	1.75	95, 96	51	50	2.5	250	67
27	11	1.4	10:40	731.656 - 734.160	.17	1.95	1.95	84, 86	55	55	2.5	250	54
17	12	1.85	10:45	734.160 - 736.852	.10	1.15	1.15	87 88	54	55	2.5	250	54
75	1	2.2	11:03	736.852 - 739.850	.10	1.15	1.15	88, 90	55	55	2.0	250	59
65	2	1.6	11:27	739.850 - 742.505	~~.15~~ .15	1.75	1.75	96 97	56	56	2.5	250	68
55	3	1.7	11:40	742.505 - 745.455	.15	1.75	1.75	99, 100, 101	56	56	2.5	250	67
35	4	1.4	12:23	745.455 - 748.140	.20	2.30	2.30	93, 94 95	58	55	2.5	250	69
25	5	1.62	12:30	748.140 - 751.275	.20	2.30	2.30	100 101	57	55	2.5	250	66
(5)	6	1.7	1:24	751.275 - 754.590	.20	2.30	2.30	92 93	57	55	2.5	250	58
(67)	7	1.5	1:33	754.590 - 757.566	.21	2.40	2.40	96 97	57	56	2.5	250	61
(83)	8	1.3	1:41	757.566 - 760.164	.21	2.40	2.40	96 97	57	56	2.5	250	55
(73)	9	1.42	1:46	760.164 - 763.057	.22	2.55	2.55	99 100	56	56	2.5	250	57
(63)	10	1.20	2:07	763.057 - 765.525	.22	2.55	2.55	95 96	51	54	2.5	250	48
(53)	11	1.30	2:12	765.525 - 768.114	.20	2.30	2.30	98, 99	51	54	3.0	250	49
(43)	12	1.40	2:21	768.114 - 770.650	.17	1.95	1.96	98 99	50	54	2.5	251	52

COMMENTS:

Pushed 45 ft closed dampers

36.71 | 770.650 | 66.255 | Top = .414 | 1.996 | 93.56 | 49.56

Pre-test L.C. - good → +19" Hg.
Post-test L.C. - good - 28" Hg
(leaked @ .01 ft³/min)
EWB

FIELD DATA

Pitot L.C. +5" H2O (neg) +3.5" H2O (pos)
EWB
AGS

PLANT Ashland Coke
DATE 11/13/80
SAMPLING LOCATION Minster Stein outlet
SAMPLE TYPE Method #5
RUN NUMBER #3
OPERATOR G. Pollitt, C.J. Holtzapfel
AMBIENT TEMPERATURE ~ 35°F ~
BAROMETRIC PRESSURE
STATIC PRESSURE, (P_s) +.2" H2O
FILTER NUMBER (s) #5

PROBE LENGTH AND TYPE 10' Heated
NOZZLE I.D. .500"
ASSUMED MOISTURE, % 3.90
SAMPLE BOX NUMBER —
METER BOX NUMBER Aero-100
METER $\Delta H_@$ .328
C FACTOR .998
PROBE HEATER SETTING 250°F
HEATER BOX SETTING 250°F
REFERENCE Δp .163 - .160

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY Push

	TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
				775.037									
77	1	1.52	7:30	775.037 - 777.745	.17	1.95	1.95	84 85	37	37	2.5	250	37
57	2	3.3	7:42	777.745 - 783.833	.18	2.05	2.05	90, 91, 93	36	37	2.5	250	37
47	3	1.5	7:58	783.833 - 786.550	.17	1.95	1.95	92 93	37	38	2.2	248	36
37	4	1.6	8:05	786.550 - 789.510	.18	2.05	2.05	92, 93	38	39	2.5	249	38
27	5	1.5	8:36	789.510 - 792.396	.20	2.30	2.30	85, 86	41	42	2.5	250	37
7	6	1.6 (1.3)	8:42	792.396 - 795.414	.19	2.18	2.18	92, 93	42	42	2.5	247	40
75	7	1.6	8:58	795.414 - 801.016	(.20) .23 (.16)	2.6 (2.3)	2.60	97, 98, 100	44	43	3.0	250	41
65	8	2.1	9:05	801.016 - 805.236	.22	2.50	2.50	100, 101	45	44	3.0	250	45
55	9	1.6	9:12	805.236 - 808.435	.21	2.40	2.40	97, 98	47	45	2.5	250	48
35	10	1.5	9:35	808.435 - 811.382	.21	2.40	2.40	93, 94, 95	49	47	2.25	250	45
27	11	1.5	9:46	811.382 - 814.310	.20	2.30	2.30	94, 95	50	48	2.5	251	46
5	12	1.3	10:49	814.310 - 816.872	.20	2.30	2.3	94, 95	55	55	2.25	250	50
83	1	1.9	11:09	816.872 - 819.986	.15	1.7	1.7	103, 102	54	55	2.5	250	48
73	2	1.8	11:20	819.986 - 823.050	.15	1.7	1.7	104, 105	55	55	3.0	250	56
63	3	1.86	11:32	823.050 - 826.266	.15	1.7	1.7	108, 109	56	56	2.5	250	58
53	4	1.5	11:37	826.266 - 828.837	.15	1.7	1.7	107,	57	56	2.5	250	62
45	5	1.6	11:43	828.837 - 831.705	.17	1.95	1.95	105, 106	58	57	3.0	250	64
43	6	1.9	12:26	831.705 - 835.010	.15	1.7	1.7	105, 106, 109	62	60	2.5	250	61
25	7	1.5	12:28	835.010 - 837.668	.17	1.95	1.95	109, 110	62	61	2.5	250	67
33	8	2.5	12:53	837.668 - 842.555	.20	2.30	2.30	109, 110, 111	64	62	2.5	250	66
23	9	3.0	1:01	842.555 - 848.368	.19	2.2	2.20	108, 109,	66	63	2.5	250	68
13	10	1.6	1:30	848.368 - 851.347	.18	2.05	2.05	104	65	66	2.5	248	69
3	11	1.75	1:37	851.347 - 854.525	.17	1.95	1.95	105, 106	66	65	3.5	250	69
81	12	1.41	2:14	854.525 -	.20	2.3	2.3	104, 104	65	66	3.0	250	67

COMMENTS:

θ=44.14 857.342 82.305 $\bar{r}_p$=.428 2099 99.79 52

VIII. LABORATORY REPORT

A) Acetone Purity (See lab data sheets attached)

The acetone used for rinsing the front half of the sampling train was tested ("blank run") as described in Appendix Two, EPA Method #5, Section 4.2, Page 114. (See Table 8)

TABLE 8

ACETONE RINSE WEIGHINGS

Test	Tare Weight(g)	Final Weight(g)	Weight Gain(g)
#1	109.1082	109.1082	.0130
#2	108.8371	108.8632	.0261
#3	111.7827	111.7861	.0034

B) Train Clean-Up (See lab data sheets attached)

The impinger train(s) were cleaned and all of the sample recovered in accordance with EPA Method 5, Section 4.2, pp. 112-114 (Appendix Two).

C) Filter Weighings

All filters were desiccated and weighed according to EPA Methods.

Final weighings are seen in Table 9.

TABLE 9

FILTER WEIGHINGS

Test Run	Tare Weight(g)	Final Constant Weight(g)	Weight Gain(g)
#1	1.0800	1.0866	.0066
#2	1.0741	1.0801	.0060
#3	1.1186	1.1272	.0086

D) ORSAT Analysis

See Tables 10, 11, 12, attached.

E) Lab Data Sheets

(See Following)

TABLE 10

DRY MOLECULAR WEIGHT DETERMINATION

PLANT Ashland Coke
DATE November 11, 1980
SAMPLING TIME (24-hr CLOCK) 7 - 2 (~ 1 min x ~ 30 samples)
SAMPLING LOCATION Minister Stein Outlet
SAMPLE TYPE (BAG, INTEGRATED, CONTINUOUS) Composite
ANALYTICAL METHOD ORSAT
AMBIENT TEMPERATURE
OPERATOR G. Pollitt, J. L. Jones

COMMENTS:

RUN / GAS	1		2		3		AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS (DRY BASIS) M_d, lb/lb-mole
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET			
CO_2	.4	.4					.4	44/100	.176
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2 READING)	19.6	19.2					19.2	32/100	6.144
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2 READING)	19.6	0					0	28/100	0
N_2 (NET IS 100 MINUS ACTUAL CO READING)		80.4					80.4	28/100	22.512
								TOTAL	28.83

TABLE 11

DRY MOLECULAR WEIGHT DETERMINATION

PLANT Ashland Coke
DATE November 12, 1980
SAMPLING TIME (24-hr CLOCK)
SAMPLING LOCATION Minister Stein Outlet
SAMPLE TYPE (BAG, INTEGRATED, CONTINUOUS) Composite
ANALYTICAL METHOD ORSAT
AMBIENT TEMPERATURE
OPERATOR J. L. Jones

COMMENTS:

GAS \ RUN	1		2		3		AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS (DRY BASIS) M_d, lb/lb-mole
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET			
CO_2	.8	.8					.8	44/100	.352
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2 READING)	19.8	19.0					19.0	32/100	6.08
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2 READING)	19.8	0					0	28/100	0
N_2 (NET IS 100 MINUS ACTUAL CO READING)		80.2					80.2	28/100	22.456
								TOTAL	28.888

TABLE 12

DRY MOLECULAR WEIGHT DETERMINATION

PLANT Ashland Coke
DATE November 13, 1980
SAMPLING TIME (24-hr CLOCK)
SAMPLING LOCATION Minister Stein Outlet
SAMPLE TYPE (BAG, INTEGRATED, CONTINUOUS) Composite
ANALYTICAL METHOD ORSAT
AMBIENT TEMPERATURE
OPERATOR J. L. Jones

COMMENTS:

RUN / GAS	1		2		3		AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS (DRY BASIS) M_d, lb/lb-mole
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET			
CO_2	.2	.2					.2	44/100	.088
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2 READING)	19.0	18.8					18.8	32/100	6.016
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2 READING)	19.2	.2					.2	28/100	.056
N_2 (NET IS 100 MINUS ACTUAL CO READING)		79.8					79.8	28/100	22.344
								TOTAL	28.504

Research Appliance Company, Route 8, Gibsonia, Pa. 15044

ENVIRONMENTAL CONTROL LABORATORY

ROUTINE REPORT FORM

To: J. Welch SAMPLE NO. Test #1 PROJECT NO. 1980-90-001

Source: Ashland Coke - Minston Stem Scrubber - Thickener Overflow

Sample Date: 11/11/80 Sample Time: Sample Collected By: B J Vance

Lab. Reference: 1105 Pg 40

Parameter	Sample No.	Time Value
~~Acidity~~	5989	7 AM
~~Alkalinity~~	5989	7 AM
~~Biochemical Oxygen Demand~~	5990	8 AM
~~Chemical Oxygen Demand~~	5990	8 AM
~~Chloride~~	5991	9 AM
~~Cyanide~~	5991	9 AM
~~Dissolved Solids~~	5992	10 AM
~~Fecal Coliform~~	5992	10 AM
~~Fluoride~~	5993	11 AM
~~Hardness~~	5993	11 AM
~~Iron~~	5994	12 Noon
~~Amm Nitrogen~~	5994	12 Noon
~~Oil & Grease~~	5995	1 PM
~~pH~~	5995	1 PM
~~Phenols~~	5996	2 PM
~~Residual Chlorine~~	5996	2 PM
~~Suspended Solids~~		
~~Total Solids~~		

Parameter	Units	Value	
Suspended Solid	mg/L	32	597
TOTAL Solids	mg/L	629	
Suspended Solids	mg/L	53	592
TOTAL Solids	mg/L	645	
Suspended Solids	mg/L	16	648
TOTAL Solids	mg/L	664	
Suspended Solids	mg/L	15	684
TOTAL Solids	mg/L	699	
Suspended Solids	mg/L	4	671
TOTAL Solids	mg/L	675	
Suspended Solids	mg/L	15	736
TOTAL Solids	mg/L	751	
Suspended Solids	mg/L	22	767
TOTAL Solids	mg/L	789	
Suspended Solids	mg/L	7	765
TOTAL Solids	mg/L	772	

cc:

Analysis by: B J Vance

Analysis Date 11/14/80

Approved by: John J Welch

Date Report Issued Verbal: Written:

Form #2

Roberts Prtg. Co. 4 Ironton, Ohio

ENVIRONMENTAL CONTROL LABORATORY

ROUTINE REPORT FORM

To: J. Welch SAMPLE NO. Test #2 PROJECT NO. 6580-90-001

Source: Ashland Coke - Minister Stein Scrubber - Thickener overflow

Sample Date: 11/12/80 Sample Time: Sample Collected By: [illegible]

Lab. Reference: 1105 Pg 43

Parameter	Sample Units No.	Time Value
[redacted]	6009	7 AM
[redacted]	6009	7 AM
[redacted]	6010	8 AM
[redacted]	6010	8 AM
[redacted]	6011	9 AM
[redacted]	6011	9 AM
[redacted]	6012	10 AM
[redacted]	6012	10 AM
[redacted]	6013	11 AM
[redacted]	6013	11 AM
[redacted]	6014	12 Noon
[redacted]	6014	12 Noon
[redacted]	6015	1 PM
[redacted]	6015	1 PM
[redacted]	6016	2 PM
[redacted]	6016	2 PM
[redacted]		
[redacted]		

Parameter	Units	Value	
Suspended Solids	mg/L	30	769
Total Solids	mg/L	799	
Suspended Solids	mg/L	60	620
Total Solids	mg/L	680	
Suspended Solids	mg/L	14	825
Total Solids	mg/L	839	
Suspended Solids	mg/L	14	751
Total Solids	mg/L	765	
Suspended Solids	mg/L	11	813
Total Solids	mg/L	824	
Suspended Solids	mg/L	8	806
Total Solids	mg/L	814	
Suspended Solids	mg/L	54	790
Total Solids	mg/L	844	
Suspended Solids	mg/L	12	814
Total Solids	mg/L	826	

cc:

Analysis by: [illegible]

Analysis Date 11/17/80

Approved by: John L. Welch

Date Report Issued Verbal: Written

Form #2

Roberts Prtg. Co. 4 Ironton, Ohio

EWP
File

ENVIRONMENTAL CONTROL LABORATORY

ROUTINE REPORT FORM

To: J. Welch SAMPLE NO. Test #3 PROJECT NO. 6980-90 001

Source: Ashland Coke-Minister Stem Scrubber-Thickener Overflow

Sample Date: 11/13/80 Sample Time: Sample Collected By: B Vance

Lab. Reference: #105 Pg 48

Parameter	Units No	Sample Time Value
~~Cyanide~~	6036	7 AM
~~Alkalinity~~	6036	7 AM
~~Biochemical Oxygen Demand~~	6037	8 AM
~~Chemical Oxygen Demand~~	6037	8 AM
~~Chloride~~	6038	9 AM
~~Sulfate~~	6038	9 AM
~~Dissolved Solids~~	6039	10 AM
~~Specific Conductance~~	6039	10 AM
~~Phenolics~~	6040	11 AM
~~Sulfides~~	6040	11 AM
~~Iron~~	6041	12 Noon
~~Total Nitrogen~~	6041	12 Noon
~~Oil & Grease~~	6042	1 PM
~~pH~~	6042	1 PM
~~Phenols~~	6043	2 PM
~~Ammonia-Nitrogen~~	6043	2 PM
~~Suspended Solids~~		
~~Total Solids~~		

Parameter	Units	Value
Suspended Solids	mg/L	70
Total Solids	mg/L	554
Suspended Solids	mg/L	65
Total Solids	mg/L	606
Suspended Solids	mg/L	48
Total Solids	mg/L	604
Suspended Solids	mg/L	38
Total Solids	mg/L	604
Suspended Solids	mg/L	30
Total Solids	mg/L	580
Suspended Solids	mg/L	30
Total Solids	mg/L	587
Suspended Solids	mg/L	27
Total Solids	mg/L	584
Suspended Solids	mg/L	17
Total Solids	mg/L	580

cc:

Analysis by: B Vance

Analysis Date 11/20/80

Approved by John J. Welch

Date Report Issued Verbal: Written:

Form #2

Roberts Prtg. Co. 4 Ironton, Ohio

11/10/80 ASHLAND COKE - MINISTER STACK TEST

6880 - 96 - 001

Test — Gelman Glass Fiber Filters 142 mm

	#1	#1	#2	#2
	Outlet Test #1 11/11/80	Inlet Test #1 11/11/80	Inlet 11/12/80 Test #2	Outlet Test #2 11/13/80
1st weighing	1.0867	1.1156	1.1255	1.0800
9 AM	(1) 1.0800	(2) 1.0712	(3) 1.0810	(4) 1.0741
	.0067	.0444	.0445	.0059

Test

	#3	#3
	11/13/80 Test #3 Outlet	11/13/80 Test #3 Inlet
1st weighing 9 AM	1.1271	1.1580
	(5) 1.1186	(6) 1.1144
	.0085	.0436

(7) 1.1077 (8) 1.1127 (9) 1.1118

(10) 1.1172

11/14/80 Gelman Glass Fiber 142 mm

2nd weighing 11 AM

	(1) 1.0866	(2) 1.1156
	1.0800	1.0712
	.0066	.0444

Silica Gel

(1) 200 gms
(2) 200 gms
(3) 200 gms
(4) 200 gms
(5) 200 gms
(6) 200 gms
(7) 200 gms
(8) 200 gms
(9) 200 gms
(10) 200 gms

1.1256	1.0801
(3) 1.0810	(4) 1.0741
.0446	.0060

11/13/80

second weighing

1.1272	1.1582
(5) 1.1186	(6) 1.1144
.0086	.0438

[illegible] 11/25/80

11/1/90 ASHLAND Coke - M/S

TEST #2 6920-90-001

INLET Probe Nozzle ECL-49 .2505"

IMPINGER #1	340 mls H_2O	00	-6.0
IMPINGER #2	410 mls H_2O	400	+10
IMPINGER #3	45 mls H_2O	0	45
Silica Gel	201 gms	200	1

0 gms

IMPINGERS + WASH = 1000 mls

OUTLET Probe nozzle ECL-31 .500"

IMPINGER #1	- 390 mls H_2O	400	-10
IMPINGER #2	- 403 mls H_2O	400	3
IMPINGER #3	7 mls H_2O		7
Silica Gel	215 gms		15

15 gms

IMPINGERS + WASH = 900 mls + 52 mls = 952 mls

[illegible] 11/7/90

11-12-80

ASHLAND COKE
Minister - Stein TEST #2

6980-90-001

Nozzle RINSE = ✓ OK
Filter RINSE = ✓ OK
Filter to Des. = ✓ OK

OUTLET Impingers — Probe Nozzle ECL-31 .500"

#1 - 400 ml - 400 = 0.0
#2 - 400 ml - 400 = 0.0
#3 - 6.5 mls - 0 = 6.5
Silica Gel - 219 grams - 200 = 19.0

25.5 grams

#1 + #2 + #3 + wash
FINAL Volume - 1010 mls

INLET IMPINGERS — Probe Nozzle ECL-49 .2505"

#1 - 490 - 400 = + 90 mls
#2 - 310 - 400 = - 90
#3 - 0 = 0
Silica Gel 201 gms - 1 / 1 gm — 0 gms

Impingers + Washes 950 mls

SK Dittel

11/14/80 Ashland Coke - M/S Stack Test #3
11/13/80

6980-90-001

OUTLET Probe Nozzle ECL-31 .500"

Nozzle Rinse : OK
Filter Rinse OK
Filter to Dec. OK

OUTLET IMPINGERS

#1	408	400	8
#2	402	400	2
#3	16		16
Silica gel	210		10
			36 gms H_2O

Impinger + H_2O Washes - 985 mls

INLET Probe Nozzle ECL-48 .2505"

IMPINGERS

#1	396 -	400	-4
#2	400 -	400	-0
#3	0		
Silica Gel	186 -	200	-14
			0 gms H_2O

Washes 105 TOTAL Volume imp 1, 2, 3 + washes 1010 mls

11/14/80 Ashland Chem - H/S Scrubber Test #1

Thickener Overflow

6980 - 90 - 001

Solids mg/L = $\frac{\text{mg wt} \times 1000}{\text{ml of sample}}$

#5989

11/11/80 Thickener overflow
7 AM 100 ml Sample

	T.S.
16.6149	85.3572
(1) 16.6117	(9) 85.2943
.0032	.0629

$\frac{.0032 \times 1000 \times 1000}{100}$ = 32 mg/L 629 mg/L

#5990

11/11/80 Thickener overflow
8 AM 100 ml Sample

	T.S.
16.6368	74.4493
(2) 16.6315	(10) ~~74.3848~~
.0053	.0645

53 mg/L 645 mg/L

#5991

11/11/80 Thickener overflow
9 AM 100 ml Sample

	T.S.
18.3322	3288
(3) 18.3306	(6) 75.2619
.0016	.0664

16 mg/L 664 mg/L

#5992

11/11/80 Thickener overflow
10 AM 100 ml's

18.7065	3374
(4) 18.7050	(5) 78.2675
.0015	.0699

15 mg/L 699 mg/L

#5993

11/11/80 Thickener overflow
11 AM 100 ml's

18.4556	74.2572
(5) 18.4532	(12) 74.1897
.0024	.0675

4 mg/L 675 mg/L

#5994

11/11/80 Thickener overflow
12 Noon 100 ml Sample

18.6056	8914
(10) 18.6041	(13) 78.8163
.0015	.0751

15 mg/L 751 mg/L

#5995

11/11/80 Thickener overflow
1 PM 100 ml

	T.S.
5311	74.7807
(8) 16.5289	(14) 74.7018
.0022	.0789

22 mg/L 789 mg/L

#5996

11/11/80 Thickener overflow
2 PM 100 ml

	T.S.
16.8958	78.8113
(9) 16.8951	(15) 78.7341
.0007	.0772

7 mg/L 772 mg/L

11/14/80 — Ashland Minister Stein Sampling 6980-90-2

Acetone used for washings was all from Lot # 703172 Cert. ACS
Beakers for Acetone Wash

	Tare Wts.	Sample in Beaker	Date
#1	109.1082	Outlet Test #1	11/11/80
2	108.8371	Outlet Test #2	11/12/80
3	111.7827	Outlet Test #3	11/13/80
4	108.4191	Inlet Test #1	11/11/80
5	109.8343	Inlet Test #2	11/12/80
6	109.8680	Inlet Test #3	11/13/80
7	111.7474	Blank 250 mls Acetone Lot #(A19) 703172	

11/17/80 Ashland Coke - 19/5 STK TEST

TOTAL Solids $\frac{mg/wt \times 1000}{mls\ sample}$ 6980-90-001

TEST #1

#001 INLET impinger 1, 2, 3 + washes H_2O
TOTAL Volume - 1000
100ml sample

52.6096
(1) 52.6071
.0025

79.4215
(2) 79.4190
.0025

81.2782 .0026
(9) 81.2745
.0027

TEST #1

#002 OUTLET impinger 1, 2, 3 + H_2O Washes
TOTAL Volume - 952
100ml sample

77.8489
(3) 77.8484
.0005

85.7281
(4) 85.7155
.0006

.0005

88.2510
(10) 88.2500
.0010

TEST #2

#019 INLET impinger 1, 2, 3 + washes H_2O
TOTAL Volume 950
100ml sample

81.8252
(5) 81.8248
.0004

76.9434
(6) 76.9425
.0009

76.8159 .00083
(11) 76.8147
.0012

TEST #2

#018 OUTLET impinger 1, 2, 3 + washes H_2O
TOTAL Volume - 1010
100ml sample

77.8392
(7) 77.8381
.0011

81.0563
(8) 81.0557
.0006

.0009

TEST #3

#035 INLET impinger 1, 2, 3 + H_2O washes
TOTAL Volume - 985 mls
100 mls sample

82.2722
(9) 82.2727

86.2819
(10) 86.2874
.0045

82.2755
82.2722
.0033

.0039

TEST #3

#034 OUTLET impinger 1, 2, 3 + H_2O washes
TOTAL Volume 1010 mls

80.5835
(12) 80.5809
.0026

76.8066
(14) 76.8046
.0020

.0023

Ashland Coke - 19/5 STK TEST #2
Thickener overflow

6980-96-001

#6009

	T.S
	52.6895
10 AM (10) 18.0109	
19.0078	(11) 52.6096
.0630	.0799

$\frac{.0030 \times 1000 \times 1000}{100} = 30$ mg/l

$\frac{.0799 \times 1000 \times 1000}{100} = 799$ mg/l

#6010

	T.S
	79.4895
8 AM 16.8718	
(11) 16.8658	(12) 79.4215
.0060	.0680

susp Solids $\frac{.0060 \times 1000 \times 1000}{100} = 60$ mg/l

Total Solids $\frac{.0680 \times 1000 \times 1000}{100} = 680$ mg/l

#6011

	T.S
	77.9328
17.1352	
9 AM 17.1338	(3) 77.8489
.0014	.0839

Solids $\frac{.0014 \times 1000 \times 1000}{100} = 14$ mg/l

Solids $\frac{.0839 \times 1000 \times 1000}{100} = 839$ mg/l

#6012

	T.S
	85.8006
10 AM 16.5689	
(15) 16.5675	(14) 85.7241
.0014	.0765

susp Solids $\frac{.0014 \times 1000 \times 1000}{100} = 14$ mg/l

Tot Solids $\frac{.0765 \times 1000 \times 1000}{100} = 765$ mg/l

#6013

	T.S.
	81.9076
11 AM 16.3683	
(6) 16.3672	(5) 81.8252
.0011	.0824

susp Solids $\frac{.0011 \times 1000 \times 1000}{100} = 11$ mg/l

T. Solids $\frac{.0824 \times 1000 \times 1000}{100} = 824$ mg/l

#6014

	T.S.
	77.0248
12 Noon 16.5955	
(20) 16.5947	(16) 76.9434
.0008	.0814

susp Solids $\frac{.0008 \times 1000 \times 1000}{100} =$

Tot Solids $\frac{.0814 \times 1000 \times 1000}{100} = 814$ mg/l

#6015

	T.S
	77.9236
1 PM 4823	
(5) 18.4769	(7) 77.8392
.0054	.0844

susp Solids $\frac{.0054 \times 1000 \times 1000}{100} = 54$ mg/l

Tot Solids $\frac{.0844 \times 1000 \times 1000}{100} = 844$ mg/l

#6016

	T.S.
	81.1389
2 PM 18.5951	
(6) 18.5939	(8) 81.0563
.0012	.0826

susp Solids $\frac{.0012 \times 1000 \times 1000}{100} = 12$ mg/l

Tot Solids $\frac{.0826 \times 1000 \times 1000}{100} = 826$ mg/l

Outlet

11/18/80 Minister Stein Sampling: Ashland, Ky. 6980-90-C

Note: See page 41 for beaker tare information

11/11/80 **Outlet Test #1** Acetone Wash Weighing

	#1 11/18/80 4:00PM.	#2 11/19/80 9:00AM	#3 11/19/80 3:30PM
Final	109.1211	109.1214	109.1212
Tare	109.1082	109.1082	109.1082
Wt Gain	.0129g	.0132g	.0130

11/12/80 **Outlet Test #2**

	#1 11/19/80 8:45AM	#2 11/19/80 11:30AM	#3 11/19/80 3:30PM
Final	108.8634	108.8633	108.8632
Tare	108.8371	108.8371	108.8371
Wt. Gain	.0263	.0262	.0261

11/13/80 **Outlet Test #3**

	#1 11/18/80 4:00PM	#2 11/19/80 8:50AM	#3 11/19/80 3:15PM
Final	111.7860	111.7863	111.7861
Tare	111.7827	111.7827	111.7827
Wt. Gain	.0033	.0036	.0034

Acetone Blank 250 mls (Lot # 703172) ACS

	#1 11/18/80 4:00PM	
Final	111.7477	111.7476
Tare	111.7474	111.7474
Wt. Gain	.0003	.0002

Outlet 1111.

6/20 Ashland Coke - 1/15 Test #3 6980-90-001.
Thickener overflow

TOTAL + Suspended Solids mg/L = $\frac{\text{mg wt solids} \times 1000}{\text{mls sample}}$

#6036
7 AM Thickener overflow

7084	88.3040
18.7014	(11) 88.2446
.0070	.0554

$\frac{.0070 \times 1000 \times 1000}{100}$ = 70 mg/L

(1.4) $\frac{.0554 \times 1000 \times 1000}{100}$ = 554 mg/L

6038
9 AM Thickener overflow

16.6144	77.8989
(10) 16.6096	(9) 77.8385
.0048	.0604

$\frac{.0048 \times 1000 \times 1000}{100}$ = 48 mg/L Susp Solids

$\frac{.0604 \times 1000 \times 1000}{100}$ = 604 mg/L T. Solids

6040
11 AM Thickener overflow

16.5294	81.8779
(8) 16.5264	(5) 81.8199
.0030	.0580

$\frac{.0030 \times 1000 \times 1000}{100}$ = 30 mg/L Susp Solids

$\frac{.0580 \times 1000 \times 1000}{100}$ = 580 mg/L T. Solids

6042
1 PM Thickener overflow

18.0061	77.8866
(10) 18.0054	(7) 77.8282
.0027	.0584

$\frac{.0027 \times 1000 \times 1000}{100}$ = 27 mg/L Susp Solids

$\frac{.0584 \times 1000 \times 1000}{100}$ = 584 mg/L T. Solids

#6037
8 AM Thickener overflow

16.6355	79.4626
(12) 16.6290	(12) 79.4020
.0065	.0606

$\frac{.0065 \times 1000 \times 1000}{100}$ = 65 mg/L Susp Solids

$\frac{.0606 \times 1000 \times 1000}{100}$ = 606 mg/L Tot. Solids

6039
10 AM Thickener overflow

18.4556	85.7688
(13) 18.4512	(14) 85.7084
.0038	.0604

$\frac{.0038 \times 1000 \times 1000}{100}$ = 38 mg/L Susp Solids

$\frac{.0604 \times 1000 \times 1000}{100}$ = 604 mg/L T. Solids

6041
12 Noon Thickener overflow

16.8943	76.6969
(5) 16.8913	(6) 76.6382
.0030	.0587

$\frac{.0030 \times 1000 \times 1000}{100}$ = 30 mg/L Susp Solids

$\frac{.0587 \times 1000 \times 1000}{100}$ = 587 mg/L T. Solids

6043
2 PM Thickener overflow

16.8664	81.1110
(11) 16.8647	(5) 81.0530
.0017	.0580

$\frac{.0017 \times 1000 \times 1000}{100}$ = 17 mg/L Susp Solids

$\frac{.0580 \times 1000 \times 1000}{100}$ = 580 mg/L T. Solids

Ashland.

IX. CALIBRATION DATA

A) Meter Box Calibrations

The Aerotherm Meter Boxes were calibrated before and after the compliance testing. A pre-calibrated Dry Gas Meter (of the same type used in the meter box) was used to calibrate the meter boxes. This pre-calibrated D.G.M. is a Rockwell-415, serial number 431-721, its calibration is N.B.S. traceable (see National Energy Service Company Letter of November 13, 1980, attached) and it is considered to be a secondary standard. The Rockwell-415 D.G.M. was used in place of a wet test meter, see calibration sheets attached and Appendix One (pg. 21).

Pre-calibrations	11/3/80	γ = .998	$\Delta H@$ = .328
Post-calibrations	12/5/80	γ =1.00	$\Delta H@$ = .334

Calibrations show the meter box performed with at least 98% accuracy and +99.8% precision to its previous calibration.

Note: Calculations were performed on a T. I. 59 Programmable Calculator, copies of the print outs are supplied.

NATIONAL ENERGY SERVICE COMPANY

Telephone 614-928-1945

645 East Main Street
P.O. Box 832
Hebron, Ohio 43025

RECEIVED
NOV 17 1980

November 13, 1980

Mr. Gene Pollitt
Allied Chemical
3330 S. Third Street
Ironton, Ohio 45638

Dear Mr. Pollitt:

This letter certifies that the following equipment used by National Energy Service Company, 645 E. Main Street, Hebron, Ohio, 43025, to calibrate gas measuring devices for accuracy is traceable to the National Bureau of Standards, by the following determinations:

1. The 10 cubic foot Bell Prover, Serial Number 2874, is calibrated with a certified steel tape #16534 and precision gauges according to the National Bureau of Standards handbook #117.

2. The five (5) 5 cubic foot Bell Provers, Serial Numbers 4186, 4185, 4184, 4187, & 1445, are calibrated with certified steel tape #4082 and precision gauges according to the National Bureau of Standards handbook #117.

3. The Automatic Transfer Equipment which incorporates a 1.5M Roots Meter and a 7M Roots Meter is traceable to the National Bureau of Standards through an American Meter Model 12M, Serial Number TP12259, which has been calibrated on a 10 cubic meter Bell Prover, Serial Number 4242. This Bell Prover is calibrated with a certified steel tape #6216 and precision gauges according to the National Bureau of Standards handbook #117.

The above 10 cubic foot Bell Prover and the five (5) 5 cubic foot Bell Provers are also annually checked with a Stillman Standard, American Meter #1012, National Bureau of Standards Serial Number 21. An annual inspection with the Stillman Standard is required by the Ohio Public Utilities Commission; performed by the Ohio Public Utilities Commission and carries their certification in accordance with handbook #E4.

Yours truly,

Joseph P. Lofink

Joseph P. Lofink
Vice President and General Manager

METER CONSOLE CALIBRATION FORM Pre-M-5 Compliance

Name Gene Pollitt Date 11-3-80

Console No. Acm-100 520-095 Dry Gas Meter No. 431-721

Wet Test Meter No. _____ Correction Factor _____

(10) Barometric Pressure, P_b 29.60 in. Hg' Previous Calibration Date _____

Dry gas meter - initial and final reading	(11) Orifice manometer setting, ΔH, in. H_2O	(12) Gas volume wet test meter V_w, ft^3	(13) Gas volume dry gas meter V_d, ft^3	(14) Temperature Wet test Meter t_w, °F	(15) Dry gas meter Inlet t_{di}, °F	Outlet t_{do}, °F	Average t_d, °F	(16) Time θ, min	γ	ΔH@
457.110										
447.100	0.5	1.0	5	10	10.110	24.5	77	76	76.5	7.13	.987	0.299
511.675										
501.555	1.0	2.0	5	20	20.120	24.5	82	76	79	10.313	.994	.316
497.725										
477.725	2.0	3.0	10	20	20.100	24.5	91	78.5	84.75	8.54	1.00	.336
517.820										
497.725	4.0		10	20	20.095	24.5	90	77.5	83.75	7.49	.999	.346
537.530										
517.820	6.0	5.0	10	20	20.010	25	95.5	80.5	88	6.599	1.01	.346
	8.0		10			(17)						
								Average			.998	.328

Calculations @ T.I. 59 - Programmable

ΔH	$\frac{\Delta H}{13.6}$	γ: $\frac{V_w P_b (t_d + 460)}{V_d\left(P_b + \frac{\Delta H}{13.6}\right)(t_w + 460)}$	ΔH@: $\frac{0.0317\ \Delta H}{P_b\ (t_d + 460)}\left[\frac{(t_w + 460)\ \theta}{V_w}\right]^2$
0.5	0.0368		
1.0	0.0737		
2.0	0.147		
4.0	0.294		
6.0	0.431		
8.0	0.588		

γ = Ratio of accuracy of wet test meter to dry test meter. Tolerance = ± 0.02

ΔH@ = Orifice pressure differential that gives 0.75 cfm of air at 70°F and 29.92 inches of mercury, in. H_2O. Tolerance - ± 0.15

Orifice ΔH@ should fall between 1.59 - 2.09 or modification may be necessary for some sampling situations.

11/3/80

Aero-100

Aerotherm METER BOX

CALIBRATION DATA

ΔH=1.0

.9874048806 = Y

0.298787711 ΔHA

ΔH=2.0

.9944722204 = Y

.3162893828 ΔHA

ΔH=3.0

1.003600514 = Y

.3356627926 ΔHA

ΔH=4.0

.9995428562 = Y

.3458621846 ΔHA

ΔH=5.0

1.007461006 = Y

.3459991856 ΔHA

Aerotherm METER CONSOLE CALIBRATION FORM

orifice # 2

Post - M-5 Compliance

Name Gene W. Pellitt III Date 12-5-80

Console No. Aero-100 Dry Gas Meter No. 431721

Wet Test Meter No. — Correction Factor —

(10) Barometric Pressure, P_b 29.76 in. Hg' Previous Calibration Date 11-3-80

Dry gas meter - initial and final reading	(11) Orifice manometer setting, ΔH, in. H_2O	(12) Gas volume wet test meter V_w, ft^3	(13) Gas volume dry gas meter V_d, ft^3	(14) Temperature Wet test Meter t_w, °F	(15) Dry gas meter Inlet t_{di}, °F	Outlet t_{do}, °F	Average t_d, °F	(16) Time θ, min	γ	ΔH@
876.554										.328
868.502	1.0	8.0	8.052	79.16	79 80 80 (80)	79 79 79 (79)	79.5	5.52	.992	.309
884.710										
876.674	2.0	8.0	8.036	78.8	82 82 82 (82)	79 79 79 (79)	81.5	4.31*	.996	.364
904.845										
884.825	3.0	20	20.120	79.88	88 92 93 91	79 80 80 79.75	85.4	8.35	.997	.315
925.289										
905.176	4.0	20	20.113	78.8	92 94 95	81 81 81	88	7.47	1.00	.342
945.457										
925.360	5.0	20	20.097	79.5	97 99 97 98	82 83 81 82	89.4	6.58	1.00	.342
	8.0	10			(96.75)	(82)				
							Average		.997	.334

Calculations @ T.I. 59 - Programmable

ΔH	$\frac{\Delta H}{13.6}$	γ $\frac{V_w P_b (t_d + 460)}{V_d\left(P_b + \frac{\Delta H}{13.6}\right)(t_w + 460)}$	ΔH@ $\frac{0.0317\ \Delta H}{P_b (t_d + 460)}\left[\frac{(t_w + 460)\ \theta}{V_w}\right]^2$
0.5	0.0368		
1.0	0.0737		
2.0	0.147		
4.0	0.294		
6.0	0.431		
8.0	0.588		

γ = Ratio of accuracy of wet test meter to dry test meter. Tolerance = ± 0.02

ΔH@ = Orifice pressure differential that gives 0.75 cfm of air at 70°F and 29.92 inches of mercury, in. H_2O. Tolerance - ± 0.15

Orifice ΔH@ should fall between 1.59 - 2.09 or modification may be necessary for some sampling situations.

12-5-80

Acotherm METER BOX
Aero-100
CALIBRATION DATA

$\Delta H = 1.0$

0.991718231 = Y

.3086548232 = ΔHA

$\Delta H = 2.0$

.9955891495 = Y

.3640568031 = ΔHA

$\Delta H = 3.0$

.9968106993 = Y

.3145421861 = ΔHA

$\Delta H = 4.0$

1.001463045 = Y

.3418473451 = ΔHA

$\Delta H = 5.0$

1.001068235 = Y

.3423581367 = ΔHA

IX. CALIBRATION DATA (continued)

B) Nozzle Calibrations

A digital, dial caliper was used to calibrate the nozzle. An inside measurement was taken on each of ten (10) different diameters (see attached calibration sheets).

DATE 9/27/80 Fishkind - Minister - Stein 1980-90

pre test calibrations

Nozzle # reading #1 — Nozzle Calibrations —

Nozzle #	reading #1	#2	#3	#4	#5	#6	#7	#8	#9	#10
ECL-24	.1219	.122	.122	.122	.1218	.1215	.122	.122	.122	.122
ECL-25	.248	.2475	.2485	.2472	.248	.2482	.246	.2478	.2481	.248
ECL-26	.241	.2405	.240	.2401	.240	.2405	.240	.2405	.240	.240
ECL-27	.247	.2465	.248	.2475	.2472	.2468	.2471	.2470	.2472	.2470
ECL-28	.4330	.4332	.4331	.4335	.4330	.4331	.4332	.4330	.4335	.4331
ECL-29	.4330	.4331	.4332	.4332	.4330	.4332	.4330	.4331	.4331	.4330
ECL-30	.505	.505	.505	.505	.505	.5051	.505	.505	.5052	.505
ECL-31	.500	.500	.4999	.500	.500	.500	.500	.500	.4999	.500
ECL-32	.510	.5105	.5099	.5101	.5101	.5101	.5101	.5101	.510	.510
ECL-33	.501	.5015	.5010	.501	.5008	.510	.5101	.510	.510	.5101
ECL-34	.4995	.500	.5001	.500	.5001	.5001	.4997	.4999	.500	.5001
ECL-35	.4852	.4850	.4851	.4848	.4849	.485	.4847	.4852	.485	.485
ECL-36	.5081	.5080	.5079	.5081	.5080	.5081	.5078	.5079	.508	.5071
ECL-37	.5049	.5050	.5051	.5048	.5046	.5050	.5058	.5056	.5056	.5055
ECL-38	.5001	.5000	.5002	.5002	.5001	.5000	.5000	.5003	.5001	.5000
ECL-39	.5098	.5099	.5097	.5099	.5098	.5097	.5100	.5100	.5099	.509
ECL-40	.5670	.5672	.5673	.5672	.5672	.5673	.5670	.5671	.5670	.566
ECL-41	.5660	.5661	.5659	.5658	.5662	.5660	.5661	.5659	.5660	.566
ECL-42	.6262	.6256	.6258	.6260	.6260	.6259	.6258	.6260	.6260	.62
ECL-43	.6265	.6268	.6264	.6269	.6270	.6271	.6270	.6268	.6266	.62
ECL-44	.6852	.6850	.6847	.6862	.6856	.6855	.6860	.6849	.6852	.68
ECL-45	.6860	.6862	.6858	.6856	.6859	.6861	.6864	.6855	.6855	.68
ECL-46	.1241	.1240	.1242	.1238	.1240	.1240	.1240	.1240	.1240	.12
ECL-47	.2510	.2508	.2500	.2500	.2499	.2500	.2510	.2501	.250	.250
ECL-48	.250	.250	.250	.250	.250	.250	.250	.250	.250	.250
ECL-49	.2501	.2506	.2510	.2510	.2505	.2505	.250	.250	.2510	.250

NOZZLE SIZE CALIBRATION

Nozzle Number ECL-34 Date: 12-8-80

Measurement Number	I.D. Inches
1	.4995
2	.5000
3	.5001
4	.5000
5	.5001
6	.5001
7	.4997
8	.4999
9	.5000
10	.5001
Avg.	.500 Inches

Last Use Date New Measurements by E. W. Pottitt III

previous Date 9/22/80

IX. CALIBRATION DATA (continued)

C) Pitot Tube Calibrations

The pitot tube was assigned a baseline value (for Cp) of .84 (page 94, Figure 2-2, Appendix Two) because the one used (Aero Pt-10) was new and measurements before and after testing confirmed that the pitot met design criteria as given in EPA-Methods.

ALLIED CHEMICAL CORPORATION
CHEMICALS COMPANY
ENVIRONMENTAL CONTROL LABORATORY

PITOT TUBE CALIBRATION FORM

Pitot Tube No. Aero-P.t.-10 Date 12-5-80

Pitot Type, Length - for Aerotherm probes

$$Cp(s) = 0.99 \sqrt{\frac{\Delta p(\text{standard})}{\Delta p(s)}} = \sim .84$$

SIDE A

Δp(standard) .01 Δp(s) .014 Cp(s) .837

Δp(standard)	Δp(s)	Cp(s)
.05	.0695	.84
0.1	.138	.843
0.5	.697	
1.0	1.39	.839
2.0	2.78	.84
3.0	4.16	
4.0	5.55	.841
5.0	6.95	.839

SIDE B

Δp(standard) .01 Δp(s) .014 Cp(s) .837

Δp(standard)	Δp(s)	Cp(s)
.05	.070	.836
.1	.139	.839
.5	.698	.838
1.0	1.41	.834
2.0	2.77	.841
3.0	4.16	.841
4.0	5.54	.841
5.0	6.98	.838

Manometer No. _____

Manometer Leak check: good - @ + 3.0 inches water.

Condition of pitot tips: Good

Eugene W. Pettitt III
Signature

IX. CALIBRATION DATA (continued)

D) Thermometer and Thermocouple Calibrations

The digital read out supplied in the Aerotherm Meter Box was calibrated by attaching a thermocouple to one of the optional readings and running it out of the meter box and checking it against a mercury-in-glass thermometer. (See attached data sheet).

ALLIED CHEMICAL CORPORATION
CHEMICALS COMPANY
ENVIRONMENTAL CONTROL LABORATORY

THERMOMETER AND THERMOCOUPLE CALIBRATIONS

THERMOMETER NO. → Std - 0-300°C DATE 12-5-80

THERMOCOUPLE* READ OUT NO. Acro-100 Meter Box

STANDARD THERMOMETER NO. Std. 0-300°C Hg in glass.

STANDARD TEMP. 0°C	THERMO~~METER~~ couple TEMP. 32 °F	TEMPERATURE DIFFERENCE 0°F
22.0°C —	72°F	< 1.0°F
99.5°C —	211°F	< 1.0°F
230°C —	445°F	-1.0°F

*Supplies Readings For:

1) Stack Temperature
2) Probe Temperature
3) Impinger Outlet Temperature
4) Option
5) Option
6) Filter Oven Temperature
7) D.G.M. Inlet Temperature
8) D.G.M. Outlet Temperature

Eugene W. Pollitt III
Signature

IX. CALIBRATION DATA (continued)

E) Probe and Filter Heaters

Both the probe and filter oven were constantly monitored throughout the test (see field data sheets). The thermocouple readout was calibrated as shown in Section D.

APPENDIX ONE

MAINTENANCE, CALIBRATION, AND OPERATION OF ISOKINETIC SOURCE-SAMPLING EQUIPMENT

by

Jerome J. Rom
Applied Technology Division

ENVIRONMENTAL PROTECTION AGENCY
Office of Air Programs
Research Triangle Park, North Carolina
March 1972

The APTD (Air Pollution Technical Data) series of reports is issued by the Environmental Protection Agency, to report technical data of interest to a limited number of readers. Copies of APTD reports are available free of charge to Federal employees, current contractors and grantees, and nonprofit organizations - as supplies permit - from the Office of Technical Information and Publications, Environmental Protection Agency, Research Triangle Park, North Carolina 27711, or from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22151.

Office of Air Programs Publication No. APTD-0576

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MAINTENANCE, CALIBRATION, AND OPERATION OF ISOKINETIC SOURCE-SAMPLING EQUIPMENT

INTRODUCTION

The purpose of this publication is to explain the maintenance, calibration, and operation of the isokinetic source-sampling equipment described in Construction Details of Isokinetic Source-Sampling Equipment[1] as performed by the Emission Testing Branch of the Office of Air Programs, Environmental Protection Agency. This procedure has been used satisfactorily and is presented as a guide to assist interested personnel in using the equipment.

The sampling train has four major components: (1) the pitobe assembly, which includes the probe nozzle, a heated glass probe, and a pitot tube for monitoring gas velocity during sampling; (2) the meter box assembly, which consists of a system of manometers, an orifice meter, a vacuum pump, a dry gas meter, and electrical controls for sampling; (3) the sample box assembly, which contains the glassware; and (4) the umbilical cord, which connects the sample box with the meter box. A representation of the sampling train is shown in Figure 1. The maintenance and calibration procedure described for each of the components should be followed in the shop or laboratory in preparation for each sampling test.

459-345 O - 72 - 2

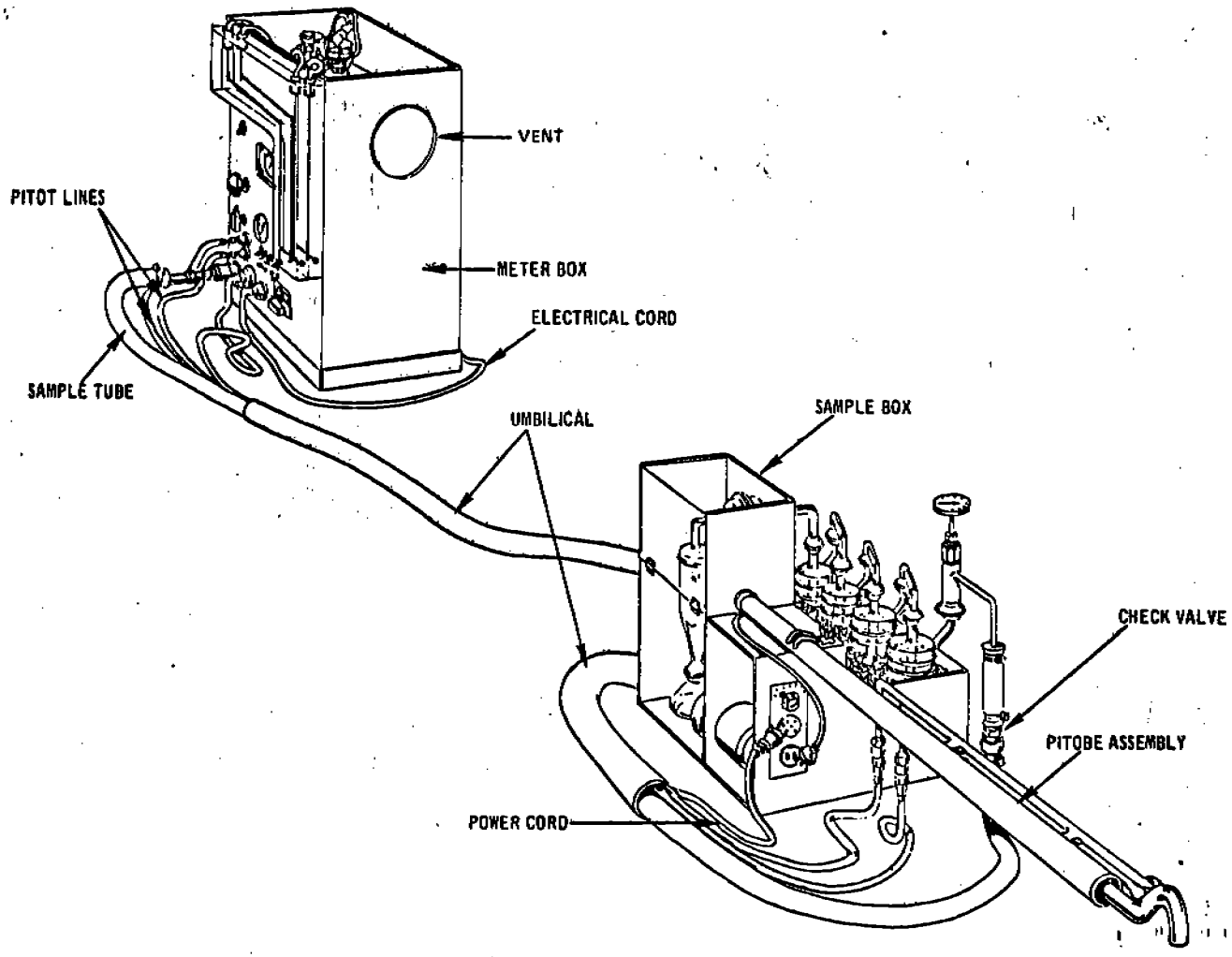


Figure 1. Sampling train.

MAINTENANCE

PITOBE ASSEMBLY

Preliminary Disassembly

To disassemble the pitobe, first remove the Swagelok* union (parts 2 through 7) except for the welded nut (8) as shown in Figure 2. The nozzle (1) is usually removed in the field and carried separately. Check for broken glass chips.

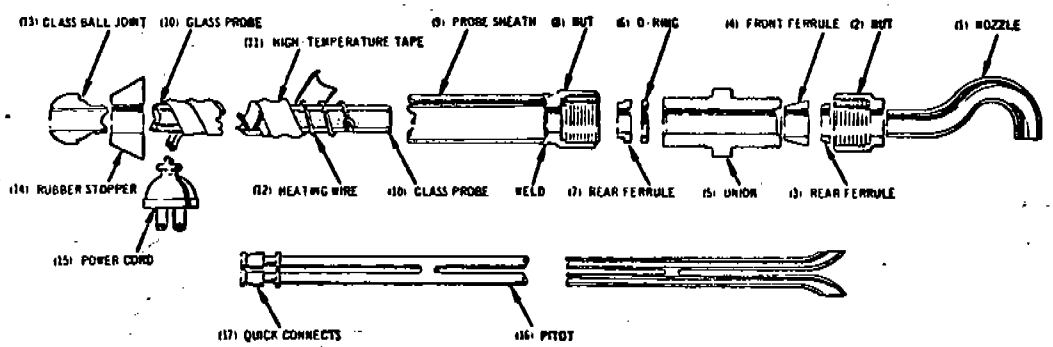


Figure 2. Pitobe assembly.

Probe

Remove the glass probe (10) from the sheath (9) and check visually for broken or fractured sections. The most common area of broken or fractured sections is within 1-1/2 inches from the front and approximately 3 inches from the rear. Some fractures on the back end are hard to see because of the tape (11) and rubber stopper (14). One way of checking is to gently twist the glass probe and listen for grating sounds. Inspect the electrical system of the probe for visible shorts or burned spots shown by uniform darkening of the high-temperature insulation tape (11), and the power cord connection (15). Then plug the power cord into a variable transformer and set the power rating at about 55 volts. The probe should become warm to the touch over its entire length in a few minutes. If the probe does not heat, check the variable transformer for proper voltage and for loose connections in the plug (15) and Nichrome wire. Shorts are indicated by partial heating in

*Mention of a specific company or product name does not constitute endorsement by the Environmental Protection Agency.

A sample check list is shown in Figure 3. There should be at least two sets of pitobes of the desired length for each sample box with each pitobe identified.

Date _____ Probe No. _____

Probe

- Glass probe _____
- Rubber stopper _____
- Insulation tape _____
- Power cord extension _____
- Heating system _____
- Clean _____

Pitot-probe sheath

- Quick connects _____
- Pitot tube _____
- Sheath and welded nut _____
- Clean _____
- Calibration (pitot tube) _____

Swagelok union

- Probe side
  - Rear ss ferrule (backwards) _____
  - Rubber O-ring _____
  - Asbestos cord _____
- Union _____
- Nozzle side
  - Front ss ferrule _____
  - Rear ss ferrule _____
- Clean _____
- General remarks: _____

Note: 25-foot Nichrome wire on particulate probes.

Initial each item when checked and write in any remarks.

Figure 3. Suggested pitobe assembly check list.

NOZZLES

Inspect the knife edge of the nozzle for damage. If damaged, repair and recalibrate the nozzle according to the procedure in the Calibration section. Clean the nozzle by scrubbing and rinse with distilled, deionized water, and then with acetone; air dry. Cover the open ends with serum caps or similar covers to avoid contamination or damage to the knife edge.

There should be a selection of nozzles ranging from 1/8 to 1/2 inch in diameter in 1/16-inch increments with two or three sets of each size. The exact diameters should be etched on the shank of each of the nozzles and all the nozzles kept in a separate box.

METER BOX ASSEMBLY

Casing

Remove the meter box casing, check the general condition, and make necessary repairs.

Pump Oil and Filter

Change the pump lubricating oil (28), if dirty; fill to mark; and clean the pump filter (27). The parts are identified in Figure 4.

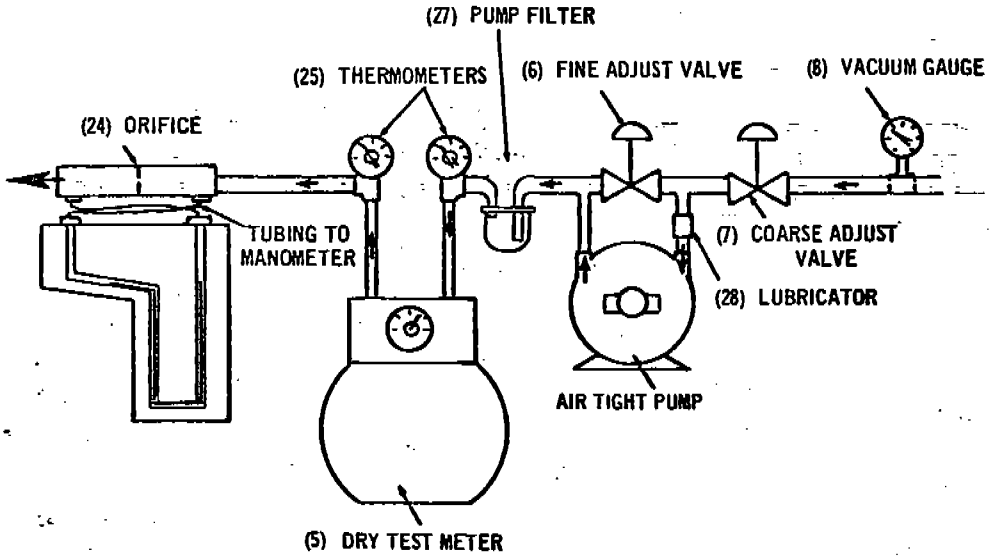


Figure 4. Pump-meter assembly.

Thermometers

Check the dry-gas-meter thermometers (25). The temperature should check against room temperature using a mercury-in-glass thermometer as the standard.

Quick Connects

Wipe the quick connects (9) clean (Figure 5). A drop of penetrating oil helps keep them in good working condition.

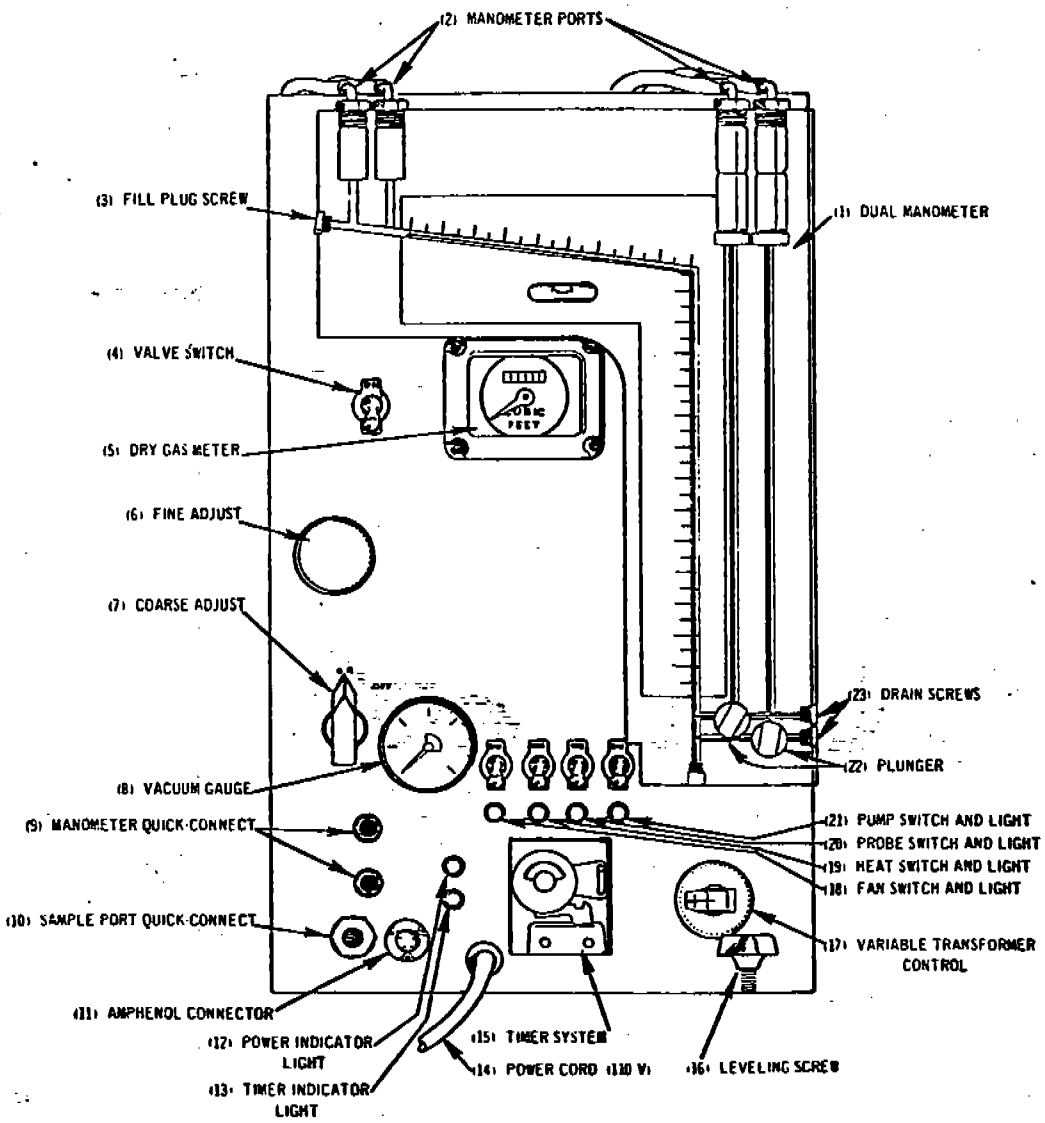


Figure 5. Front panel of meter box.

Dual Manometer

Visually check the pitot and orifice manometer lines. They should be free of fluid. Check for leaks, especially around the fluid-level plunger (22) and drain screws (23) shown in Figure 5. Replace the fluid-level plunger or O-rings, if necessary. Wipe the dual manometer (1) clean. The back can be cleaned with compressed air or the device can be removed from the box and wiped clean. If the dual manometer is unusually dirty, clean as recommended by the manufacturer. Replace the red manometer fluid, if it is faded. Manometer fluids are color-coded: red is used for the pitot tube manometer and yellow for the orifice manometer (or a similar combination) for ease of reading in the field.

After making sure that the manometer ports (2) are open and the manometer lines connected, level the manometer and check the fluid level. The manometer can be filled with fluid by removing the screw (3) on the left side. When the manometer is zeroed, the fluid-level plunger should have about 1/4- to 1/2-inch travel inward.

Pitot-Tube Lines

Blow through the pitot-tube quick connects (9) to check for obstructions. The sealing balls in these quick connects should be removed to allow for free movement of air. The pitot-tube manometer should respond.

Solenoid Valve

Plug the meter-box power cord into a 110-volt outlet. The power indicator light (12) should go on and a click should be heard. The click is the sound of the solenoid valves moving into the position shown in Figure 6. If the clicking sound does not occur, check the power source, plug, power cord and connections, bulb, and solenoid valve.

The valve switch (4), shown in Figure 5, operates the solenoid valve assembly, which contains three 2-way solenoid valves (Figure 6). Two are usually open and one is closed. When the valve switch is turned on, the two open valves close and the flow into the manometer is blocked and the closed solenoid valve opens to allow the pressure to equalize. This allows the manometer to be zeroed while the pump is running.

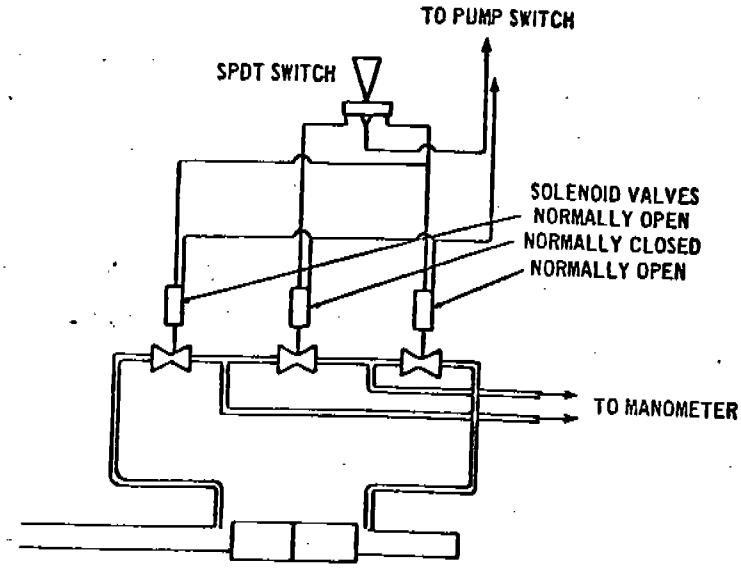


Figure 6. Solenoid assembly diagram.

The solenoid assembly operates only on the orifice manometer. To zero the pitot tube manometer, the pitot tube lines can be disconnected at the quick connects on the meter box.

Lights and Switches

Turn the coarse-adjust valve (7) to the off position and open fully the fine-adjust valve (6). Turn on all switches (18 through 21) to check the lights. The heater light should not go on until the fan switch is also on. If any of the lights do not function, check for defective parts, including switches, lights, fuses, and wiring.

Orifice Meter Lines

Turn off all switches except the pump switch (21). Turn on the valve switch (4) and carefully adjust the coarse-adjust and fine-adjust valves. The orifice meter manometer should respond to valve controls. If no movement is observed, check the solenoid valves or the orifice meter system.

Timer

Leaving the pump on, check the timer system (15), which should operate only when the pump is on. Malfunction of the timer can be caused by decreased voltage supply or a worn synchronous motor. The timer has different cams for various time periods or cycles, but the most commonly used is 5 minutes. Check the

timing for at least two cycles. The buzzer and timer light (13) should go on at the end of the specified cycle. The duration of the buzz can be regulated by adjusting the notch on the timer. Turn the pump off.

Amphenol Outlet and Variable Transformer

Check the Amphenol outlet with a voltmeter or check light by connecting the leads to the different terminals (Figure 7). When connected across the variable transformer, the voltage meter or check light should respond correspondingly.

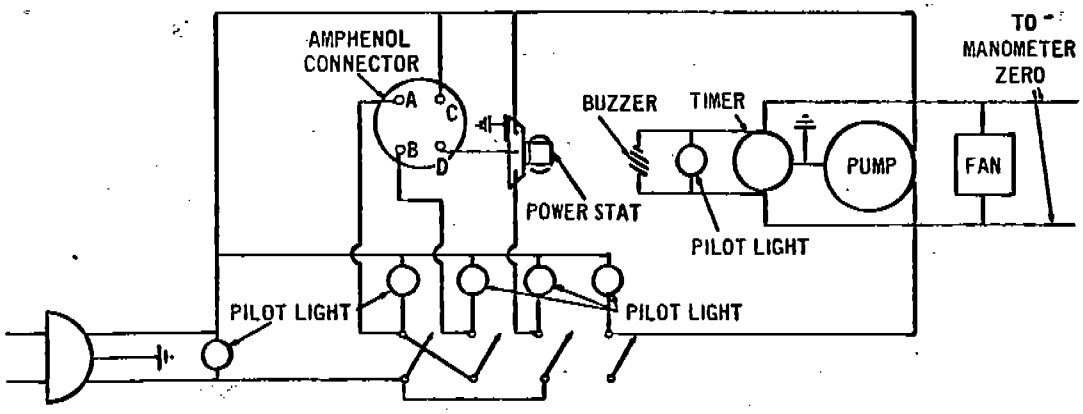


Figure 7. Meter box wiring diagram.

Vacuum System

Insert a plugged male quick connect into the sample port (10), shown in Figure 5. Make sure that the valve switch (4) is off and then activate the pump. Turn the coarse-adjust valve to the on position and close fully the fine-adjust valve. The vacuum gauge (8) should read about 27 inches of mercury for a barometric pressure of 30 inches of mercury. Check the leakage rate using the reading on the dry gas meter (5) and a watch. If leakage exceeds 0.02 cubic foot per minute, find and correct the leak or leaks. Parts to check are the pump, vacuum gauge, metering valves, and pipes.

Calibration

After all systems are functioning properly, calibrate the dry gas meter (5) shown in Figure 5 and the orifice meter (24) shown in Figure 4 according to the procedure in the Calibration section.

A sample check list and a calibration and calculation sheet are shown in Figures 8 and 9. For recording purposes, the meter box should be numbered.

Date _____ Box No. _____ Dry gas meter No. _____

Pump oil and filter _____

Quick connects _____

Dry-gas meter thermometers _____

Dual manometer system _____

Pitot-tube lines _____

Solenoid valve _____

Lights and switches _____

Orifice-meter lines _____

Timer _____

Amphenol outlet _____

Variable transformer _____

Vacuum system

Metering valve _____

Vacuum gauge _____

Leak check at _____ inches of mercury - leakage = _____

Calibration (orifice and meter) _____

General remarks _____

_____

_____

Initial each item when checked and write in any remarks.

Figure 8. Suggested meter box assembly check list.

SAMPLE BOX ASSEMBLY

Ice Bath

Fill the ice bath (4) with water and check for leaks (Figure 10).

Electrical System

Using an Amphenol adapter (Figure 11), plug into a 110-volt source. The fan and heater should go on. Failure to operate may be caused by a faulty electrical source, a poor connection, a defective fan, or a defective heating element. The

Date _____ Box No. _____

Barometric pressure, P_b = ___in. Hg Dry gas meter No. _____

Orifice manometer setting, ΔH, in. H_2O	Gas volume wet test meter V_w, ft^3	Gas volume dry gas meter V_d, ft^3	Temperature						
			Wet test	Dry gas meter			Time θ, min	γ	$\Delta H@$
			Meter t_w, °F	Inlet t_{di}, °F	Outlet t_{do}, °F	Average t_d, °F			
0.5	5								
1.0	5								
2.0	10								
4.0	10								
6.0	10								
8.0	10								
						Average			

Calculations

ΔH	$\frac{\Delta H}{13.6}$	γ	$\Delta H@$
		$\frac{V_w P_b (t_d + 460)}{V_d\left(P_b + \frac{\Delta H}{13.6}\right)\left(t_w + 460\right)}$	$\frac{0.0317\ \Delta H}{P_b\ (t_{do} + 460)}\left[\frac{(t_w + 460)\ \theta}{V_w}\right]^2$
0.5	0.0368		
1.0	0.0737		
2.0	0.147		
4.0	0.294		
6.0	0.431		
8.0	0.588		

γ = Ratio of accuracy of wet test meter to dry test meter. Tolerance = ± 0.01

$\Delta H@$ = Orifice pressure differential that gives 0.75 cfm of air at 70° F and 29.92 inches of mercury, in. H_2O. Tolerance - ± 0.15

Figure 9. Suggested orifice and dry gas meter calibration and calculation form.

wiring diagram is shown in Figure 12. Check thermostat operation by inserting a dial thermometer in the heated section of the box. The temperature will generally fluctuate 20 to 30° about the average after it stabilizes. The usual setting is 250° F, but the thermostat can be adjusted to the setting desired.

Check the probe heater plug with a voltmeter or with a 110-volt check light.

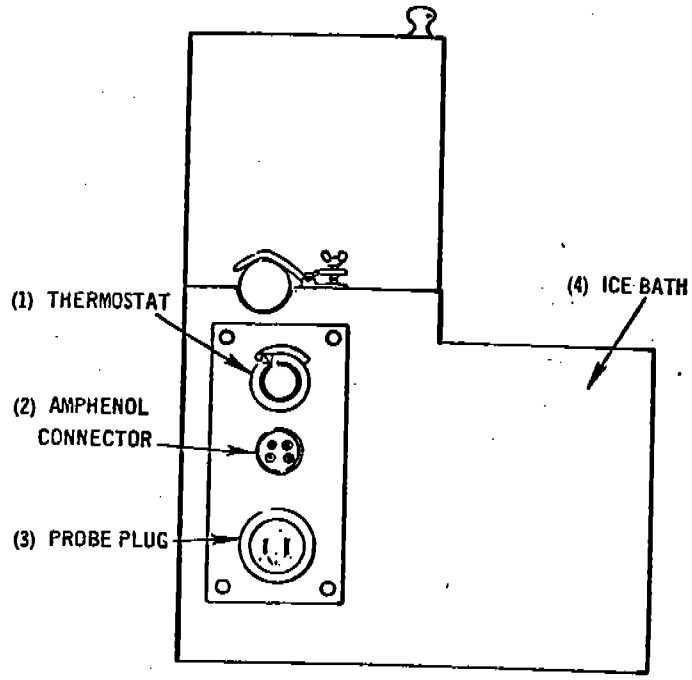


Figure 10. Sample box.

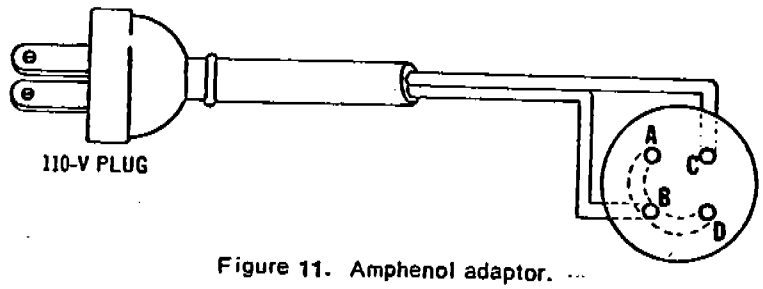


Figure 11. Amphenol adaptor.

A sample check list is shown in Figure 13. Again, for recording purposes, the box should be numbered. At least two sets of the sample-box assembly, including the glassware for each meter box, should be on hand for a stack test and preferably more, depending on the number of runs required in a day. The availability of several sets increases efficiency during the test since the sample train can be cleaned while the second run is being made or the trains can be cleaned after all runs have been completed.

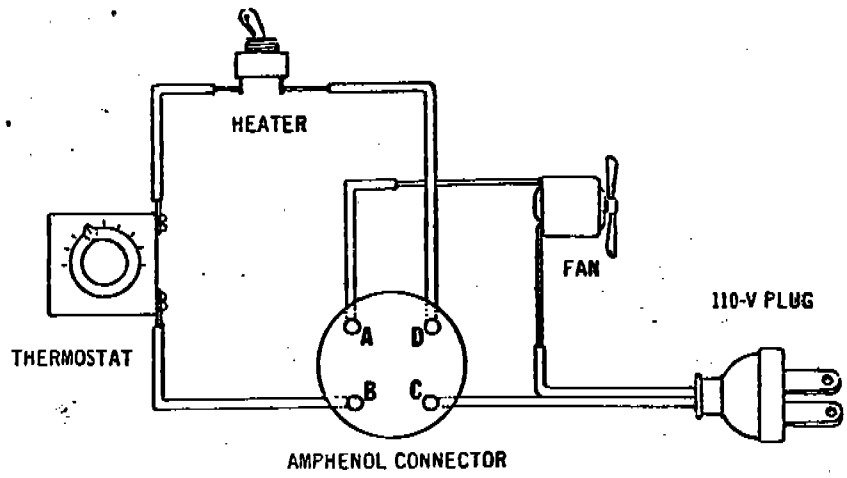


Figure 12. Amphenol wiring diagram.

Date _____ Box No. _____

Ice bath _____

Electrical system

Heater _____

Blower _____

Probe receptacle _____

Thermostat _____

Setting for average temperature of ___ °F

Temperature variation ___ °F ± ___ °F

General remarks _____

_____

_____

Initial each item when checked and write in any remarks.

Figure 13. Suggested sample box check list.

Glass Parts

Wipe the grease from the joints of the cyclone (1) and flask (2), filter holder (4), glass connectors (5), and impingers (3), shown in Figure 14. Wash with glass cleaning detergent. For hard-to-clean parts use dichromate sulfuric acid cleaning solution. Rinse with distilled, deionized water, and then acetone; air dry. Reassemble the impinger portions using a thin coat of acetone-insoluble silicone stopcock grease on the upper half of the taper joints (Figure 15). Cover all exposed openings to avoid contamination.

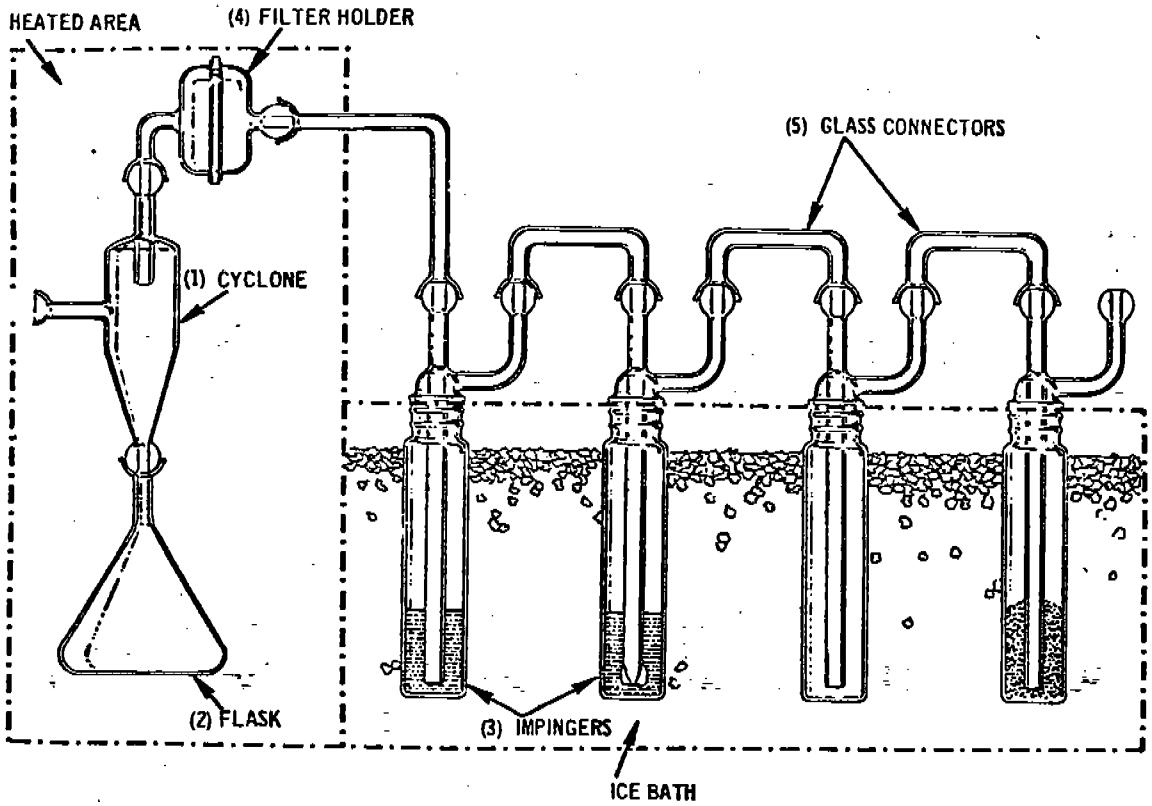


Figure 14. Sample box glassware assembly.

Glass Frit

If the glass frit (7), shown in Figure 16, is dirty, place it in boiling, concentrated HCl for 0.5 hour. Rinse with distilled, deionized water, and then acetone; air dry. If the frit still does not appear clean, boil for 2 hours in concentrated H_2SO_4 plus a few drops of sodium or potassium nitrate. Rinse well with distilled,

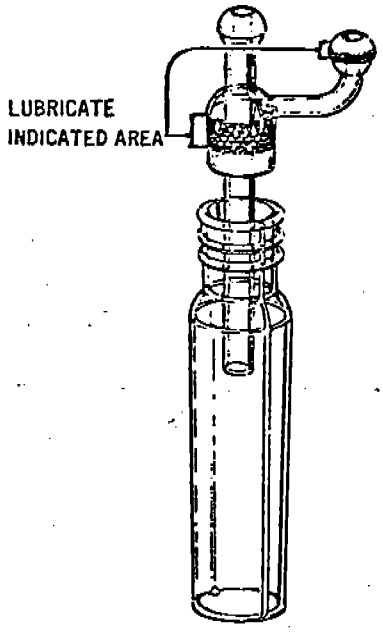


Figure 15. Impinger.

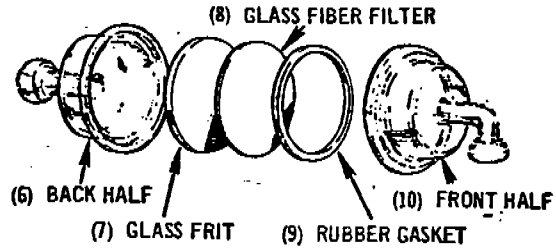


Figure 16. Glass filter holder assembly.

deionized water, and then acetone; air dry. This procedure should also be followed with new frits. The filter-holder assembly is shown in Figure 16.

Assemble the filter holder and components for a pressure-drop check as shown in Figure 17 (see dry gas meter and orifice meter under Calibration). Turn the pump on and adjust flow on the orifice manometer to $\Delta H@$. If the vacuum gauge

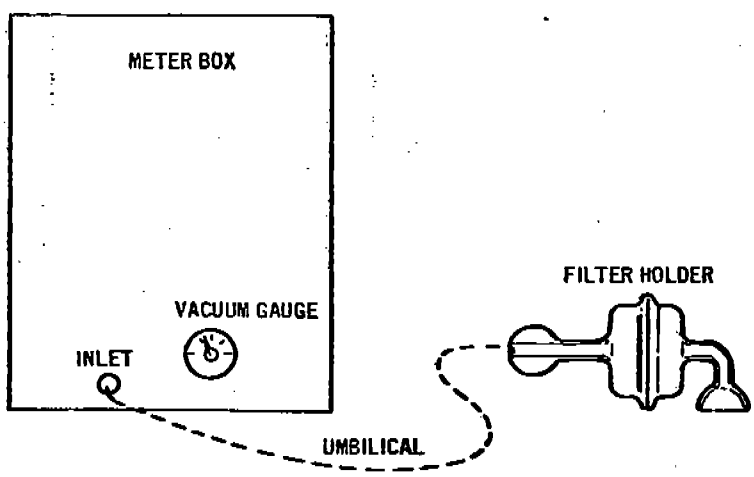


Figure 17. Glass frit pressure drop check.

on the meter box reads higher than 2 inches of mercury, the frit either is too fine and should be replaced or is dirty and should be cleaned and checked again.

Greenburg-Smith Impinger Orifice

Fill the Greenburg-Smith impinger tube with water. If the water does not drain through the orifice in 6 to 8 seconds, it should be replaced. This is only required for new impingers.

Filter-Holder Gasket

Clean the filter-holder gasket by washing. Rinse with distilled, deionized water, and then acetone; air dry.

UMBILICAL CORD

Quick Connects

Wipe the vacuum line and pitot line (1-2) quick connects clean (Figure 18). A drop of penetrating oil on each helps keep them in good working condition.

Thermometer

Check the dial thermometer (4). The temperature should check against room temperature when a mercury-in-glass thermometer is used as the standard.

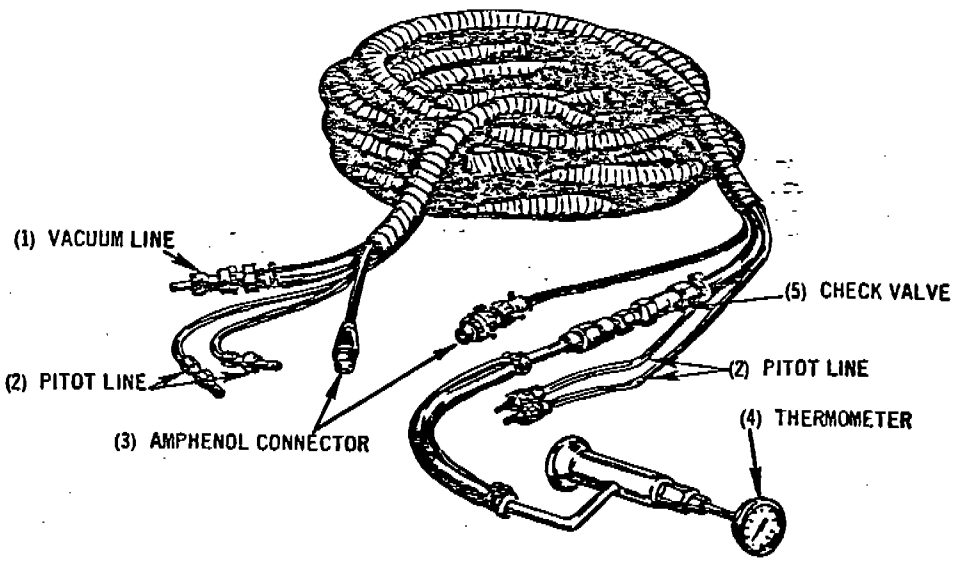


Figure 18. Umbilical cord.

Electrical Lines

Check the electrical lines (3) for continuity using an ohmmeter or a battery-light system. Make sure that the leads are connected to the proper prongs. If there is no continuity in any of the lines, check the Amphenol connections. If this is not the problem, replace the cord.

Check Valve

Disconnect the joint at the check valve (5) and add a drop of lubricating oil on the valve.

Vacuum and Pitot Lines

Test the vacuum line for leaks by blocking the inlet with the plugged ball joint. Connect the line to the meter box and check for leakage as before. If leakage is noted, check all connections first and then, if necessary, check the tubing. If the cause is not readily identified, slightly pressurize the line and check for leaks using soapy water.

Connect one end of the pitot-tube line to a 36-inch U-tube mercury manometer or a similar device. Pull a vacuum of at least 10 inches, seal the tubing at the pump end, and check for leaks by noting the mercury manometer. Do the same for the other side. If leakage is noted, check the tubing the same way as for the vacuum line.

A sample check list is shown in Figure 19. For recording purposes, the umbilical cord should be numbered.

Date _____ Umbilical No. _____

Quick connects _____

Thermometer _____

Electrical check _____

Check valve _____

Leak test

Vacuum line _____

Pitot lines _____

General remarks _____

_____

_____

_____

Initial each item when checked and write in any remarks.

Figure 19. Suggested umbilical cord check list.

CALIBRATION

NOZZLE DIAMETER

Using a micrometer, measure the inside diameter of the nozzle to the nearest 0.001 inch. Make 10 separate measurements using different diameters each time and obtain the average of the measurements. The largest deviation from the average should not exceed 0.002 inch. If the nozzle is satisfactory, polish off the old inscribed value or, if new, etch the value of the inside diameter on the outside of the nozzle.

PITOT TUBE

Measure the velocity pressure, ΔP, at the same point within a cross section of a straight run of ductwork (8 diameters downstream and 2 diameters upstream from any point of disturbance) with a standard pitot tube and the S-type pitot tube for the desired range of gas velocities. The S-type pitot should be calibrated twice, reversing the direction of the legs during the second calibration. Make at least three determinations for each direction. Determine the pitot tube coefficient for each direction as:

$$C_{P(s)} = 0.99\sqrt{\frac{\Delta P\ (\text{standard})}{\Delta P(s)}}$$

Use only those pitot tubes in which the average coefficient, C_p, equals 0.85 ± 0.02 in both directions, since the nomograph used with the sampling train is designed for this number.

DRY GAS METER AND ORIFICE METER

Connect the components as shown in Figure 20. The wet test meter is a 1-cubic-foot-per-revolution meter with $\pm$ 1 percent accuracy. Run the pump for about 15 minutes with the orifice manometer set at about 0.5 inch of water to allow the pump to warm up and to permit the interior surface of the wet test meter to be wetted. Then gather the information as requested on the data sheet in Figure 9. Calculate γ, the ratio of accuracy of the wet test meter to the dry test meter, and $\Delta H_@$. If an average γ of 1.0 ± 0.01 is not obtained, the dry gas meter should be

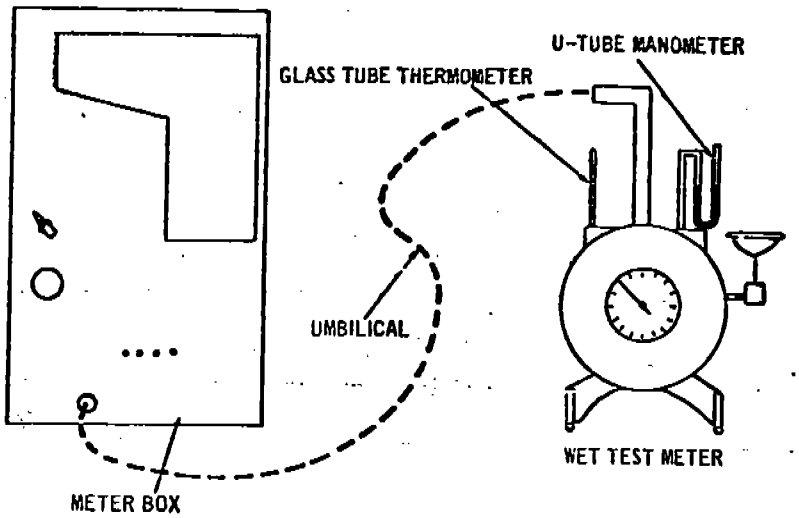


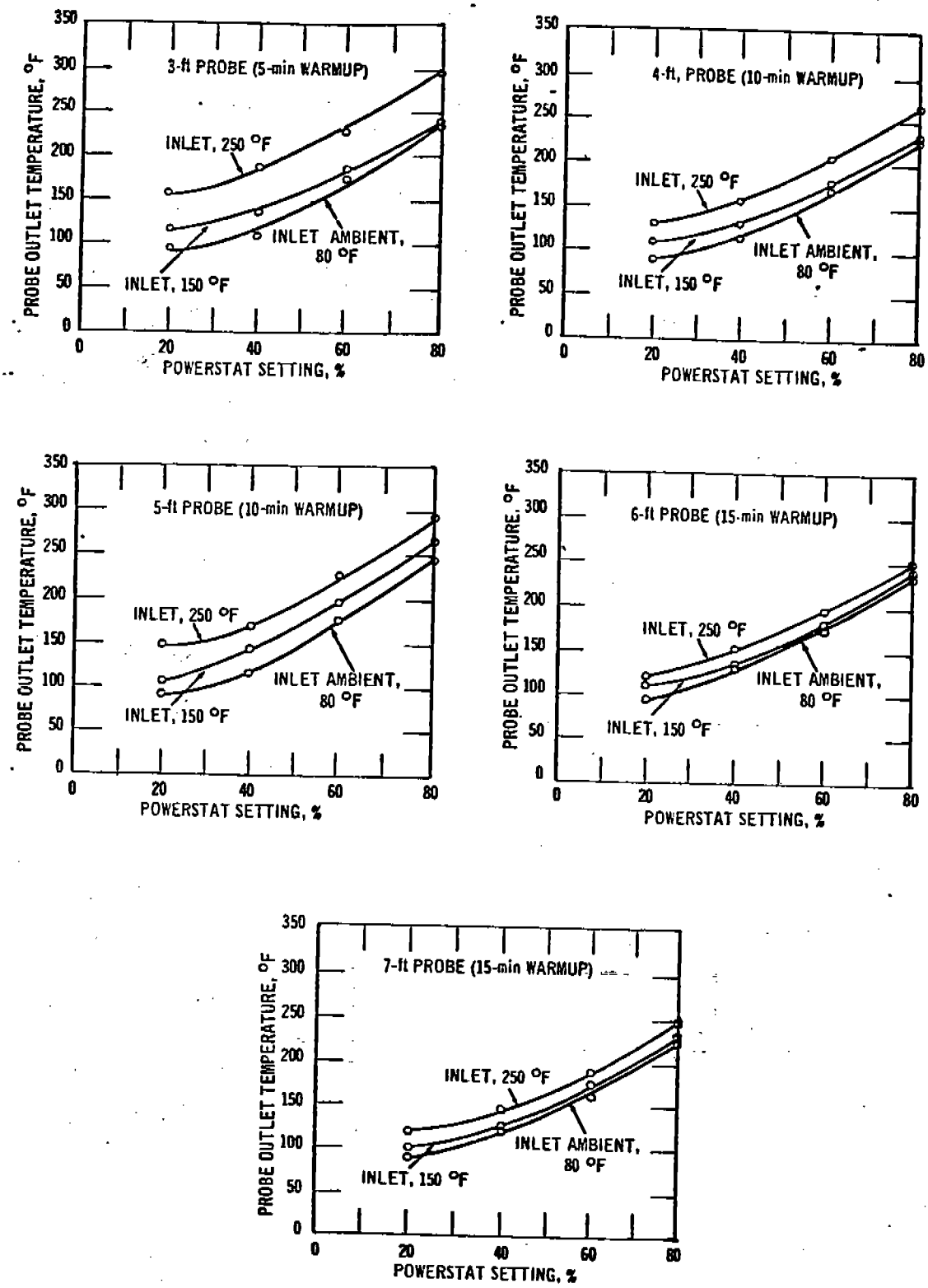
Figure 20. Calibration setup.

adjusted until γ meets the specification. This can be accomplished by removing the plate on top of the gas meter and adjusting the linkages.

Since the nomograph is designed for a $\Delta H@$ of 1.84 inches of water, a value within 0.25 inch of 1.84 inches of water is desirable. If a value in this range is not obtained, the orifice opening should be adjusted or the orifice replaced. In addition, $\Delta H@$ should not vary by more than $\pm$ 0.15 over the range of operation of 0.5 to 8 inches of water. If the $\Delta H@$ is acceptable, record $\Delta H@$ on the front of the meter box.

HEATING PROBE CALIBRATION

If the probes are constructed as outlined in Reference 1, the graphs in Figure 21 may be used to determine the probe heat setting required. If the probes are not constructed as outlined or a calibration of the probes is required, similar graphs can be constructed by using a heat source and measuring the inlet and outlet temperatures at the various variable transformer settings while passing air through at about 0.75 cubic foot per minute.



NOTE: Flow rate held constant at 0.75; 50% change in flow rate has little effect on probe temperature.

Figure 21. Probe temperatures.

FIELD OPERATION

Preparing the site so that the equipment can be positioned is frequently the most difficult part of sampling. Scaffolding must occasionally be erected when the sample port is not near a catwalk or other structure. The duorail[2] has been found to be a useful tool for sampling small-diameter stacks. At many sites the sampler must use his ingenuity to get the sampling equipment to the sample port.

In selecting the site, the sampler should keep in mind that the distance from the probe to the bottom of the sample box is about 13 inches. Although the equipment was designed to fit into 2-1/2-inch holes, it has been found that 3-inch holes allow easier entrance and removal without nicking the nozzle or picking up deposited dust.

Because sampling approaches vary, the description of the operation of the isokinetic sampling equipment will be confined to the use of the nomographs, assembly of the components, and adjustment of the flow rate to isokinetic conditions once the probe is positioned at the desired sampling point.

NOMOGRAPHS

The correction factor nomograph (Figure 22) and the operating nomograph (Figure 23) have been designed for use with the sampling train as aids for rapid isokinetic sampling rate adjustments and for selection of a convenient nozzle size. To determine the correction factor, C, on the nomograph, the following information is first required:

1. Percent moisture, % H_2O. This may be determined from a previous test or presurvey, or before the sample run.
2. Orifice calibration factor, $\Delta H_@$. This is determined from the laboratory calibration (see section on Calibration).
3. Meter temperature, T_m. Temperature at the meter rises above ambient temperature because of the pump and can easily be estimated with experience. An estimate within 10° F (approximately ± 1 percent error) is all

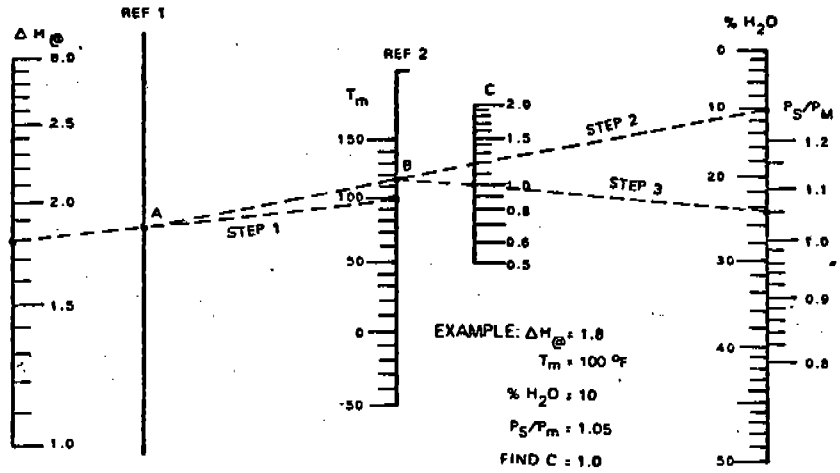


Figure 22. Nomograph for correction factor C.

that is necessary (an initial estimate of about 25° F above ambient temperature has been used).

4. Stack pressure, P_s. This is measured before the sample run; or if the sampling site is near the exit of the stack, atmospheric pressure is used.

5. Meter pressure, P_m. Same as atmospheric pressure.

To obtain correction factor, C (Figure 22):

1. Draw line from $\Delta H_@$ to T_m to obtain point "A" on reference line 1 (REF 1).

2. Draw line from point "A" to % H_2O to obtain point "B" on reference line 2 (REF 2).

3. Draw line from point "B" to the calculated value P_s/P_m to obtain correction factor, C.

To select the nozzle size and to set the K-factor on the operating nomograph, the following information is first required:

1. C factor. This is obtained from the correction-factor nomograph (Figure 22).

2. Stack temperature, T_s. This is determined in °F by a rough temperature traverse to within ± 25° F before the sample run.

3. Average velocity pressure, ΔP. This is determined by a rough preliminary pitot traverse, using the average of minimum and maximum ΔP's in

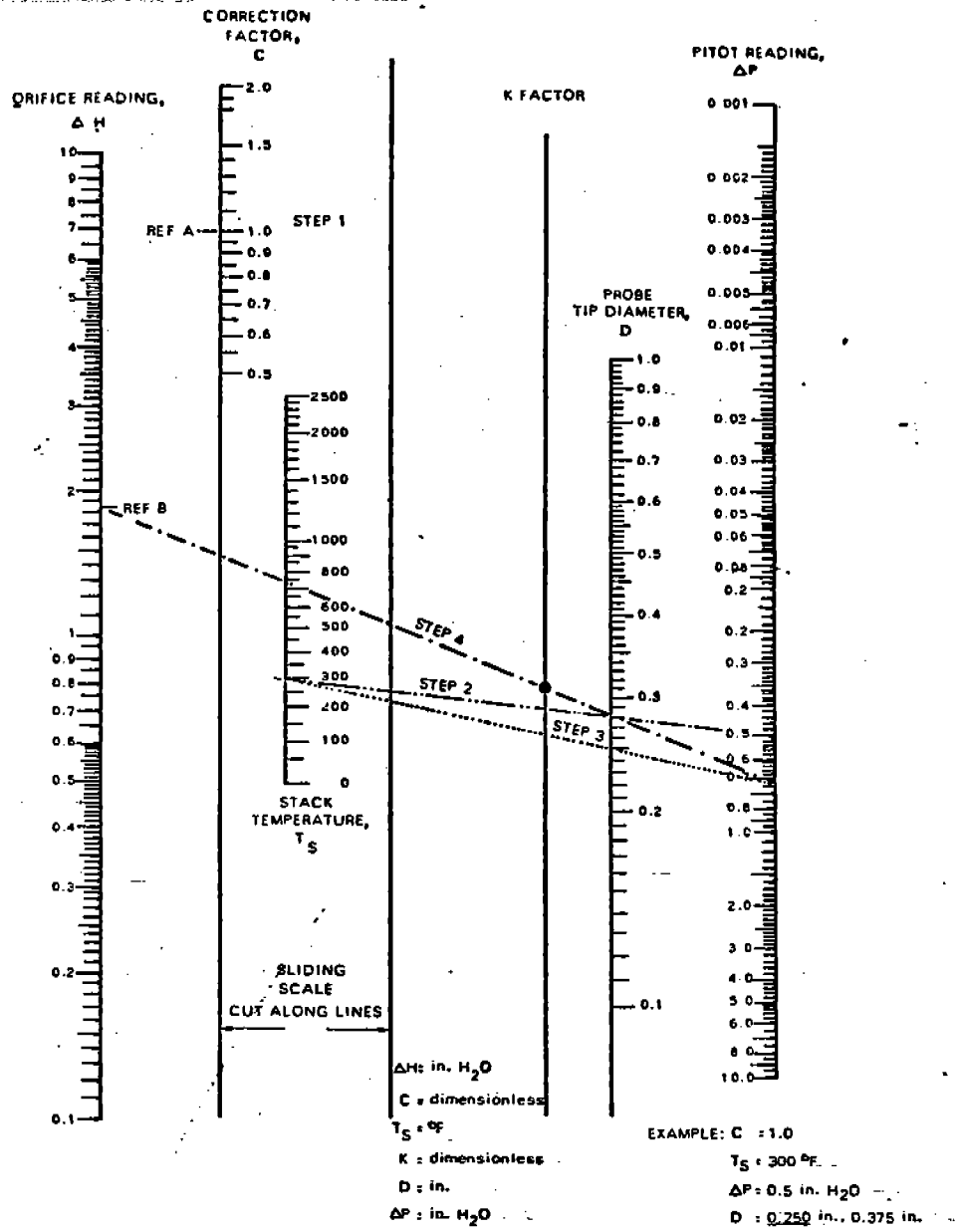


Figure 23. Use of the nomograph in selecting nozzle size and setting K factor.

inches of water.

4. Exact available nozzle sizes, D. This is obtained from calibration of available nozzles.

To select the nozzle size and to set the K-factor pivot point, use the following procedure (Figure 23):

1. Set correction factor, C, on sliding scale to the reference mark, "A."
2. Align T_s with average ΔP, note probe tip diameter on D scale, and select exact nozzle size closest to it.
3. Align T_s with exact nozzle size selected and obtain a value on the ΔP scale.
4. Align the ΔP value with reference mark, "B", on ΔH scale, and set the K-factor pivot point.

To obtain the orifice meter setting, ΔH, for isokinetic conditions after the K-factor pivot point has been set, use the following procedure (Figure 24):

1. Position the pitobe nozzle at the sampling point.
2. Read the pitot tube ΔP.
3. Align the ΔP through the K-factor pivot point.
4. Obtain ΔH and adjust metering valves.

The nomograph assumes the following once the K-factor pivot point is set:

1. T_s does not change more than 25° for $T_s < 1000°$ F or 50° for $T_s > 1000°$ F.
2. D is not changed during the test.
3. T_m was estimated correctly and does not vary more than 10°.
4. Percent H_2O remains constant, within $\pm$ 1.0%.
5. P_s and P_m remain constant, within $\pm$ 1.0%.

SAMPLE COLLECTION ASSEMBLY

Pitobe Assembly

After selecting a suitable probe length, remove the cover from the nozzle side of the stainless steel union on the probe sheath. Ensure that the probe side of the union contains a stainless steel back ferrule inserted backwards and a Viton A O-ring, and that the nozzle side has a stainless steel front and back ferrule (Figure 2). If the stack temperature is above 500° F, replace the Viton A O-ring with asbestos cord.

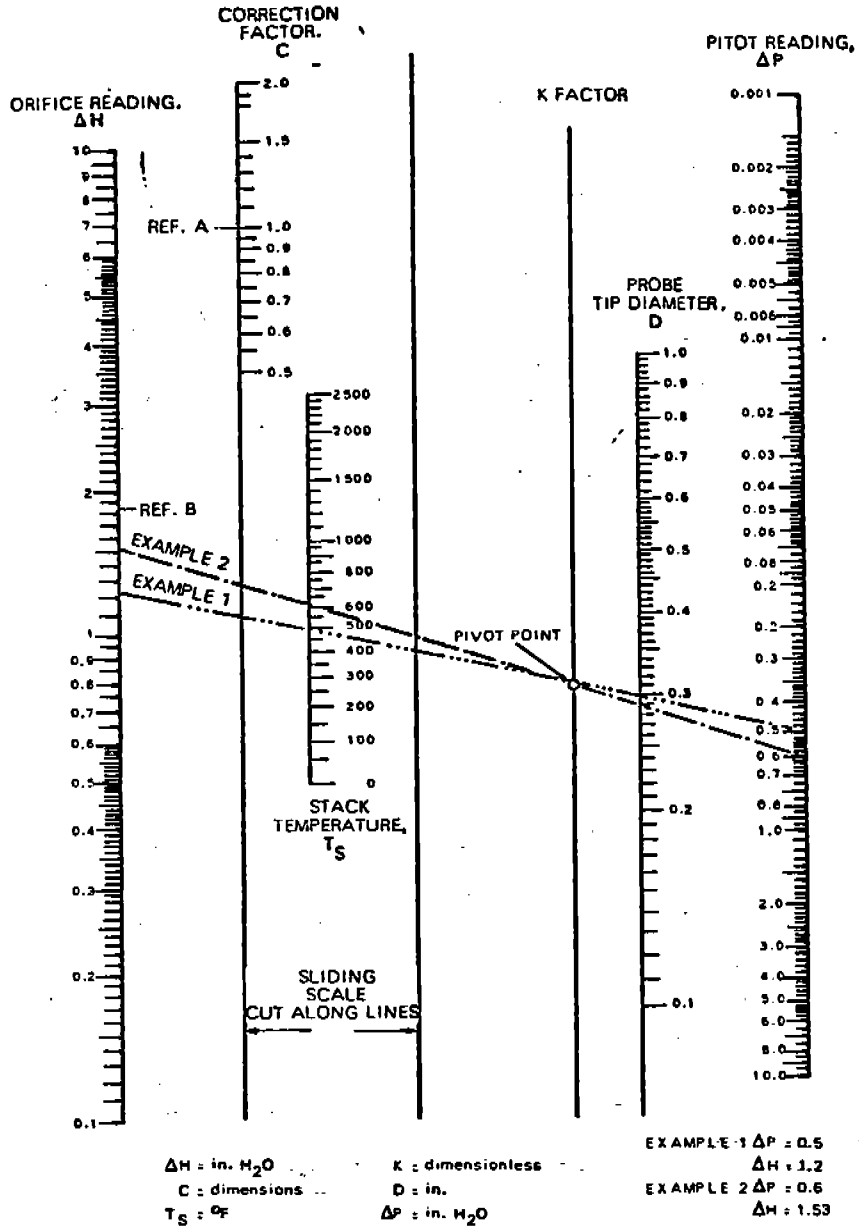


Figure 24. Nomograph operation to obtain desired orifice meter settings.

Remove the cover from the shank end of the selected nozzle (obtained from the nomograph), insert the nozzle in the probe sheath union, and finger tighten the union. Avoid the use of wrenches as this would bind the ferrules to the nozzle shank and could cause the glass probe to crack. Keep the nozzle tip and the ball joint on the glass probe covered until the assembly of the equipment is complete and sampling is about to begin. Mark the probe with heat-resistant tape or by

some other method to denote the proper distance into the stack or duct for each sampling point.

Attach a temperature probe to the metal sheath of the sampling probe so that the sensor extends beyond the probe tip and does not touch any metal. Its position should be about 1 inch from the pitot tube and probe nozzle to avoid interference with the gas flow.

Sample Box Assembly

Place the tared filter in the filter holder and record the filter number on the data sheet. Tighten the clamps around the filter holder to prevent leakage around the rubber gasket.

Assemble the collection system, as shown in Figure 1 or as dictated by the requirements of the test, using a very light coat of silicone grease (acetone non-reactive) on the lower half of all the male ball joints (Figure 15).

LEAK TEST

Place the meter box in a convenient position up to 200 feet from the test port and connect the vacuum line of the umbilical cord to the inlet of the meter box and the outlet of the last Greenburg-Smith impinger of the sample box. Check the ball joint stopper in the inlet to the cyclone for possible leakage. Turn the coarse-adjust valve on the meter box to the off position and open the fine-adjust valve slowly until fully opened. Partially close the fine-adjust valve until the vacuum gauge reads 10 inches of mercury; then check the dry gas meter for flow. If the flow through the dry gas meter exceeds 0.02 cubic foot per minute at 10 inches of mercury gauge pressure, the leak or leaks must be found and corrected.

When the check is complete, first remove the plug from the inlet to the cyclone, and immediately turn off the vacuum pump. This prevents water from the impingers from being forced backward into the filter and cyclone.

FINAL SAMPLING TRAIN ASSEMBLY

Remove the cover from the ball joint on the probe, lightly grease the lower half of the ball joint with silicone grease (Figure 15), and connect the probe. Make sure that the rubber stopper is snug in the opening in the sample box. Secure the probe by tightening the probe holding clamps.

Make all necessary electrical and pitot-tube line connections. Set the variable transformer on the meter box so that the desired probe temperature is obtained (use Figure 21 as a guide). Set the thermostat on the sample box at 250° F or at the desired temperature. Turn on the heater, blower, and probe switches on the meter box. Allow the sample box and probe to heat for at least 15 minutes before starting the test and make periodic checks and adjustments to assure the desired sample box temperature.

Fill the impinger section of the sample box with ice and a little water. Add ice periodically during testing to maintain the temperature of the gas leaving the last impinger at less than 70° F.

SAMPLE RUN

Record all necessary initial data such as that shown at the top of the sample data sheet in Figure 25, including the initial dry gas meter reading. Turn off the coarse-adjust valve on the meter box, fully open the fine-adjust valve, and set the timer cam to zero. Remove the cover from the nozzle tip and place the pitobe at the first sampling point. Record the clock time, read ΔP on the pitot tube manometer, and determine ΔH from the nomograph as shown previously.

Turn the pump on and set ΔH on the meter box first by adjusting the coarse-adjust valve and then the fine-adjust valve.

The sample run plan should consider the number of traverse points and the sampling time at each point. A good rule of thumb to follow is to collect a weight of particulate matter equal to about 20 percent of the filter weight. The upper limit is usually set by the pressure drop across the filter and the amount of condensate the impingers can hold. Generally the length of sampling time at each traverse point is 5 or 10 minutes.

During the sample traverse the pitobe is moved from point to point without turning the pump off except when changing ports. The ΔP should be monitored and adjustments made on the orifice meter with the aid of the nomograph when necessary. Besides the regular time interval recordings, a set of readings should be recorded when the ΔP changes by more than 20 percent.

Plant _____

Run number _____

Location _____

Date _____

Operator _____

Sample box number _____

Meter box number _____

VERY IMPORTANT - FILL IN ALL BLANKS

Read and record at the start of each test point.

Ambient temperature, °F _____

Barometric pressure, in. Hg _____

Assumed moisture, % _____

Heater box setting, °F _____

Probe tip diameter, in. _____

Probe length, ft. _____

Probe heater setting _____

Point	Clock time	Dry gas meter, ft^3	Pitot, in. H_2O ΔP	Orifice ΔH, in. H_2O		Dry gas temperature, °F		Pump vacuum, in. Hg gauge	Box temperature, °F	Impinger temperature, °F	Stack pressure, in. Hg	Stack temperature, °F
				Desired	Actual	Inlet	Outlet					

Comments:

Figure 25. Suggested particulate field data form.

SHUTDOWN

When testing has been completed, turn off the vacuum pump, remove the pitobe from the stack, and take a final set of readings. Turn off the heater, blower, and probe heat switches and remove the probe from the sampling port. Cover the nozzle tip as soon as it is cool enough in order to avoid contamination or loss of sample. Disconnect the probe from the cyclone inlet and cover both the end of the probe and the inlet to the cyclone. Disconnect the umbilical cord from the sample box and cover the last impinger outlet. The probe and sample box are then ready for cleanup and the analytical procedure.

REFERENCES

1. Martin, Robert M. Construction Details of Isokinetic Source-Sampling Equipment. Air Pollution Control Office, Environmental Protection Agency, Research Triangle Park, N. C. Publication No. APTD-0581. April 1971.

2. Smith, Walter S. et al. Stack Gas Sampling Improved and Simplified with New Equipment. Presented at 60th Annual Meeting of Air Poll. Control Assoc., Cleveland, Ohio. June 11-16, 1967.

U. S. GOVERNMENT PRINTING OFFICE : 1972 O -549-345

ERRATA FOR APTD-0576

MAINTENANCE, CALIBRATION, AND OPERATION
OF ISOKINETIC SOURCE-SAMPLING EQUIPMENT

1. Page 12, Figure 9. Change second equation under Calculations to

$$\frac{0.0317\ \Delta H}{P_b\ (t_{do} + 460)} \left[\frac{(t_w + 460)\ \theta}{V_w} \right]^2$$

2. Replace pages 27 and 29 with attached pages that contain corrections in the ΔP scale of the nomographs in Figures 23 and 24.

APPENDIX TWO

necessarily acceptable in all applications. Therefore, an owner electing to use such potentially approvable techniques or alternatives is responsible for: (1) assuring that the techniques or alternatives are in fact applicable and are properly executed; (2) including a written description of the alternative method in the test report (the written method must be clear and must be capable of being performed without additional instruction, and the the degree of detail should be similar to the detail contained in the reference methods); and (3) providing any rationale or supporting data necessary to show the validity of the alternative in the particular application. Failure to meet these requirements can result in the Administrator's disapproval of the alternative.

METHOD 1.—SAMPLE AND VELOCITY TRAVERSES FOR STATIONARY SOURCES

1. *Principle and Applicability*

1.1 Principle. To aid in the representative measurement of pollutant emissions and/or total volumetric flow rate from a stationary source, a measurement site where the effluent stream is flowing in a known direction is selected, and the cross-section of the stack is divided into a number of equal areas. A traverse point is then located within each of these equal areas.

1.2 Applicability. This method is applicable to flowing gas streams in ducts, stacks, and flues. The method cannot be used when: (1) flow is cyclonic or swirling (see Section 2.4), (2) a stack is smaller than about 0.30 meter (12 in.) in diameter, or 0.071 m^2 (113 $in.^2$) cross-sectional area, or (3) the measurement site is less than two stack or duct diameters downstream or less than a half diameter upstream from a flow disturbance.

The requirements of this method must be considered before construction of a new facility from which emissions will be measured; failure to do so may require subsequent alterations to the stack or deviation from the standard procedure. Cases involving variants are subject to approval by the Administrator, U.S. Environmental Protection Agency.

2. *Procedure*

2.1 Selection of Measurement Site. Sampling or velocity measurement is performed at a site located at least eight stack or duct diameters downstream and two diameters upstream from any flow disturbance such as a bend, expansion, or contraction in the stack, or from a visible flame. If necessary, an alternative location may be selected, at a position at least two stack or duct diameters downstream and a half diameter upstream from any flow disturbance. For a rectangular cross section, an equivalent diameter (D_e) shall be calculated from the following equation, to determine the upstream and downstream distances:

$$D_e = \frac{2LW}{L+W}$$

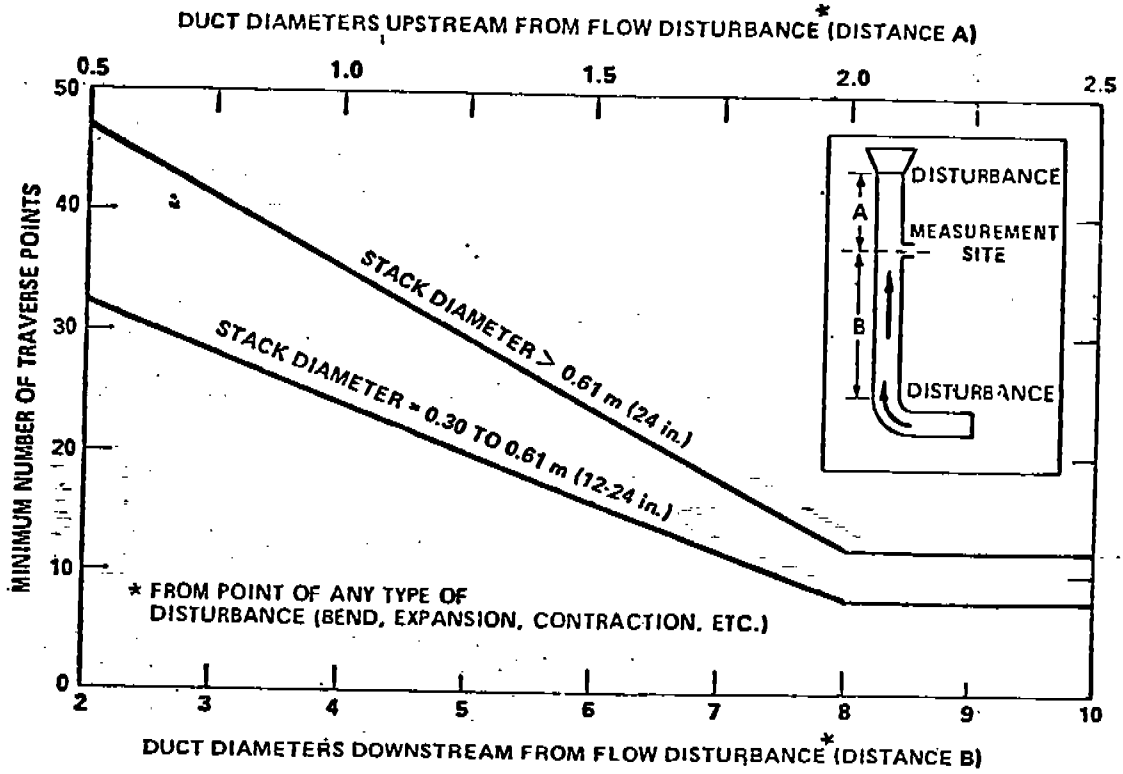


Figure 1-1. Minimum number of traverse points for particulate traverses.

where L=length and W=width.

2.2 Determining the Number of Traverse Points.

2.2.1 Particulate Traverses. When the eight- and two-diameter criterion can be met, the minimum number of traverse points shall be: (1) twelve, for circular or rectangular stacks with diameters (or equivalent diameters) greater than 0.61 meter (24 in.); (2) eight, for circular stacks with diameters between 0.30 and 0.61 meter (12-24 in.); (3) nine, for rectangular stacks with equivalent diameters between 0.30 and 0.61 meter (12-24 in.).

When the eight- and two-diameter criterion cannot be met, the minimum number of traverse points is determined from Figure 1-1. Before referring to the figure, however, determine the distances from the chosen measurement site to the nearest upstream and downstream disturbances, and divide each distance by the stack diameter or equivalent diameter, to determine the distance in terms of the number of duct diameters. Then, determine from Figure 1-1 the minimum number of traverse points that corresponds: (1) to the number of duct diameters upstream; and (2) to the number of diameters downstream. Select the higher of the two minimum numbers of traverse points, or a greater value, so that for circular stacks the number is a multiple of 4, and for rectangular stacks, the number is one of those shown in Table 1-1.

TABLE 1-1. *Cross-sectional layout for rectangular stacks*

Number of traverse points	*Matrix layout*
9	3x3
12	4x3
16	4x4
20	5x4
25	5x5
30	6x5
36	6x6
42	7x6
49	7x7

[Appendix A, Method 1]

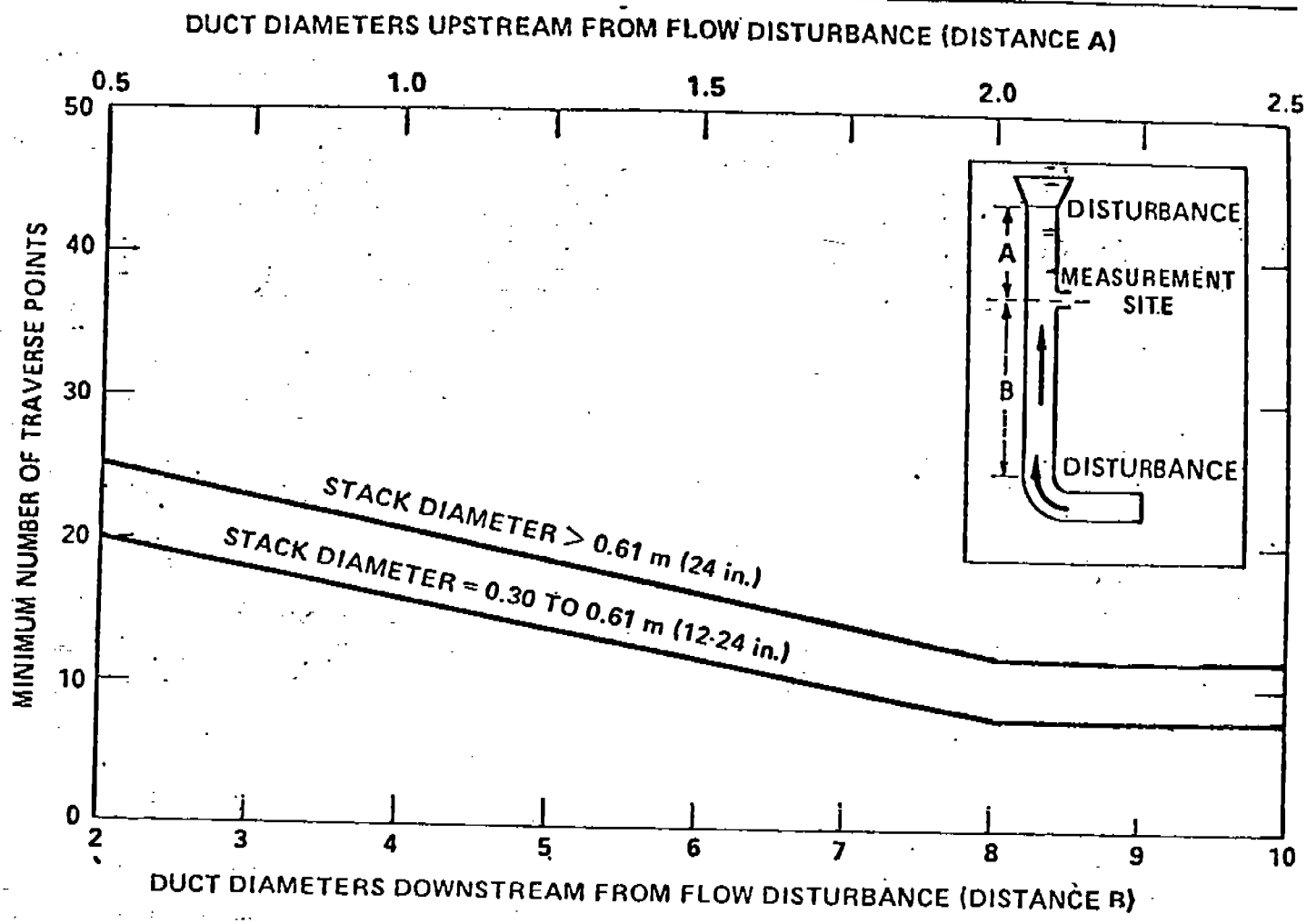


Figure 1-2. Minimum number of traverse points for velocity (nonparticulate) traverses.

2.2.2 Velocity (Non-Particulate) Traverses. When velocity or volumetric flow rate is to be determined (but not particulate matter), the same procedure as that for particulate traverses (Section 2.2.1) is followed, except that Figure 1-2 may be used instead of Figure 1-1.

2.3 Cross-Sectional Layout and Location of Traverse Points.

2.3.1 Circular Stacks. Locate the traverse points on two perpendicular diameters according to Table 1-2 and the example shown in Figure 1-3. Any equation (for examples, see Citations 2 and 3 in the Bibliography) that gives the same values as those in Table 1-2 may be used in lieu of Table 1-2.

For particulate traverses, one of the diameters must be in a plane containing the greatest expected concentration variation, e.g., after bends, one diameter shall be in the plane of the bend. This requirement becomes less critical as the distance from the disturbance increases; therefore, other diameter locations may be used, subject to approval of the Administrator.

In addition, for stacks having diameters greater than 0.61 m (24 in.) no traverse points shall be located within 2.5 centimeters (1.00 in.) of the stack walls; and for stack diameters equal to or less than 0.61 m (24 in.), no traverse points shall be located within 1.3 cm (0.50 in.) of the stack walls. To meet these criteria, observe the procedures given below.

2.3.1.1 Stacks With Diameters Greater Than 0.61 m (24 in.). When any of the traverse points as located in Section 2.3.1 fall within 2.5 cm (1.00 in.) of the stack walls, relocate them away from the stack walls to: (1) a distance of 2.5 cm (1.00 in.); or (2) a distance equal to the nozzle inside diameter, whichever is larger. These relocated traverse points (on each end of a diameter) shall be the "adjusted" traverse points.

Whenever two successive traverse points are combined to form a single adjusted traverse point, treat the adjusted point as two separate traverse points, both in the sampling (or velocity measurement) procedure, and in recording the data.

TRAVERSE POINT	DISTANCE, % of diameter
1	4.4
2	14.7
3	29.5
4	70.5
5	85.3
6	95.6

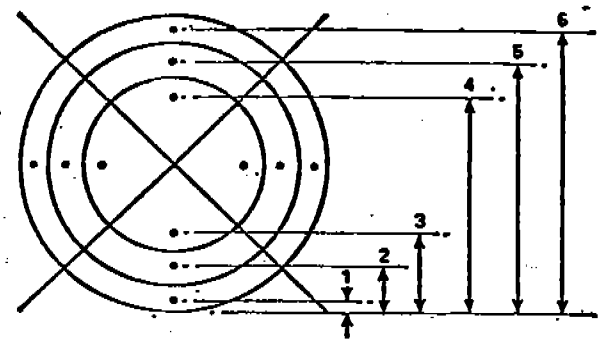


Figure 1-3. Example showing circular stack cross section divided into 12 equal areas, with location of traverse points indicated.

Table 1-2. 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											
	2	4.	6	8	10	12	14	16	18	20	22	24
1	14.6	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	85.4	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3		75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4		93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5			85.4	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	35.6	26.9	22.0	18.8	16.5	14.6	13.2
7				89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1
8				96.8	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	26.2	23.0
10					97.4	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	73.8	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

2.3.1.2 Stacks With Diameters Equal to or Less Than 0.61 m (24 in.). Follow the procedure in Section 2.3.1.1, noting only that any "adjusted" points should be relocated away from the stack walls to: (1) a distance of 1.2 cm (0.50 in.); or (2) a distance equal to the nozzle inside diameter, whichever is larger.

2.3.2 Rectangular Stacks. Determine the number of traverse-points as explained in Sections 2.1 and 2.2 of this method. From Table 1-1, determine the grid configuration. Divide the stack cross-section into as many equal rectangular elemental areas as traverse points, and then locate a traverse point at the centroid of each equal area according to the example in Figure 1-4.

If the tester desires to use more than the minimum number of traverse points, expand the "minimum number of traverse points" matrix (see Table 1-1) by adding the extra traverse points along one or the other or both legs of the matrix; the final matrix need not be balanced. For example, if a 4x3 "minimum number of points" matrix were expanded to 36 points, the final matrix could be 9x4 or 12x3, and would not necessarily have to be 6x6. After constructing the final matrix, divide the stack cross-section into as many equal rectangular, elemental areas as traverse points, and locate a traverse point at the centroid of each equal area.

The situation of traverse points being too close to the stack walls is not expected to arise with rectangular stacks. If this problem should ever arise, the Administrator must be contacted for resolution of the matter.

2.4 Verification of Absence of Cyclonic Flow. In most stationary sources, the direction of stack gas flow is essentially parallel to the stack walls. However, cyclonic flow may exist (1) after such devices as cyclones and inertial demisters following venturi scrubbers, or (2) in stacks having tangential inlets or other duct configurations which tend to induce swirling; in these instances, the presence or absence of cyclonic flow at the sampling location must be determined. The following techniques are acceptable for this determination.

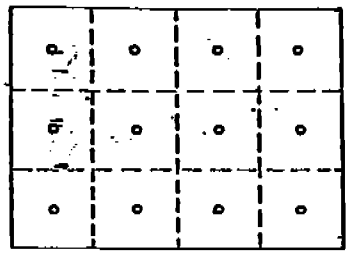


Figure 1-4. Example showing rectangular stack cross section divided into 12 equal areas, with a traverse point at centroid of each area.

Level and zero the manometer. Connect a Type S pitot tube to the manometer. Position the Type S pitot tube at each traverse point, in succession, so that the planes of the face openings of the pitot tube are perpendicular to the stack cross-sectional plane; when the Type S pitot tube is in this position, it is at "0° reference." Note the differential pressure (Δp) reading at each traverse point. If a null (zero) pitot reading is obtained at 0° reference at a given traverse point, an acceptable flow condition exists at that point. If the pitot reading is not zero at 0° reference, rotate the pitot tube (up to ±90° yaw angle), until a null reading is obtained. Carefully determine and record the value of the rotation angle (α) to the nearest degree. After the null technique has been applied at each traverse point, calculated the average of the absolute values of α; assign α values of 0° to those points for which no rotation was required, and include these in the overall average. If the average value of α is greater than 10°, the overall flow condition in the stack is unacceptable and alternative methodology, subject to the approval of the Administrator, must be used to perform accurate sample and velocity traverses.

3. *Bibliography*

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

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

5. Hanson, H. A., et al. Particulate Sampling Strategies for Large Power Plants Including Nonuniform Flow. USEPA, ORD, ESRL, Research Triangle Park, N.C. EPA-600/2-76-170. June 1976.

6. Entropy Environmentalists, Inc. Determination of the Optimum Number of Sampling Points: An Analysis of Method 1 Criteria. Environmental Protection Agency. Research Triangle Park, N.C. EPA Contract No. 68-01-3172, Task 7.

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

1. *Principle and Applicability*

1.1 Principle. The average gas velocity in a stack is determined from the gas density and from measurement of the average velocity head with a Type S (Stausscheibe or reverse type) pitot tube.

1.2 Applicability. This method is applicable for measurement of the average velocity of a gas stream and for quantifying gas flow.

This procedure is not applicable at measurement sites which fail to meet the criteria of Method 1, Section 2.1. Also, the method cannot be used for direct measurement in cyclonic or swirling gas streams; Section 2.4 of Method 1 shows how to determine cyclonic or swirling flow conditions. When unacceptable conditions exist, alternative procedures, subject to the approval of the Administrator, U.S. Environmental Protection Agency, must be employed to make accurate flow rate determinations; examples of such alternative procedures are: (1) to install straightening vanes; (2) to calculate the total volumetric flow rate stoichiometrically, or (3) to move to another measurement site at which the flow is acceptable.

2. *Apparatus*

Specifications for the apparatus are given below. Any other apparatus that has been demonstrated (subject to approval of the Administrator) to be capable of meeting the specifications will be considered acceptable.

[Appendix A, Method 2]

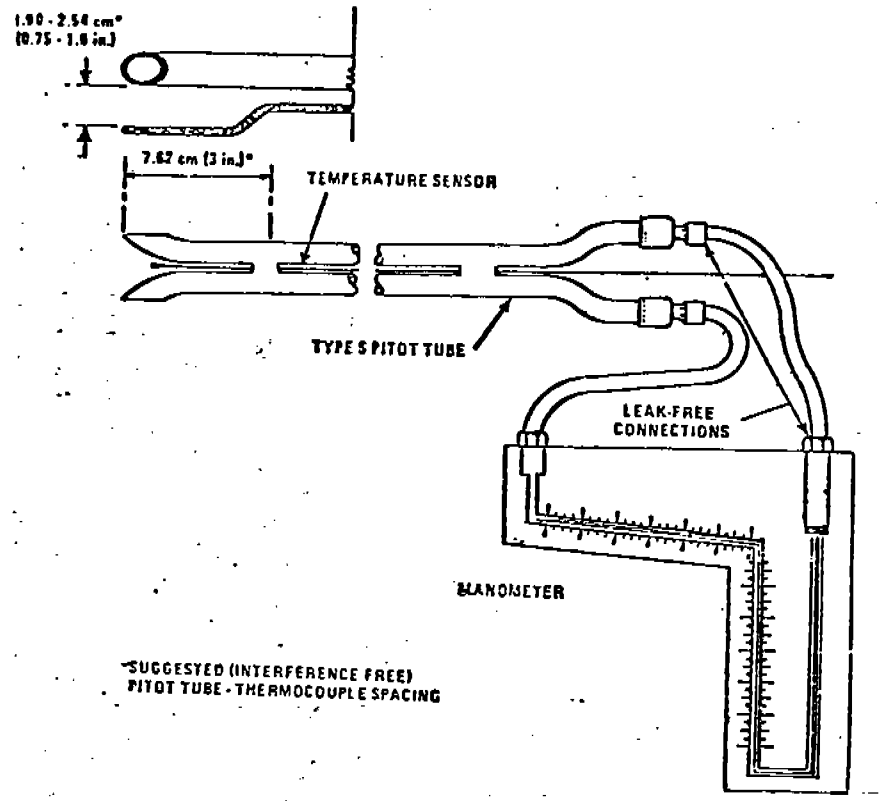


Figure 2-1. Type S pitot tube manometer assembly.

2.1 Type S Pitot Tube. The Type S pitot tube (Figure 2-1) shall be made of metal tubing (e.g., stainless steel). It is recommended that the external tubing diameter (dimension D_t, Figure 2-2b) be between 0.48 and 0.95 centimeters (3/16 and 3/8 inch). There shall be an equal distance from the base of each leg of the pitot tube to its face-opening plane (dimensions P_A and P_B, Figure 2-2b); it is recommended that this distance be between 1.05 and 1.50 times the external tubing diameter. The face openings of the pitot tube shall, preferably, be aligned as shown in Figure 2-2; however, slight misalignments of the openings are permissible (see Figure 2-3).

The Type S pitot tube shall have a known coefficient, determined as outlined in Section 4. An identification number shall be assigned to the pitot tube; this number shall be permanently marked or engraved on the body of the tube.

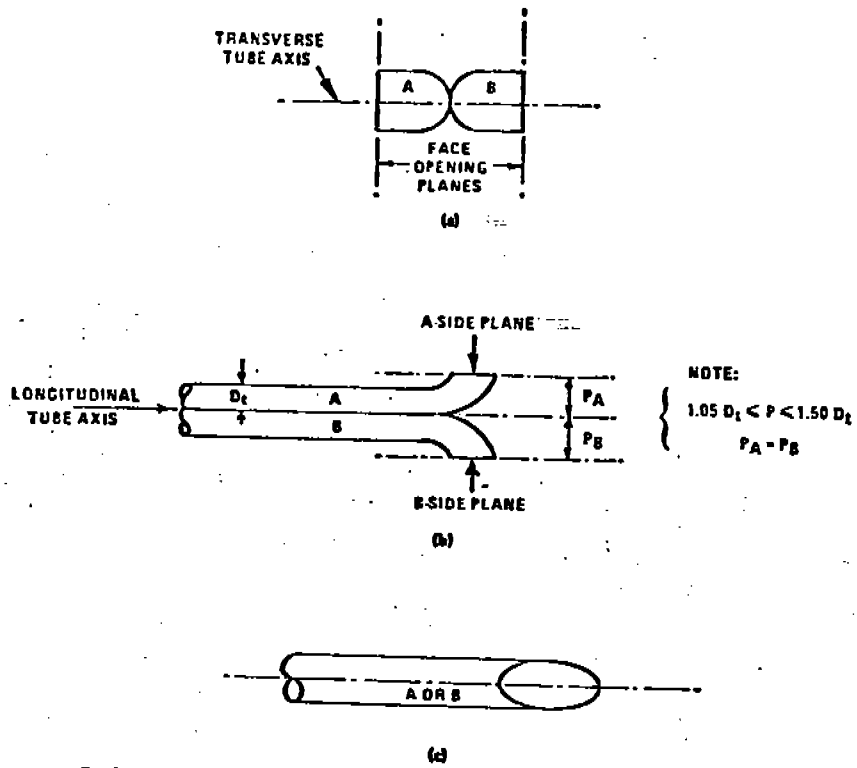


Figure 2-2. Properly constructed Type S pitot tube, shown in: (a) end view; face opening planes perpendicular to transverse axis; (b) top view; face opening planes parallel to longitudinal axis; (c) side view; both legs of equal length and centerlines coincident, when viewed from both sides. Baseline coefficient values of 0.84 may be assigned to pitot tubes constructed this way.

[Appendix A, Method 2]

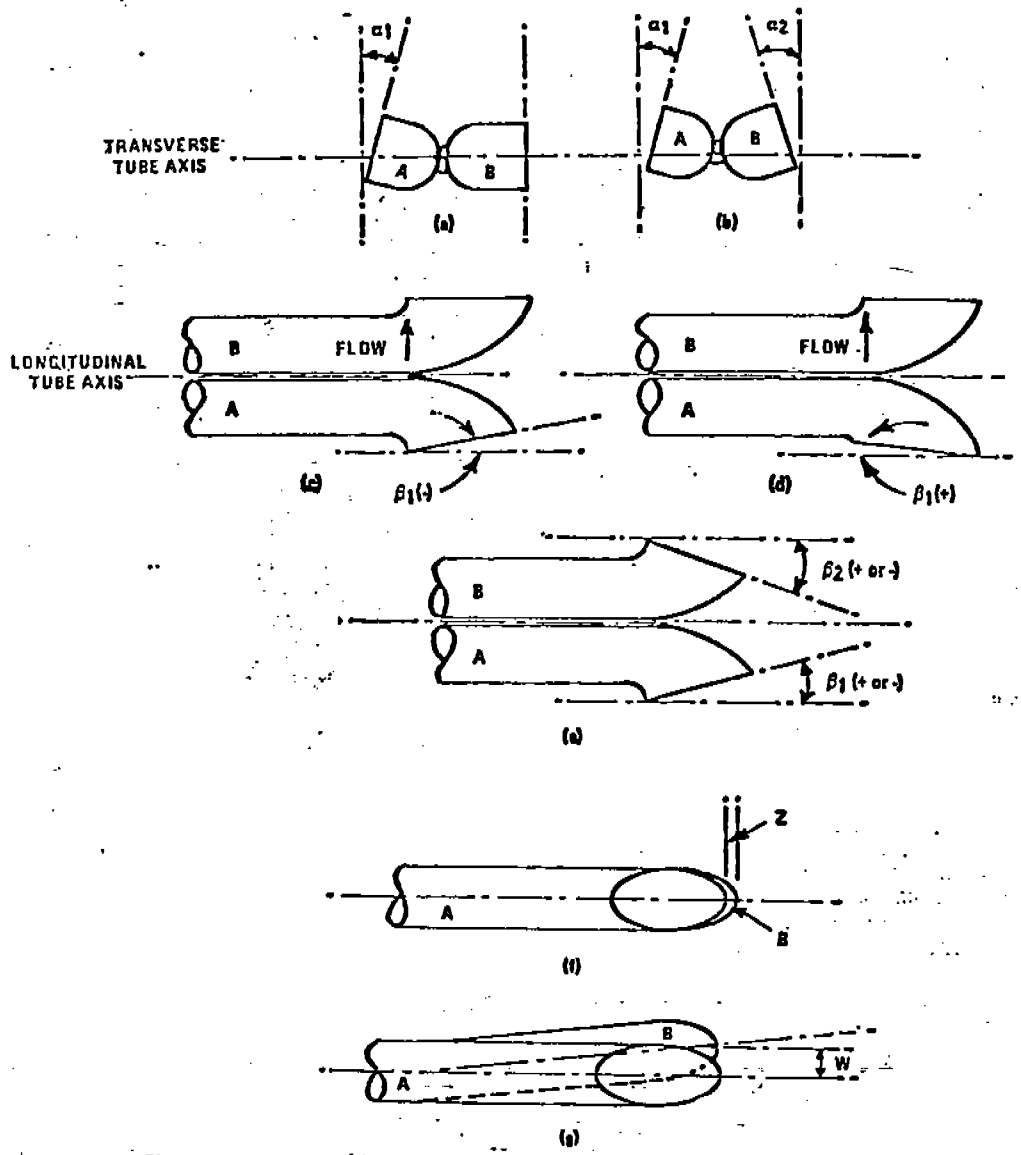


Figure 2-3. Types of face-opening misalignment that can result from field use or improper construction of Type S pitot tubes. These will not affect the baseline value of $\bar{C}p(s)$ so long as α_1 and $\alpha_2 < 10°$, β_1 and $\beta_2 < 5°$, $z < 0.32$ cm (1/8 in.) and $w < 0.08$ cm (1/32 in.) (citation 11 in Section 6).

A standard pitot tube may be used instead of a Type S, provided that it meets the specifications of Sections 2.7 and 4.2; note, however, that the static and impact pressure holes of standard pitot tubes are susceptible to plugging in particulate-laden gas streams. Therefore, whenever a standard pitot tube is used to perform a traverse, adequate proof must be furnished that the openings of the pitot tube have not plugged up during the traverse period; this can be done by taking a velocity head (Δp) reading at the final traverse point, cleaning out the impact and static holes of the standard pitot tube by "back-purging" with pressurized air, and then taking another Δp reading. If the Δp readings made before and after the air purge are the same (±5 percent), the traverse is acceptable. Otherwise, reject the run. Note that if Δp at the final traverse point is unsuitably low, another point may be selected. If "back-purging" at regular intervals is part of the procedure, then comparative Δp readings shall be taken, as above, for the last two back purges at which suitably high Δp readings are observed.

2.2 Differential Pressure Gauge. An inclined manometer or equivalent device is used. Most sampling trains are equipped with a 10-in. (water column) inclined-vertical manometer, having 0.01-in. H_2O divisions on the 0- to 1-in. inclined scale, and 0.1-in. H_2O divisions on the 1- to 10-in. vertical scale. This type of manometer (or other gauge of equivalent sensitivity) is satisfactory for the measurement of Δp values as low as 1.3 mm (0.05 in.) H_2O. However, a differential pressure gauge of greater sensitivity shall be used (subject to the approval of the Administrator), if any of the following is found to be true: (1) the arithmetic average of all Δp readings at the traverse points in the stack is less than 1.3 mm (0.05 in.) H_2O; (2) for traverses of 12 or more points, more than 10 percent of the individual Δp readings are below 1.3 mm (0.05 in.) H_2O; (3) for traverses of fewer than 12 points, more than one Δp reading is below 1.3 mm (0.05 in.) H_2O. Citation 18 in Section 6 describes commercially available instrumentation for the measurement of low-range gas velocities.

As an alternative to criteria (1) through (3) above, the following calculation may be performed to determine the necessity of using a more sensitive differential pressure gauge:

$$T = \frac{\sum_{i=1}^{n} \sqrt{\Delta p_i + K}}{\sum_{i=1}^{n} \sqrt{\Delta p_i}}$$

where:

Δp_i = Individual velocity head reading at a traverse point, mm H_2O (in. H_2O).

n = Total number of traverse points.

K = 0.13 mm H_2O when metric units are used and 0.005 in H_2O when English units are used.

If T is greater than 1.05, the velocity head data are unacceptable and a more sensitive differential pressure gauge must be used.

NOTE.—If differential pressure gauges other than inclined manometers are used (e.g., magnehelic gauges), their calibration must be checked after each test series. To check the calibration of a differential pressure gauge, compare Δp readings of the gauge with those of a gauge-oil manometer at a minimum of three points, approximately representing the range of Δp values in the stack. If, at each point, the values of Δp as read by the differential pressure gauge and gauge-oil manometer agree to within 5 percent, the differential pressure gauge shall be considered to be in proper calibration. Otherwise, the test series shall either be voided, or procedures to adjust the measured Δp values and final results shall be used, subject to the approval of the Administrator.

2.3 Temperature Gauge. A thermocouple, liquid-filled bulb thermometer, bimetallic thermometer, mercury-in-glass thermometer, or other gauge capable of measuring temperature to within 1.5 percent of the minimum absolute stack temperature shall be used. The temperature gauge shall be attached to the pitot tube such that the sensor tip does not touch any metal; the gauge shall be in an interference-free arrangement with respect to the pitot tube face openings (see Figure 2-1 and also Figure 2-7 in Section 4). Alternate positions may be used if the pitot tube-temperature gauge system is calibrated according to the procedure of Section 4. Provided that a difference of not more than 1 percent in the average velocity measurement is introduced, the temperature gauge need not be attached to the pitot tube; this alternative is subject to the approval of the Administrator.

2.4 Pressure Probe and Gauge. A piezometer tube and mercury- or water-filled U-tube manometer capable of measuring stack pressure to within 2.5 mm (0.1 in.) Hg is used. The static tap of a standard type pitot tube or one leg of a Type S pitot tube with the face opening planes positioned parallel to the gas flow may also be used as the pressure probe.

2.5 Barometer. A mercury, aneroid, or other barometer capable of measuring atmospheric pressure to within 2.5 mm Hg (0.1 in. Hg) may be used. In many cases, the barometric reading may be obtained from a nearby national weather service station, in which case the station value (which is the absolute barometric pressure) shall be requested and an adjustment for elevation differences between the weather station and the sampling point shall be applied at a rate of minus 2.5 mm (0.1 in.) Hg per 30-meter (100 foot) elevation increase, or vice-versa for elevation decrease.

2.6 Gas Density Determination Equipment. Method 3 equipment, if needed (see Section 3.6), to determine the stack gas dry molecular weight, and Reference Method 4 or Method 5 equipment for moisture content determination; other methods may be used subject to approval of the Administrator.

2.7 Calibration Pitot Tube. When calibration of the Type S pitot tube is necessary (see Section 4), a standard pitot tube is used as a reference. The standard pitot tube shall, preferably, have a known coefficient, obtained either (1) directly from the National Bureau of Standards, Route 270, Quince Orchard Road, Gaithersburg, Maryland, or (2) by calibration against another standard pitot tube with an NBS-traceable coefficient. Alternatively, a standard pitot tube designed according to the criteria given in 2.7.1 through 2.7.5 below and illustrated in Figure 2-4 (see also Citations 7, 8, and 17 in Section 6) may be used. Pitot tubes designed according to these specifications will have baseline coefficients of about 0.99±0.01.

2.7.1 Hemispherical (shown in Figure 2-4), ellipsoidal, or conical tip.

2.7.2 A minimum of six diameters straight run (based upon D, the external diameter of the tube) between the tip and the static pressure holes.

2.7.3 A minimum of eight diameters straight run between the static pressure holes and the centerline of the external tube, following the 90 degree bend.

2.7.4 Static pressure holes of equal size (approximately 0.1 D), equally spaced in a piezometer ring configuration.

2.7.5 Ninety degree bend, with curved or mitered junction.

2.8 Differential Pressure Gauge for Type S Pitot Tube Calibration. An inclined manometer or equivalent is used. If the single-velocity calibration technique is employed (see Section 4.1.2.3), the calibration differential pressure gauge shall be readable to the nearest 0.13 mm H_2O (0.005 in. H_2O). For multivelocity calibrations, the gauge shall be readable to the nearest 0.13 mm H_2O (0.005 in H_2O) for Δp values between 1.3 and 25 mm H_2O (0.05 and 1.0 in. H_2O), and to the nearest 1.3 mm H_2O (0.05 in. H_2O) for Δp values above 25 mm H_2O (1.0 in. H_2O). A special, more sensitive gauge will be required to read Δp values below 1.3 mm H_2O (0.05 in. H_2O) (see Citation 18 in Section 6).

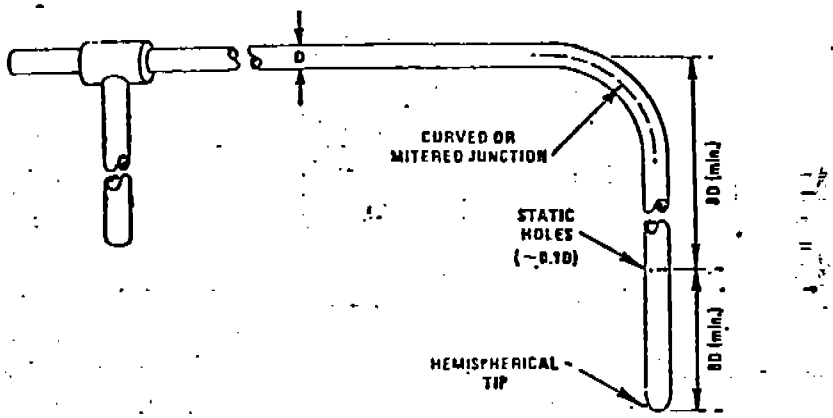


Figure 2-4. Standard pitot tube design specifications.

3. *Procedure*

3.1 Set up the apparatus as shown in Figure 2-1. Capillary tubing or surge tanks installed between the manometer and pitot tube may be used to dampen Δp fluctuations. It is recommended, but not required, that a pretest leak-check be conducted, as follows: (1) blow through the pitot impact opening until at least 7.6 cm (3 in.) H_2O velocity pressure registers on the manometer; then, close off the impact opening. The pressure shall remain stable for at least 15 seconds; (2) do the same for the static pressure side, except using suction to obtain the minimum of 7.6 cm (3 in.) H_2O. Other leak-check procedures, subject to the approval of the Administrator, may be used.

3.2 Level and zero the manometer. Because the manometer level and zero may drift due to vibrations and temperature changes, make periodic checks during the traverse. Record all necessary data as shown in the example data sheet (Figure 2-5).

3.3 Measure the velocity head and temperature at the traverse points specified by Method 1. Ensure that the proper differential pressure gauge is being used for the range of Δp values encountered (see Section 2.2). If it is necessary to change to a more sensitive gauge, do so, and remeasure the Δp and temperature readings at each traverse point. Conduct a post-test leak-check (mandatory), as described in Section 3.1 above, to validate the traverse run.

3.4 Measure the static pressure in the stack. One reading is usually adequate.

3.5 Determine the atmospheric pressure.

PLANT _____

DATE _____ RUN NO. _____

STACK DIAMETER OR DIMENSIONS, m(in.) _____

BAROMETRIC PRESSURE, mm Hg (in. Hg) _____

CROSS SECTIONAL AREA, $m^2(ft^2)$ _____

OPERATORS _____

PITOT TUBE I.D. NO. _____

AVG. COEFFICIENT, C_p = _____

LAST DATE CALIBRATED _____

SCHEMATIC OF STACK CROSS SECTION

Traverse Pt. No.	Vel. Hd., Δp mm (in.) H_2O	Stack Temperature t_s, °C (°F)	Stack Temperature T_s, °K (°R)	P_g mm Hg (in. Hg)	$\sqrt{\Delta p}$
		Average			

Figure 2-5. Velocity traverse data.

3.6 Determine the stack gas dry molecular weight. For combustion processes or processes that emit essentially CO_2, O_2, CO, and N_2, use Method 3. For processes emitting essentially air, an analysis need not be conducted; use a dry molecular weight of 29.0. For other processes, other methods, subject to the approval of the Administrator, must be used.

3.7 Obtain the moisture content from Reference Method 4 (or equivalent) or from Method 5.

3.8 Determine the cross-sectional area of the stack or duct at the sampling location. Whenever possible, physically measure the stack dimmensions rather than using blueprints.

4. *Calibration*

4.1 Type S Pitot Tube. Before its initial use, carefully examine the Type S pitot tube in top, side, and end views to verify that the face openings of the tube are aligned within the specifications illustrated in Figure 2-2 or 2-3. The pitot tube shall not be used if it fails to meet these alignment specifications.

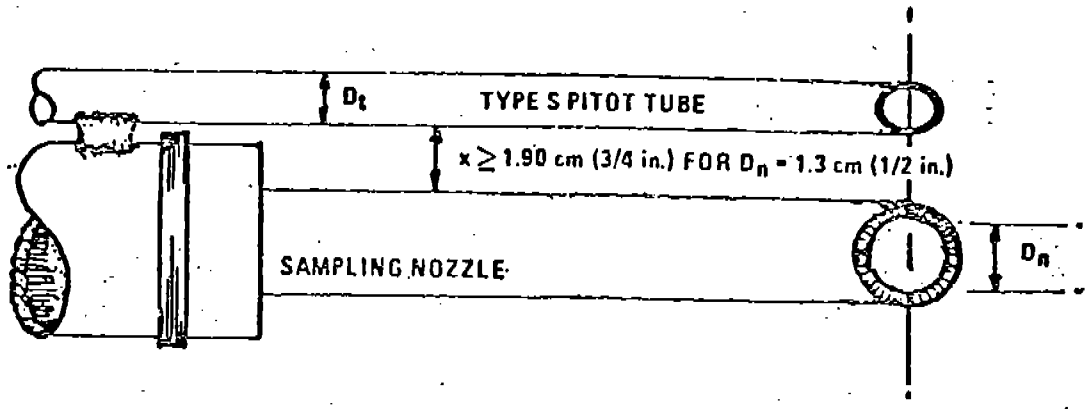
After verifying the face opening alignment, measure and record the following dimensions of the pitot tube: (a) the external tubing diameter (dimension D_t, Figure 2-2b); and (b) the base-to-opening plane distances (dimensions P_A and P_B, Figure 2-2b). If D_t is between 0.48 and 0.95 cm (3/16 and 3/8 in.) and if P_A and P_B are equal and between 1.05 and 1.50 D_t, there are two possible options: (1) the pitot tube may be calibrated according to the procedure outlined in Sections 4.1.2 through 4.1.5 below, or (2) a baseline (isolated tube) coefficient value of 0.84 may be assigned to the pitot tube. Note, however, that if the pitot tube is part of an assembly, calibration may still be required, despite knowledge of the baseline coefficient value (see Section 4.1.1).

If D_t, P_A, and P_B are outside the specified limits, the pitot tube must be calibrated as outlined in 4.1.2 through 4.1.5 below.

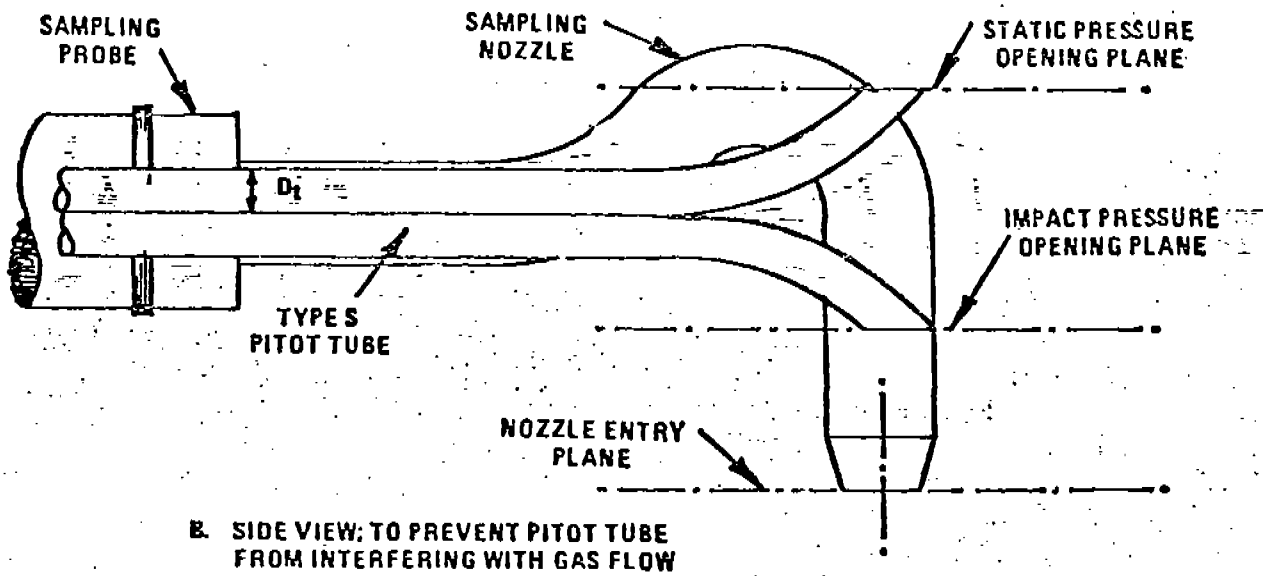
4.1.1 Type S Pitot Tube Assemblies. During sample and velocity traverses, the isolated Type S pitot tube is not always used; in many instances, the pitot tube is used in combination with other source-sampling components (thermocouple, sampling probe, nozzle) as part of an "assembly." The presence of other smapling components can sometimes affect the baseline value of the Type S pitot tube coefficient (Citation 9 in Section 6); therefore an assigned (or otherwise known) baseline coefficient value may or may not be valid for a given assembly. The baseline and assembly coefficient values will be identical only when the relative placement of the components in the assembly is such that aerodynamic interference effects are eliminated. Figures 2-6 through 2-8 illustrate interference-free component arrangements for Type S pitot tubes having external tubing diameters between 0.48 and 0.95 cm (3/16 and 3/8 in.). Type S pitot tube assemblies that fail to meet any or all of the specifications of Figures 2-6 through 2-8 shall be calibrated according to the procedure outlined in Sections 4.1.2 through 4.1.5 below, and prior to calibration, the values of the intercomponent spacings (pitot-nozzle, pitot-thermocouple, pitot-probe sheath) shall be measured and recorded.

NOTE.—Do not use any Type S pitot tube assembly which is constructed such that the impact pressure opening plane of the pitot tube is below the entry plane of the nozzle (see Figure 2-6b).

4.1.2 Calibration Setup. If the Type S pitot tube is to be calibrated, one leg of the tube shall be permanently marked A, and the other, B. Calibration shall be done in a flow system having the following essential design features:



A. BOTTOM VIEW; SHOWING MINIMUM PITOT-NOZZLE SEPARATION.



B. SIDE VIEW; TO PREVENT PITOT TUBE FROM INTERFERING WITH GAS FLOW STREAMLINES APPROACHING THE NOZZLE, THE IMPACT PRESSURE OPENING PLANE OF THE PITOT TUBE SHALL BE EVEN WITH OR ABOVE THE NOZZLE ENTRY PLANE.

Figure 2-6. Proper pitot tube - sampling nozzle configuration to prevent aerodynamic interference; buttonhook - type nozzle; centers of nozzle and pitot opening aligned; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

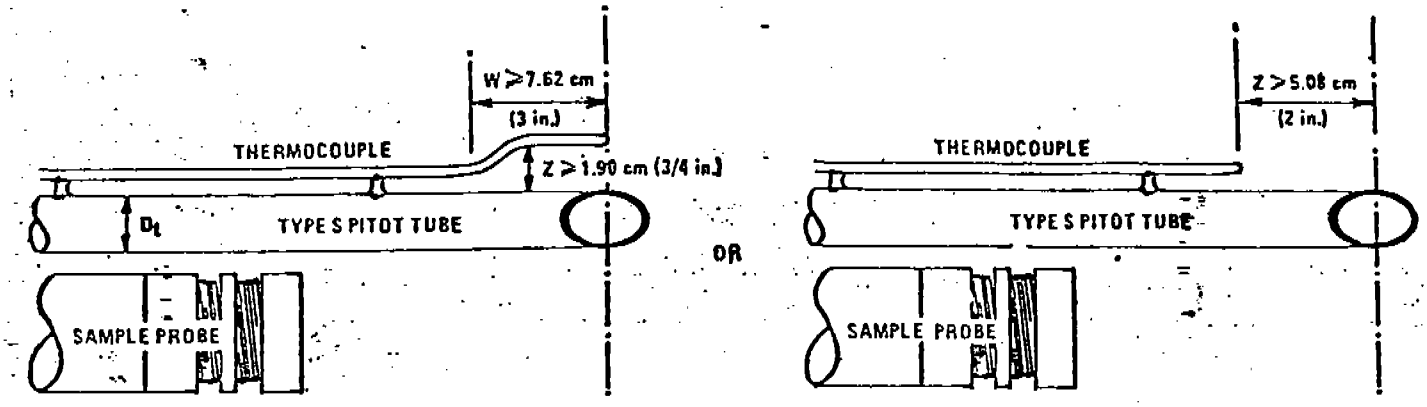


Figure 2-7. Proper thermocouple placement to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

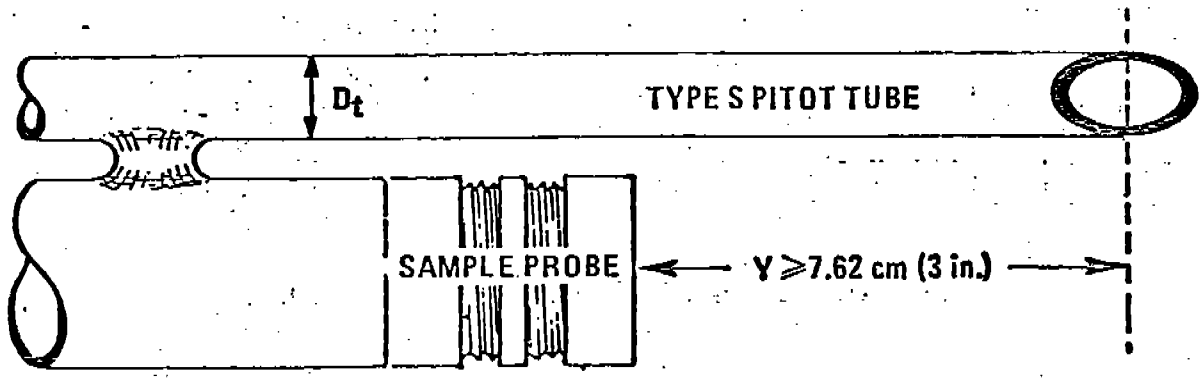


Figure 2-8. Minimum pitot-sample probe separation needed to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

4.1.2.1 The flowing gas stream must be confined to a duct of definite cross-sectional area, either circular or rectangular. For circular cross-sections, the minimum duct diameter shall be 30.5 cm (12 in.); for rectangular cross-sections, the width (shorter side) shall be at least 25.4 cm (10 in.).

4.1.2.2 The cross-sectional area of the calibration duct must be constant over a distance of 10 or more duct diameters. For a rectangular cross-section, use an equivalent diameter, calculated from the following equation, to determine the number of duct diameters:

$$D_e = \frac{2LW}{(L+W)}$$

Equation 2–1

where:
D_e = Equivalent diameter
L = Length
W = Width

To ensure the presence of stable, fully developed flow patterns at the calibration site, or "test section," the site must be located at least eight diameters downstream and two diameters upstream from the nearest disturbances.

NOTE.—The eight- and two-diameter criteria are not absolute; other test section locations may be used (subject to approval of the Administrator), provided that the flow at the test site is stable and demonstrably parallel to the duct axis.

4.1.2.3 The flow system shall have the capacity to generate a test-section velocity around 915 m/min (3,000 ft/min). This velocity must be constant with time to guarantee steady flow during calibration. Note that Type S pitot tube coefficients obtained by single-velocity calibration at 915 m/min (3,000 ft/min) will generally be valid to within ±3 percent for the measurement of velocities above 305 m/min (1,000 ft/min) and to within ±5 to 6 percent for the measurement of velocities between 180 and 305 m/min (600 and 1,000 ft/min). If a more precise correlation between C_p and velocity is desired, the flow system shall have the capacity to generate at least four distinct, time-invariant test-section velocities covering the velocity range from 180 to 1,525 m/min (600 to 5,000 ft/min), and calibration data shall be taken at regular velocity intervals over this range (see Citations 9 and 14 in Section 6 for details).

4.1.2.4 Two entry ports, one each for the standard and Type S pitot tubes, shall be cut in the test section; the standard pitot entry port shall be located slightly downstream of the Type S port, so that the standard and Type S impact openings will lie in the same cross-sectional plane during calibration. To facilitate alignment of the pitot tubes during calibration, it is advisable that the test section be constructed of plexiglas or some other transparent material.

4.1.3 Calibration Procedure. Note that this procedure is a general one and must not be used without first referring to the special considerations presented in Section 4.1.5. Note also that this procedure applies only to single-velocity calibration. To obtain calibration data for the A and B sides of the Type S pitot tube, proceed as follows:

4.1.3.1 Make sure that the manometer is properly filled and that the oil is free from contamination and is of the proper density. Inspect and leak-check all pitot lines; repair or replace if necessary.

4.1.3.2 Level and zero the manometer. Turn on the fan and allow the flow to stabilize. Seal the Type S entry port.

4.1.3.3 Ensure that the manometer is level and zeroed. Position the standard pitot tube at the calibration point (determined as outlined in Section 4.1.5.1), and align the tube so that its tip is pointed directly into the flow. Particular care should be taken in aligning the tube to avoid yaw and pitch angles. Make sure that the entry port surrounding the tube is properly sealed.

4.1.3.4 Read Δp_{std} and record its value in a data table similar to the one shown in Figure 2-9. Remove the standard pitot tube from the duct and disconnect it from the manometer. Seal the standard entry port.

4.1.3.5 Connect the Type S pitot tube to the manometer. Open the Type S entry port. Check the manometer level and zero. Insert and align the Type S pitot tube so that its A side impact opening is at the same point as was the standard pitot tube and is pointed directly into the flow. Make sure that the entry port surrounding the tube is properly sealed.

4.1.3.6 Read Δp_s and enter its value in the data table. Remove the Type S pitot tube from the duct and disconnect it from the manometer.

4.1.3.7 Repeat steps 4.1.3.3 through 4.1.3.6 above until three pairs of Δp readings have been obtained.

4.1.3.8 Repeat steps 4.1.3.3 through 4.1.3.7 above for the B side of the Type S pitot tube.

4.1.3.9 Perform calculations, as described in Section 4.1.4 below.

4.1.4 Calculations.

4.1.4.1 For each of the six pairs of Δp readings (i.e., three from side A and three from side B) obtained in Section 4.1.3 above, calculate the value of the Type S pitot tube coefficient as follows:

PITOT TUBE IDENTIFICATION NUMBER: _____ DATE: _____

CALIBRATED BY: _____

	"A" SIDE CALIBRATION			
RUN NO.	Δp_{std} cm H_2O (in. H_2O)	$\Delta p_{(s)}$ cm H_2O (in. H_2O)	$C_{p(s)}$	DEVIATION $C_{p(s)} - \bar{C}_p(A)$
1				
2				
3				
		$\bar{C}_p$ (SIDE A)		

	"B" SIDE CALIBRATION			
RUN NO.	Δp_{std} cm H_2O (in. H_2O)	$\Delta p_{(s)}$ cm H_2O (in. H_2O)	$C_{p(s)}$	DEVIATION $C_{p(s)} - \bar{C}_p(B)$
1				
2				
3				
		$\bar{C}_p$ (SIDE B)		

$$\text{AVERAGE DEVIATION} = \sigma\,(\text{A OR B}) = \frac{\sum_{1}^{3} \left| C_{p(s)} - \bar{C}_p(\text{A OR B}) \right|}{3} \leftarrow \text{MUST BE} \leq 0.01$$

$$\left| \bar{C}_p\,(\text{SIDE A}) - \bar{C}_p\,(\text{SIDE B}) \right| \leftarrow \text{MUST BE} \leq 0.01$$

Figure 2-9. Pitot tube calibration data.

$$C_{p(s)} = C_{p(std)} \sqrt{\frac{\Delta p_{std}}{\Delta p_s}}$$

Equation 2-2

where:

$C_{p(s)}$ = Type S pitot tub coeficient

$C_{p(std)}$ = Standard pitot tube coefficient; use 0.99 if the coefficient is unknown and the tube is designed according to the criteria of Sections 2.7.1 to 2.7.5 of this method.

Δp_{std} = Velocity head measured by the standard pitot tube, cm H_2O (in. H_2O)

Δp_s = Velocity head measured by the Type S pitot tube, cm H_2O (in. H_2O)

4.1.4.2 Calculate $\bar{C}_p$ (side A), the mean A-side coefficient, and $\bar{C}_p$ (side B), the mean B-side coefficient; calculate the difference between these two average values.

4.1.4.3 Calculate the deviation of each of the three A-side values of $C_{p(s)}$ from $\bar{C}_p$ (side A), and the deviation of each B-side value of $C_{p(s)}$ from $\bar{C}_p$ (side B). Use the following equation:

$$\text{Deviation} = C_{p(s)} - \bar{C}_p(\text{A or B})$$

Equation 2-3

4.1.4.4 Calculate σ, the average deviation from the mean, for both the A and B sides of the pitot tube. Use the following equation:

$$\sigma\,(\text{side A or B}) = \frac{\sum_{1}^{3} \left| C_{p(s)} - \bar{C}_p(A \text{ or } B) \right|}{3}$$

Equation 2-4

4.1.4.5 Use the Type S pitot tube only if the values of σ (side A) and σ (side B) are less than or equal to 0.01 and if the absolute value of the difference between $\bar{C}_p$ (A) and $\bar{C}_p$ (B) is 0.01 or less.

4.1.5 Special considerations.

4.1.5.1 Selection of calibration point.

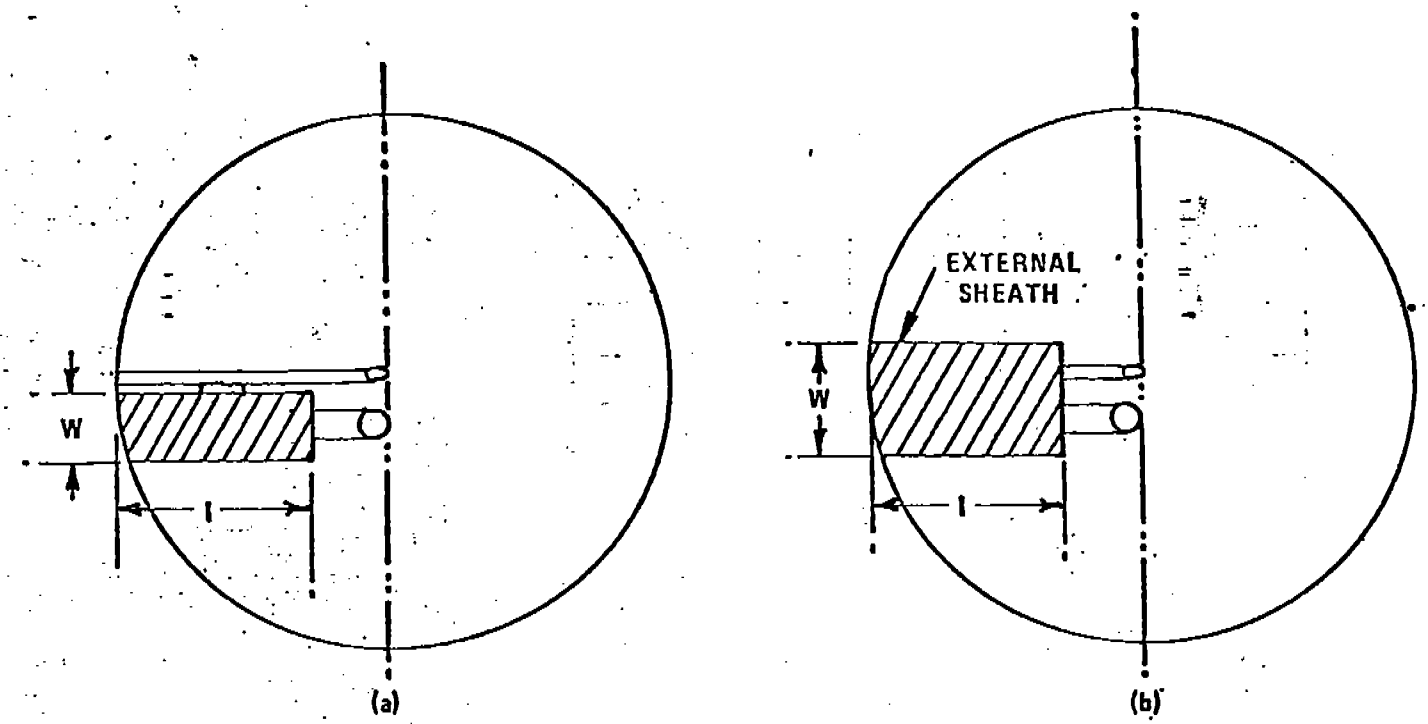
4.1.5.1.1 When an isolated Type S pitot tube is calibrated, select a calibration point at or near the center of the duct, and follow the procedures outlined in Sections 4.1.3 and 4.1.4 above. The Type S pitot coefficients so obtained, i.e., $\bar{C}_p$ (side A) and $\bar{C}_p$ (side B), will be valid, so long as either: (1) the isolated pitot tube is used; or (2) the pitot tube is used with other components (nozzle, thermocouple, sample probe) in an arrangement that is free from aerodynamic interference effects (see Figures 2-6 through 2-8).

4.1.5.1.2 For Type S pitot tube-thermocouple combinations (without sample probe), select a calibration point at or near the center of the duct, and follow the procedures outlined in Sections 4.1.3 and 4.1.4 above. The coefficients so obtained will be valid so long as the pitot tube-thermocouple combination is used by itself or with other components in an interference-free arrangement (Figures 2-6 and 2-8).

4.1.5.1.3 For assemblies with sample probes, the calibration point should be located at or near the center of the duct; however, insertion of a probe sheath into a small duct may cause significant cross-sectional area blockage and yield incorrect coefficient values (Citation 9 in Section 6). Therefore, to minimize the blockage effect, the calibration point may be a few inches off-center if necessary. The actual blockage effect will be negligible when the theoretical blockage, as determined by a projected-area model of the probe sheath, is 2 percent or less of the duct cross-sectional area for assemblies without external sheaths (Figure 2-10a), and 3 percent or less for assemblies with external sheaths (Figure 2-10b).

4.1.5.2 For those probe assemblies in which pitot tube-nozzle interference is a factor (i.e., those in which the pitot-nozzle separation distance falls to meet the specification illustrated in Figure 2-6a), the value of $C_{p(s)}$ depends upon the amount of free-space between the tube and nozzle, and therefore is a function of nozzle size. In these instances, separate calibrations shall be performed with each of the commonly used nozzle sizes in place. Note that the single-velocity calibration technique is acceptable for this purpose, even though the larger nozzle sizes (> 0.635 cm or ¼ in.) are not ordinarily used for isokinetic sampling at velocities around 915 m/min (3,000 ft/min), which is the calibration velocity; note also that it is not necessary to draw an isokinetic sample during calibration (see Citation 19 in Section 6).

4.1.5.3 For a probe assembly constructed such that its pitot tube is always used in the same orientation, only one side of the pitot tube need be calibrated (the side which will face the flow). The pitot tube must still meet the alignment specifications of Figure 2-2 or 2-3, however, and must have an average deviation (σ) value of 0.01 or less (see Section 4.1.4.4).



$$\text{ESTIMATED SHEATH BLOCKAGE (\%)} = \left[\frac{l \times W}{\text{DUCT AREA}}\right] \times 100$$

Figure 2-10. Projected-area models for typical pitot tube assemblies.

4.1.6 Field Use and Recalibration.

4.1.6.1 Field Use.

4.1.6.1.1 When a Type S pitot tube (isolated tube or assembly) is used in the field, the appropriate coefficient value (whether assigned or obtained by calibration) shall be used to perform velocity calculations. For calibrated Type S pitot tubes, the A side coefficient shall be used when the A side of the tube faces the flow, and the B side coefficient shall be used when the B side faces the flow; alternatively, the arithmetic average of the A and B side coefficient values may be used, irrespective of which side faces the flow.

4.1.6.1.2 When a probe assembly is used to sample a small duct (12 to 36 in. in diameter), the probe sheath sometimes blocks a significant part of the duct cross-section, causing a reduction in the effective value of $\overline{C}_{p(s)}$. Consult Citation 9 in Section 6 for details. Conventional pitot-sampling probe assemblies are not recommended for use in ducts having inside diameters smaller than 12 inches (Citation 16 in Section 6).

4.1.6.2 Recalibration.

4.1.6.2.1 Isolated Pitot Tubes. After each field use, the pitot tube shall be carefully reexamined in top, side, and end views. If the pitot face openings are still aligned within the specifications illustrated in Figure 2-2 or 2-3, it can be assumed that the baseline coefficient of the pitot tube has not changed. If, however, the tube has been damaged to the extent that it no longer meets the specifications of Figure 2-2 or 2-3, the damage shall either be repaired to restore proper alignment of the face openings or the tube shall be discarded.

4.1.6.2.2 Pitot Tube Assemblies. After each field use, check the face opening alignment of the pitot tube, as in Section 4.1.6.2.1; also, remeasure the intercomponent spacings of the assembly. If the intercomponent spacings have not changed and the face opening alignment is acceptable, it can be assumed that the coefficient of the assembly has not changed. If the face opening alignment is no longer within the specifications of Figures 2-2 or 2-3, either repair the damage or replace the pitot tube (calibrating the new assembly, if necessary). If the intercomponent spacings have changed, restore the original spacings or recalibrate the assembly.

4.2 Standard pitot tube (if applicable). If a standard pitot tube is used for the velocity traverse, the tube shall be constructed according to the criteria of Section 2.7 and shall be assigned a baseline coefficient value of 0.99. If the standard pitot tube is used as part of an assembly, the tube shall be in an interference-free arrangement (subject to the approval of the Administrator).

4.3 Temperature Gauges. After each field use, calibrate dial thermometers, liquid-filled bulb thermometers, thermocouple-potentiometer systems, and other gauges at a temperature within 10 percent of the average absolute stack temperature. For temperatures up to 405° C (761° F), use an ASTM mercury-in-glass reference thermometer, or equivalent, as a reference; alternatively, either a reference thermocouple and potentiometer (calibrated by NBS) or thermometric fixed points, e.g., ice bath and boiling water (corrected for barometric pressure) may be used. For temperatures above 405° C (761° F), use an NBS-calibrated reference thermocouple-potentiometer system or an alternate reference, subject to the approval of the Administrator.

If, during calibration, the absolute temperatures measured with the gauge being calibrated and the reference gauge agree within 1.5 percent, the temperature data taken in the field shall be considered valid. Otherwise, the pollutant emission test shall either be considered invalid or adjustments (if appropriate) of the test results shall be made, subject to the approval of the Administrator.

4.4 Barometer. Calibrate the barometer used against a mercury barometer.

5. *Calculations*

Carry out calculations, retaining at least one extra decimal figure beyond that of the acquired data. Round off figures after final calculation.

5.1 Nomenclature.

A = Cross-sectional area of stack, m² (ft²).

B_{ws} = Water vapor in the gas stream (from Method 5 or Reference Method 4), proportion by volume.

C_p = Pitot tube coefficient, dimensionless.

K_p = Pitot tube constant,

$$34.97 \frac{\text{m}}{\text{sec}} \left[\frac{(g/g\text{-mole})(\text{mm Hg})}{(°\text{K})(\text{mm H}_2\text{O})}\right]^{1/2}$$

for the metric system and

$$85.49 \frac{\text{ft}}{\text{sec}} \left[\frac{(\text{lb/lb-mole})(\text{in. Hg})}{(°\text{R})(\text{in. H}_2\text{O})}\right]^{1/2}$$

for the English system.

M_d = Molecular weight of stack gas, dry basis (see Section 3.6) g/g-mole (lb/lb-mole).

M_s = Molecular weight of stack gas, wet basis, g/g-mole (lb/lb-mole).

$= M_d(1-B_{ws}) + 18.0\,B_{ws}$ Equation 2-5

P_{bar} = Barometric pressure at measurement site, mm Hg (in. Hg).

P_g = Stack static pressure, mm Hg (in. Hg).

P_s = Absolute stack gas pressure, mm Hg (in. Hg).

$= P_{bar} + P_g$ Equation 2-6

P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).

Q_{sd} = Dry volumetric stack gas flow rate corrected to standard conditions, dscm/hr (dscf/hr).

t_s = Stack temperature, °C (°F).

T_s = Absolute stack temperature, °K (°R).

$= 273 + t_s$ for metric Equation 2-7

$= 460 + t_s$ for English Equation 2-8

T_{std} = Standard absolute temperature, 293 °K (528° R)

v_s = Average stack gas velocity, m/sec (ft/sec).

Δp = Velocity head of stack gas, mm H_2O (in. H_2O).

3,600 = Conversion factor, sec/hr.

18.0 = Molecular weight of water, g/g-mole (lb-lb-mole).

5.2 Average stack gas velocity.

$$v_s = K_p C_p (\sqrt{\Delta p})_{avg} \sqrt{\frac{T_{s(avg)}}{P_s M_s}}$$

Equation 2-9

5.3 Average stack gas dry volumetric flow rate.

$$Q_{sd} = 3{,}600(1-B_{ws}) v_s A \left(\frac{T_{std}}{T_{s(avg)}}\right)\left(\frac{P_s}{P_{std}}\right)$$

Equation 2-10

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

1. *Principle and Applicability*

1.1 Principle. A gas sample is extracted from a stack, by one of the following methods: (1) single-point, grab sampling; (2) single-point, integrated sampling; or (3) multi-point, integrated sampling. The gas sample is analyzed for percent carbon dioxide (CO_2), percent oxygen (O_2), and, if necessary, percent carbon monoxide (CO). If a dry molecular weight determination is to be made, either an Orsat or a Fyrite [1] analyzer may be used for the analysis; for excess air or emission rate correction factor determination, an Orsat analyzer must be used.

1.2 Applicability. This method is applicable for determining CO_2 and O_2 concentrations, excess air, and dry molecular weight of a sample from a gas stream of a fossil-fuel combustion process. The method may also be applicable to other processes where it has been determined that compounds other than CO_2, O_2, CO, and nitrogen (N_2) are not present in concentrations sufficient to affect the results.

Other methods, as well as modifications to the procedure described herein, are also applicable for some or all of the above determinations. Examples of specific methods and modifications include: (1) a multi-point sampling method using an Orsat analyzer to analyze individual grab samples obtained at each point; (2) a method using CO_2 or O_2 and stoichiometric calculations to determine dry molecular weight and excess air; (3) assigning a value of 30.0 for dry molecular weight, in lieu of actual measurements, for processes burning natural gas, coal, or oil. These methods and modifications may be used, but are subject to the approval of the Administrator. U.S. Environmental Protection Agency

2. *Apparatus*

As an alternative to the sampling apparatus and systems described herein, other sampling systems (e.g., liquid displacement) may be used provided such systems are capable of obtaining a representative sample and maintaining a constant sampling rate, and are otherwise capable of yielding acceptable results. Use of such systems is subject to the approval of the Administrator.

2.1 Grab Sampling (Figure 3-1).

2.1.1 Probe. The probe should be made of stainless steel or borosilicate glass tubing and should be equipped with an in-stack or out-stack filter to remove particulate matter (a plug of glass wool is satisfactory for this purpose). Any other material inert to O_2, CO_2, CO, and N_2 and resistant to temperature at sampling conditions may be used for the probe; examples of such material are aluminum, copper, quartz glass and Teflon.

2.1.2 Pump. A one-way squeeze bulb, or equivalent, is used to transport the gas sample to the analyzer.

2.2 Integrated Sampling (Figure 3-2).

2.2.1 Probe. A probe such as that described in Section 2.1.1 is suitable.

[1] Mention of trade names or specific products does not constitute endorsement by the Environmental Protection Agency.

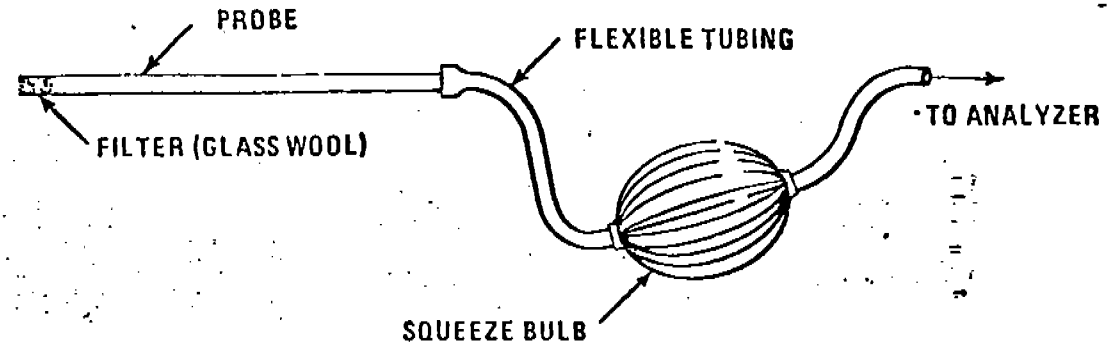

Figure 3-1. Grab sampling train.

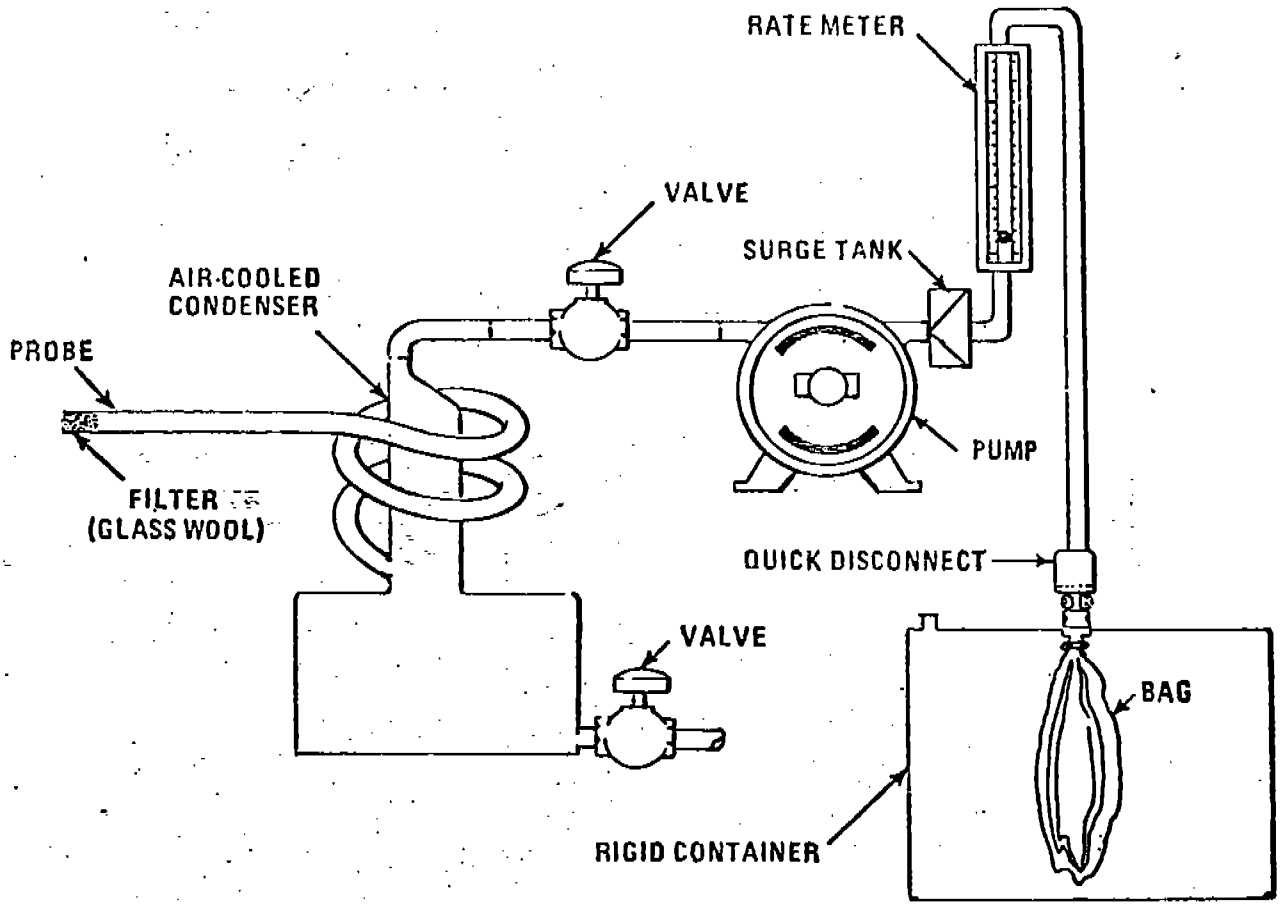

Figure 3-2. Integrated gas-sampling train.

[43 FR 1495, January 10, 1978]

2.2.2 Condenser. An air-cooled or water-cooled condenser, or other condenser that will not remove O_2, CO_2, CO, and N_2, may be used to remove excess moisture which would interfere with the operation of the pump and flow meter.

2.2.3 Valve. A needle valve is used to adjust sample gas flow rate.

2.2.4 Pump. A leak-free, diaphragm-type pump, or equivalent, is used to transport sample gas to the flexible bag. Install a small surge tank between the pump and rate meter to eliminate the pulsation effect of the diaphragm pump on the rotameter.

2.2.5 Rate Meter. The rotameter, or equivalent rate meter, used should be capable of measuring flow rate to within ±2 percent of the selected flow rate. A flow rate range of 500 to 1000 cm³/min is suggested.

2.2.6 Flexible Bag. Any leak-free plastic (e.g., Tedlar, Mylar, Teflon) or plastic-coated aluminum (e.g., aluminized Mylar) bag, or equivalent, having a capacity consistent with the selected flow rate and time length of the test run, may be used. A capacity in the range of 55 to 90 liters is suggested.

To leak-check the bag, connect it to a water manometer and pressurize the bag to 5 to 10 cm H_2O (2 to 4 in. H_2O). Allow to stand for 10 minutes. Any displacement in the water manometer indicates a leak. An alternative leak-check method is to pressurize the bag to 5 to 10 cm H_2O (2 to 4 in. H_2O) and allow to stand overnight. A deflated bag indicates a leak.

2.2.7 Pressure Gauge. A water-filled U-tube manometer, or equivalent, of about 28 cm (12 in.) is used for the flexible bag leak-check.

2.2.8 Vacuum Gauge. A mercury manometer, or equivalent, of at least 760 mm Hg (30 in. Hg) is used for the sampling train leak-check.

2.3 Analysis. For Orsat and Fyrite analyzer maintenance and operation procedures, follow the instructions recommended by the manufacturer, unless otherwise specified herein.

2.3.1 Dry Molecular Weight Determination. An Orsat analyzer or Fyrite type combustion gas analyzer may be used.

2.3.2 Emission Rate Correction Factor or Excess Air Determination. An Orsat analyzer must be used. For low CO_2 (less than 4.0 percent) or high O_2 (greater than 15.0 percent) concentrations, the measuring burette of the Orsat must have at least 0.1 percent subdivisions.

3. *Dry Molecular Weight Determination*

Any of the three sampling and analytical procedures described below may be used for determining the dry molecular weight.

3.1 Single-Point, Grab Sampling and Analytical Procedure.

3.1.1 The sampling point in the duct shall either be at the centroid of the cross section or at a point no closer to the walls than 1.00 m (3.3 ft), unless otherwise specified by the Administrator.

3.1.2 Set up the equipment as shown in Figure 3-1, making sure all connections ahead of the analyzer are tight and leak-free. If an Orsat analyzer is used, it is recommended that the analyzer be leaked-checked by following the procedure in Section 5; however, the leak-check is optional.

3.1.3 Place the probe in the stack, with the tip of the probe positioned at the sampling point; purge the sampling line. Draw a sample into the analyzer and immediately analyze it for percent CO_2 and percent O_2. Determine the percentage of the gas that is N_2 and CO by subtracting the sum of the percent CO_2 and percent O_2 from 100 percent. Calculate the dry molecular weight as indicated in Section 6.3.

3.1.4 Repeat the sampling, analysis, and calculation procedures, until the dry molecular weights of any three grab samples differ from their mean by no more than 0.3 g/g-mole (0.3 lb/lb-mole). Average these three molecular weights, and report the results to the nearest 0.1 g/g-mole (lb/lb-mole).

3.2 Single-Point, Integrated Sampling and Analytical Procedure.

3.2.1 The sampling point in the duct shall be located as specified in Section 3.1.1.

3.2.2 Leak-check (optional) the flexible bag as in Section 2.2.6. Set up the equipment as shown in Figure 3-2. Just prior to sampling, leak-check (optional) the train by placing a vacuum gauge at the condenser inlet, pulling a vacuum of at least 250 mm Hg (10 in. Hg), plugging the outlet at the quick disconnect, and then turning off the pump. The vacuum should remain stable for at least 0.5 minute. Evacuate the flexible bag. Connect the probe and place it in the stack, with the tip of the probe positioned at the sampling point; purge the sampling line. Next, connect the bag and make sure that all connections are tight and leak free.

3.2.3 Sample at a constant rate. The sampling run should be simultaneous with, and for the same total length of time as, the pollutant emission rate determination. Collection of at least 30 liters (1.00 ft³) of sample gas is recommended; however, smaller volumes may be collected, if desired.

3.2.4 Obtain one integrated flue gas sample during each pollutant emission rate determination. Within 8 hours after the sample is taken, analyze it for percent CO_2 and percent O_2 using either an Orsat analyzer or a Fyrite-type combustion gas analyzer. If an Orsat analyzer is used, it is recommended that the Orsat leak-check described in Section 5 be performed before this determination; however, the check is optional. Determine the percentage of the gas that is N_2 and CO_2 by subtracting the sum of the percent CO_2 and percent O_2 from 100 percent. Calculate the dry molecular weight as indicated in Section 6.3.

3.2.5 Repeat the analysis and calculation procedures until the individual dry molecular weights for any three analyses differ from their mean by no more than 0.3 g/g-mole (0.3 lb/lb-mole). Average these three molecular weights, and report the results to the nearest 0.1 g/g-mole (0.1 lb/lb-mole).

3.3 Multi-Point, Integrated Sampling and Analytical Procedure.

3.3.1 Unless otherwise specified by the Administrator, a minimum of eight traverse points shall be used for circular stacks having diameters less than 0.61 m (24 in.), a minimum of nine shall be used for rectangular stacks having equivalent diameters less than 0.61 m (24 in.), and a minimum of twelve traverse points shall be used for all other cases. The traverse points shall be located according to Method 1. The use of fewer points is subject to approval of the Administrator.

3.3.2 Follow the procedures outlined in Sections 3.2.2 through 3.2.5, except for the following: traverse all sampling points and sample at each point for an equal length of time. Record sampling data as shown in Figure 3-3.

4. *Emission Rate Correction Factor or Excess Air Determination*

NOTE.—A Fyrite-type combustion gas analyzer is not acceptable for excess air or emission rate correction factor determination, unless approved by the Administrator. If both percent CO_2 and percent O_2 are measured, the analytical results of any of the three procedures given below may also be used for calculating the dry molecular weight.

Each of the three procedures below shall be used only when specified in an applicable subpart of the standards. The use of these procedures for other purposes must have specific prior approval of the Administrator.

4.1 Single-Point, Grab Sampling and Analytical Procedure.

4.1.1 The sampling point in the duct shall either be at the centroid of the cross-section or at a point no closer to the walls than 1.00 m (3.3 ft), unless otherwise specified by the Administrator.

4.1.2 Set up the equipment as shown in Figure 3-1, making sure all connections ahead of the analyzer are tight and leak-free. Leak-check the Orsat analyzer according to the procedure described in Section 5. This leak-check is mandatory.

TIME	TRAVERSE PT.	Q 1pm	% DEV.[a]
	AVERAGE		

$$^{a}\%\ DEV = \left(\frac{Q - Q\ avg}{Q\ avg}\right) 100 \qquad \text{(MUST BE} \leq 10\%)$$

Figure 3-3. Sampling rate data.

4.1.3 Place the probe in the stack, with the tip of the probe positioned at the sampling point; purge the sampling line. Draw a sample into the analyzer. For emission rate correction factor determination, immediately analyze the sample, as outlined in Sections 4.1.4 and 4.1.5, for percent CO_2 or percent O_2. If excess air is desired, proceed as follows: (1) immediately analyze the sample, as in Sections 4.1.4 and 4.1.5, for percent CO_2, O_2, and CO; (2) determine the percentage of the gas that is N_2 by subtracting the sum of the percent CO_2, percent O_2, and percent CO from 100 percent; and (3) calculate percent excess air as outlined in Section 6.2.

4.1.4 To ensure complete absorption of the CO_2, O_2, or if applicable, CO, make repeated passes through each absorbing solution until two consecutive readings are the same. Several passes (three or four) should be made between readings. (If constant readings cannot be obtained after three consecutive readings, replace the absorbing solution.)

4.1.5 After the analysis is completed, leak-check (mandatory) the Orsat analyzer once again, as described in Section 5. For the results of the analysis to be valid, the Orsat analyzer must pass this leak test before and after the analysis. NOTE.—Since this single-point, grab sampling and analytical procedure is normally conducted in conjunction with a single-point, grab sampling and analytical procedure for a pollutant, only one analysis is ordinarily conducted. Therefore, great care must be taken to obtain a valid sample and analysis. Although in most cases only CO_2 or O_2 is required, it is recommended that both CO_2 and O_2 be measured, and that Citation 5 in the Bibliography be used to validate the analytical data.

4.2 Single-Point, Integrated Sampling and Analytical Procedure.

4.2.1 The sampling point in the duct shall be located as specified in Section 4.1.1.

4.2.2 Leak-check (mandatory) the flexible bag as in Section 2.2.6. Set up the equipment as shown in Figure 3-2. Just prior to sampling, leak-check (mandatory) the train by placing a vacuum gauge at the condenser inlet, pulling a vacuum of at least 250 mm Hg (10 in. Hg), plugging the outlet at the quick disconnect, and then turning off the pump. The vacuum shall remain stable for at least 0.5 minute. Evacuate the flexible bag. Connect the probe and place it in the stack, with the tip of the probe positioned at the sampling point; purge the sampling line. Next, connect the bag and make sure that all connections are tight and leak free.

4.2.3 Sample at a constant rate, or as specified by the Administrator. The sampling run must be simultaneous with, and for the same total length of time as, the pollutant emission rate determination. Collect at least 30 liters (1.00 ft³) of sample gas. Smaller volumes may be collected, subject to approval of the Administrator.

4.2.4 Obtain one integrated flue gas sample during each pollutant emission rate determination. For emission rate correction factor determination, analyze the sample within 4 hours after it is taken for percent CO_2 or percent O_2 (as outlined in Sections 4.2.5 through 4.2.7). The Orsat analyzer must be leak-checked (see Section 5) before the analysis. If excess air is desired, proceed as follows: (1) within 4 hours after the sample is taken, analyze it (as in Sections 4.2.5 through 4.2.7) for percent CO_2, O_2, and CO; (2) determine the percentage of the gas that is N_2 by subtracting the sum of the percent CO_2, percent O_2, and percent CO from 100 percent; (3) calculate percent excess air, as outlined in Section 6.2.

4.2.5 To ensure complete absorption of the CO_2, O_2, or if applicable, CO, make repeated passes through each absorbing solution until two consecutive readings are the same. Several passes (three or four) should be made between readings. (If constant readings cannot be obtained after three consecutive readings, replace the absorbing solution.)

4.2.6 Repeat the analysis until the following criteria are met:

4.2.6.1 For percent CO_2, repeat the analytical procedure until the results of any three analyses differ by no more than (a) 0.3 percent by volume when CO_2 is greater than 4.0 percent or (b) 0.2 percent by volume when CO_2 is less than or equal to 4.0 percent. Average the three acceptable values of percent CO_2 and report the results to the nearest 0.1 percent.

4.2.6.2 For percent O_2, repeat the analytical procedure until the results of any three analyses differ by no more

than (a) 0.3 percent by volume when O_2 is less than 15.0 percent or (b) 0.2 percent by volume when O_2 is greater than 15.0 percent. Average the three acceptable values of percent or equal to O_2 and report the results to the nearest 0.1 percent.

4.2.6 For percent CO, repeat the analytical procedure until the results of any three analyses differ by no more than 0.3 percent. Average the three acceptable values of percent CO and report the results to the nearest 0.1 percent.

4.2.7 After the analysis is completed, leak-check (mandatory) the Orsat analyzer once again, as described in Section 5. For the results of the analysis to be valid, the Orsat analyzer must pass this leak test before and after the analysis. Note: Although in most instances only CO_2 or O_2 is required, it is recommended that both CO_2 and O_2 be measured, and that Citation 5 in the Bibliography be used to validate the analytical data.

4.3 Multi-Point, Integrated Sampling and Analytical Procedure.

4.3.1 Both the minimum number of sampling points and the sampling point location shall be as specified in Section 3.3.1 of this method. The use of fewer points than specified is subject to the approval of the Administrator.

4.3.2 Follow the procedures outlined in Sections 4.2.2 through 4.2.7, except for the following: Traverse all sampling points and sample at each point for an equal length of time. Record sampling data as shown in Figure 3-3.

5. *Leak-Check Procedure for Orsat Analyzers*

Moving an Orsat analyzer frequently causes it to leak. Therefore, an Orsat analyzer should be thoroughly leak-checked on site before the flue gas sample is introduced into it. The procedure for leak-checking an Orsat analyzer is:

5.1.1 Bring the liquid level in each pipette up to the reference mark on the capillary tubing and then close the pipette stopcock.

5.1.2 Raise the leveling bulb sufficiently to bring the confining liquid meniscus onto the graduated portion of the burette and then close the manifold stopcock.

5.1.3 Record the meniscus position.

5.1.4 Observe the meniscus in the burette and the liquid level in the pipette for movement over the next 4 minutes.

5.1.5 For the Orsat analyzer to pass the leak-check, two conditions must be met.

5.1.5.1 The liquid level in each pipette must not fall below the bottom of the capillary tubing during this 4-minute interval.

5.1.5.2 The meniscus in the burette must not change by more than 0.2 ml during this 4-minute interval.

5.1.6 If the analyzer fails the leak-check procedure, all rubber connections and stopcocks should be checked until the cause of the leak is identified. Leaking stopcocks must be disassembled, cleaned, and regreased. Leaking rubber connections must be replaced. After the analyzer is reassembled, the leak-check procedure must be repeated.

6. *Calculations*

6.1 Nomenclature.

M_d = Dry molecular weight, g/g-mole (lb/lb-mole).
%EA = Percent excess air.
$\%CO_2$ = Percent CO_2 by volume (dry basis).
$\%O_2$ = Percent O_2 by volume (dry basis).
%CO = Percent CO by volume (dry basis).
$\%N_2$ = Percent N_2 by volume (dry basis).
0.264 = Ratio of O_2 to N_2 in air, v/v.
0.280 = Molecular weight of N_2 or CO, divided by 100.
0.320 = Molecular weight of O_2 divided by 100.
0.440 = Molecular weight of CO_2 divided by 100.

6.2 Percent Excess Air. Calculate the percent excess air (if applicable), by substituting the appropriate values of percent O_2, CO, and N_2 (obtained from Section 4.1.3 or 4.2.4) into Equation 3-1.

$$\%EA = \left[\frac{\%O_2 - 0.5\%CO}{0.264\,\%N_2 - (\%O_2 - 0.5\%CO)}\right] 100$$

Equation 3-1

NOTE.—The equation above assumes that ambient air is used as the source of O_2 and that the fuel does not contain appreciable amounts of N_2 (as do coke oven or blast furnace gases). For those cases when appreciable amounts of N_2 are present (coal, oil, and natural gas do not contain appreciable amounts of N_2) or when oxygen enrichment is used, alternate methods, subject to approval of the Administrator, are required.

6.3 Dry Molecular Weight. Use Equation 3-2 to calculate the dry molecular weight of the stack gas

$$M_d = 0.440(\%CO_2) + 0.320(\%O_2) + 0.280(\%N_2 + \%CO)$$

Equation 3-2

NOTE.—The above equation does not consider argon in air (about 0.9 percent, molecular weight of 37.7). A negative error of about 0.4 percent is introduced. The tester may opt to include argon in the analysis using procedures subject to approval of the Administrator.

7. *Bibliography*

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METHOD 4—DETERMINATION OF MOISTURE CONTENT IN STACK GASES

1. *Principle and Applicability*

1.1 Principle. A gas sample is extracted at a constant rate from the source; moisture is removed from the sample stream and determined either volumetrically or gravimetrically.

1.2 Applicability. This method is applicable for determining the moisture content of stack gas.

Two procedures are given. The first is a reference method, for accurate determinations of moisture content (such as are needed to calculate emission data). The second is an approximation method, which provides estimates of percent moisture to aid in setting isokinetic sampling rates prior to a pollutant emission measurement run. The approximation method described herein is only a suggested approach; alternative means for approximating the moisture content, e.g., drying tubes, wet bulb-dry bulb techniques, condensation techniques, stoichiometric calculations, previous experience, etc., are also acceptable.

The reference method is often conducted simultaneously with a pollutant emission measurement run; when it is, calculation of percent isokinetic, pollutant emission rate, etc., for the run shall be based upon the results of the reference method or its equivalent; these calculations shall not be based upon the results of the approximation method, unless the approximation method is shown, to the satisfaction of the Administrator, U.S. Environmental Protection Agency, to be capable of yielding results within 1 percent H_2O of the reference method.

NOTE.—The reference method may yield questionable results when applied to saturated gas streams or to streams that contain water droplets. Therefore, when these conditions exist or are suspected, a second determination of the moisture content shall be made simultaneously with the reference method, as follows: Assume that the gas stream is saturated. Attach a temperature sensor [capable of measuring to ±1° C (2° F)] to the reference method probe. Measure the stack gas temperature at each traverse point (see Section 2.2.1) during the reference method traverse; calculate the average stack gas temperature. Next, determine the moisture percentage, either by: (1) using a psychrometric chart and making appropriate corrections if stack pressure is different from that of the chart, or (2) using saturation vapor pressure tables. In cases where the psychrometric chart or the saturation vapor pressure tables are not applicable (based on evaluation of the process), alternate methods, subject to the approval of the Administrator, shall be used.

2. *Reference Method*

The procedure described in Method 5 for determining moisture content is acceptable as a reference method.

2.1 Apparatus. A schematic of the sampling train used in this reference method is shown in Figure 4-1. All components shall be maintained and calibrated according to the procedure outlined in Method 5.

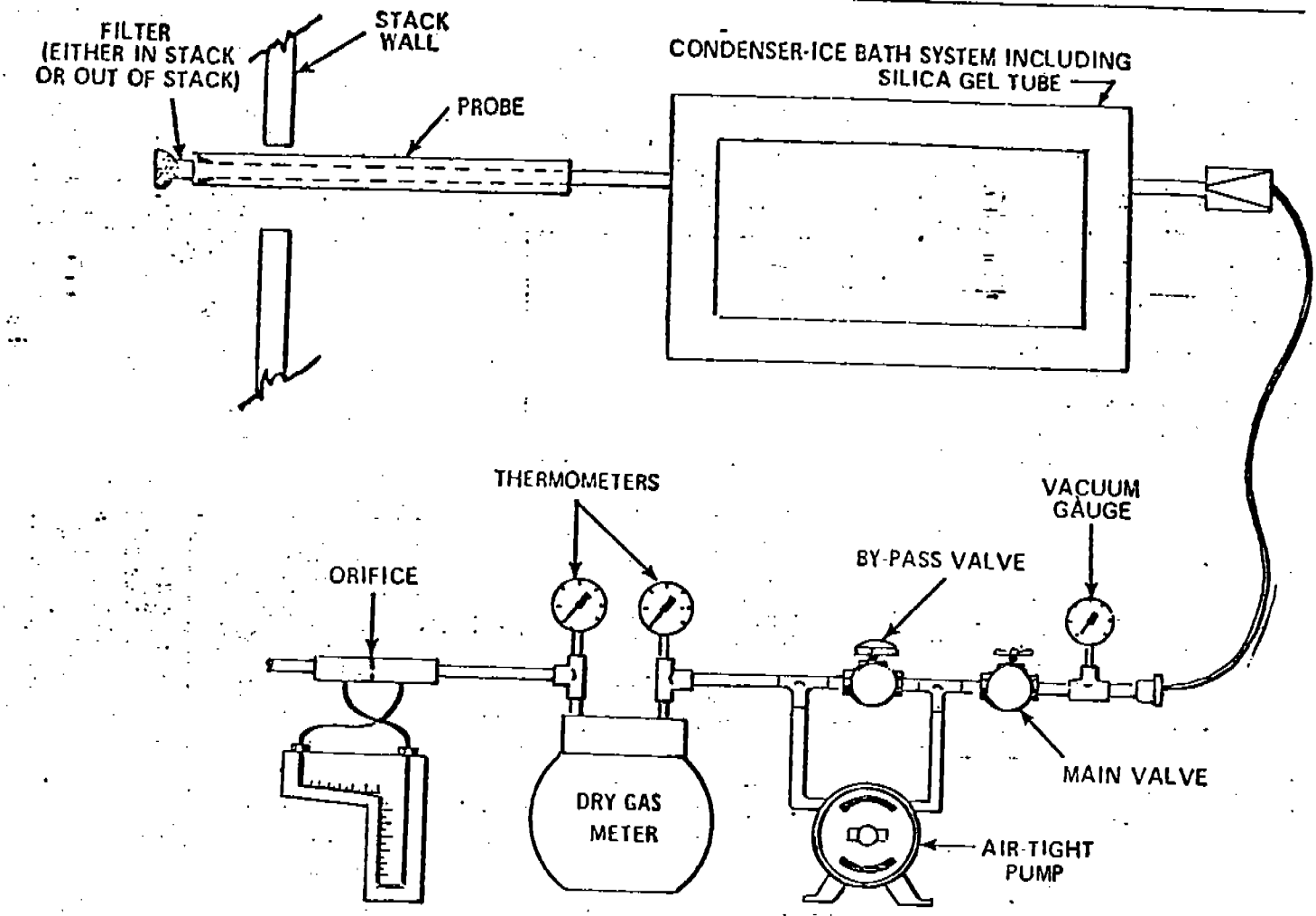

Figure 4-1. Moisture sampling train-reference method.

2.1.1 Probe. The probe is constructed of stainless steel or glass tubing, sufficiently heated to prevent water condensation, and is equipped with a filter, either in-stack (e.g., a plug of glass wool inserted into the end of the probe) or heated out-stack (e.g., as described in Method 5), to remove particulate matter.

When stack conditions permit, other metals or plastic tubing may be used for the probe, subject to the approval of the Administrator.

2.1.2 Condenser. The condenser consists of four impingers connected in series with ground glass, leak-free fittings or any similarly leak-free non-contaminating fittings. The first, third, and fourth impingers shall be of the Greenburg-Smith design, modified by replacing the tip with a 1.3 centimeter (½ inch) ID glass tube extending to about 1.3 cm (½ in.) from the bottom of the flask. The second impinger shall be of the Greenburg-Smith design with the standard tip. Modifications (e.g., using flexible connections between the impingers, using materials other than glass, or using flexible vacuum lines to connect the filter holder to the condenser) may be used, subject to the approval of the Administrator.

The first two impingers shall contain known volumes of water, the third shall be empty, and the fourth shall contain a known weight of 6- to 16-mesh indicating type silica gel, or equivalent desiccant. If the silica gel has been previously used, dry at 175° C (350° F) for 2 hours. New silica gel may be used as received. A thermometer, capable of measuring temperature to within 1° C (2° F), shall be placed at the outlet of the fourth impinger, for monitoring purposes.

Alternatively, any system may be used (subject to the approval of the Administrator) that cools the sample gas stream and allows measurement of both the water that has been condensed and the moisture leaving the condenser, each to within 1 ml or 1 g. Acceptable means are to measure the condensed water, either gravimetrically or volumetrically, and to measure the moisture leaving the condenser by: (1) monitoring the temperature and pressure at the exit of the condenser and using Dalton's law of partial pressures, or (2) passing the sample gas stream through a tared silica gel (or equivalent desiccant) trap, with exit gases kept below 20° C (68° F), and determining the weight gain.

If means other than silica gel are used to determine the amount of moisture leaving the condenser, it is recommended that silica gel (or equivalent) still be used between the condenser system and pump, to prevent moisture condensation in the pump and metering devices and to avoid the need to make corrections for moisture in the metered volume.

2.1.3 Cooling System. An ice bath container and crushed ice (or equivalent) are used to aid in condensing moisture.

2.1.4 Metering System. This system includes a vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 3° C (5.4° F), dry gas meter capable of measuring volume to within 2 percent, and related equipment as shown in Figure 4-1. Other metering systems, capable of maintaining a constant sampling rate and determining sample gas volume, may be used, subject to the approval of the Administrator.

2.1.5 Barometer. Mercury, aneroid, or other barometer capable of measuring atmospheric pressure to within 2.5 mm Hg (0.1 in. Hg) may be used. In many cases, the barometric reading may be obtained from a nearby national weather service station, in which case the station value (which is the absolute barometric pressure) shall be requested and an adjustment for elevation differences between the weather station and the sampling point shall be applied at a rate of minus 2.5 mm Hg (0.1 in. Hg) per 30 m (100 ft) elevation increase or vice versa for elevation decrease.

2.1.6 Graduated Cylinder and/or Balance. These items are used to measure condensed water and moisture caught in the silica gel to within 1 ml or 0.5 g. Graduated cylinders shall have subdivisions no greater than 2 ml. Most laboratory balances are capable of weighing to the nearest 0.5 g or less. These balances are suitable for use here.

2.2 Procedure. The following procedure is written for a condenser system (such as the impinger system described in Section 2.1.2) incorporating volumetric analysis to measure the condensed moisture, and silica gel and gravimetric analysis to measure the moisture leaving the condenser.

2.2.1 Unless otherwise specified by the Administrator, a minimum of eight traverse points shall be used for circular stacks having diameters less than 0.61 m (24 in.), a minimum of nine points shall be used for rectangular stacks having equivalent diameters less than 0.61 m (24 in.), and a minimum of twelve traverse points shall be used in all other cases. The traverse points shall be located according to Method 1. The use of fewer points is subject to the approval of the Administrator. Select a suitable probe and probe length such that all traverse points can be sampled. Consider sampling from opposite sides of the stack (four total sampling ports) for large stacks, to permit use of shorter probe lengths. Mark the probe with heat resistant tape or by some other method to denote the proper distance into the stack or duct for each sampling point. Place known volumes of water in the first two impingers. Weigh and record the weight of the silica gel to the nearest 0.5 g, and transfer the silica gel to the fourth impinger; alternatively, the silica gel may first be transferred to the impinger, and the weight of the silica gel plus impinger recorded.

2.2.2 Select a total sampling time such that a minimum total gas volume of 0.60 scm (21 scf) will be collected, at a rate no greater than 0.021 m³/min (0.75 cfm). When both moisture content and pollutant emission rate are to be determined, the moisture determination shall be simultaneous with, and for the same total length of time as, the pollutant emission rate run, unless otherwise specified in an applicable subpart of the standards.

2.2.3 Set up the sampling train as shown in Figure 4-1. Turn on the probe heater and (if applicable) the filter heating system to temperatures of about 120° C (248° F), to prevent water condensation ahead of the condenser; allow time for the temperatures to stabilize. Place crushed ice in the ice bath container. It is recommended, but not required, that a leak check be done, as follows: Disconnect the probe from the first impinger or

(if applicable) from the filter holder. Plug the inlet to the first impinger (or filter holder) and pull a 380 mm (15 in.) Hg vacuum; a lower vacuum may be used, provided that it is not exceeded during the test. A leakage rate in excess of 4 percent of the average sampling rate or 0.00057 m³/min (0.02 cfm), whichever is less, is unacceptable. Following the leak check, reconnect the probe to the sampling train.

2.2.4 During the sampling run, maintain a sampling rate within 10 percent of constant rate, or as specified by the Administrator. For each run, record the data required on the example data sheet shown in Figure 4-2. Be sure to record the dry gas meter reading at the beginning and end of each sampling time increment and whenever sampling is halted. Take other appropriate readings at each sample point, at least once during each time increment.

2.2.5 To begin sampling, position the probe tip at the first traverse point. Immediately start the pump and adjust the flow to the desired rate. Traverse the cross section, sampling at each traverse point for an equal length of time. Add more ice and, if necessary, salt to maintain a temperature of less than 20° C (68° F) at the silica gel outlet.

2.2.6 After collecting the sample, disconnect the probe from the filter holder (or from the first impinger) and conduct a leak check (mandatory) as described in Section 2.2.3. Record the leak rate. If the leakage rate exceeds the allowable rate, the tester shall either reject the test results or shall correct the sample volume as in Section 6.3 of Method 5. Next, measure the volume of the moisture condensed to the nearest ml. Determine the increase in weight of the silica gel (or silica gel plus impinger) to the nearest 0.5 g. Record this information (see example data sheet, Figure 4-3) and calculate the moisture percentage, as described in 2.3 below.

2.3 Calculations. Carry out the following calculations, retaining at least one extra decimal figure beyond that of the acquired data. Round off figures after final calculation.

PLANT _____

LOCATION _____

OPERATOR _____

DATE _____

RUN NO. _____

AMBIENT TEMPERATURE _____

BAROMETRIC PRESSURE _____

PROBE LENGTH m(ft) _____

SCHEMATIC OF STACK CROSS SECTION

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STACK TEMPERATURE °C (°F)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH), mm(in.) H_2O	METER READING GAS SAMPLE VOLUME m^3 (ft^3)	ΔV_m m^3 (ft^3)	GAS SAMPLE TEMPERATURE AT DRY GAS METER		TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER, °C (°F)
						INLET (Tm_{in}), °C (°F)	OUTLET (Tm_{out}), °C (°F)	
TOTAL						Avg.	Avg.	
AVERAGE						Avg.		

Figure 4-2. Field moisture determination-reference method.

	IMPINGER VOLUME, ml	SILICA GEL WEIGHT, g
FINAL		
INITIAL		
DIFFERENCE		

Figure 4-3. Analytical data - reference method.

2.3.1 Nomenclature.

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

M_w = Molecular weight of water, 18.0 g/g-mole (18.0 lb/lb-mole).

P_m = Absolute pressure (for this method, same as barometric pressure) at the dry gas meter, mm Hg (in. Hg).

P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).

R = Ideal gas constant, 0.06236 (mm Hg) (m^3)/(g-mole) (°K) for metric units and 21.85 (in. Hg) (ft^3)/(lb-mole) (°R) for English units.

T_m = Absolute temperature at meter, °K (°R).

T_{std} = Standard absolute temperature, 293° K (528° R).

V_m = Dry gas volume measured by dry gas meter, dcm (dcf).

ΔV_m = Incremental dry gas volume measured by dry gas meter at each traverse point, dcm (dcf).

$V_{m(std)}$ = Dry gas volume measured by the dry gas meter, corrected to standard conditions, dscm (dscf).

$V_{wc(std)}$ = Volume of water vapor condensed corrected to standard conditions, scm (scf).

$V_{wsg(std)}$ = Volume of water vapor collected in silica gel corrected to standard conditions, scm (scf).

V_f = Final volume of condenser water, ml.

V_i = Initial volume, if any, of condenser water, ml.

W_f = Final weight of silica gel or silica gel plus impinger, g.

W_i = Initial weight of silica gel or silica gel plus impinger, g.

Y = Dry gas meter calibration factor.

ρ_w = Density of water, 0.9982 g/ml (0.002201 lb/ml).

2.3.2 Volume of water vapor condensed.

$$V_{wc(std)} = \frac{(V_f - V_i)\rho_w R T_{std}}{P_{std} M_w} = K_1 (V_f - V_i)$$

Equation 4-1

where:

K_1 = 0.001333 m^3/ml for metric units
= 0.04707 ft^3/ml for English units

2.3.3 Volume of water vapor collected in silica gel.

$$V_{wsg(std)} = \frac{(W_f - W_i) R T_{std}}{P_{std} M_w} = K_2 (W_f - W_i)$$

Equation 4-2

where:

K_2 = 0.001335 m^3/g for metric units
= 0.04715 ft^3/g for English units

2.3.4 Sample gas volume.

$$V_{m(std)} = V_m Y \frac{(P_m)(T_{std})}{(P_{std})(T_m)} = K_3 Y \frac{V_m P_m}{T_m}$$

Equation 4-3

where:

K_3 = 0.3858 °K/mm Hg for metric units
= 17.64 °R/in. Hg for English units

NOTE.—If the post-test leak rate (Section 2.2.8) exceeds the allowable rate, correct the value of V_m in Equation 4-3, as described in Section 6.3 of Method 5.

2.3.5 Moisture Content.

$$B_{ws} = \frac{V_{wc(std)} + V_{wsg(std)}}{V_{wc(std)} + V_{wsg(std)} + V_{m(std)}}$$

Equation 4-4

NOTE.—In saturated or moisture droplet-laden gas streams, two calculations of the moisture content of the stack gas shall be made, one using a value based upon the saturated conditions (see Section 1.2), and another based upon the results of the impinger analysis. The lower of these two values of B_{ws} shall be considered correct.

2.3.6 Verification of constant sampling rate. For each time increment, determine the ΔV_m. Calculate the average. If the value for any time increment differs from the average by more than 10 percent, reject the results and repeat the run.

3. *Approximation Method*

The approximation method described below is presented only as a suggested method (see Section 1.2).

3.1 Apparatus.

3.1.1 Probe. Stainless steel or glass tubing, sufficiently heated to prevent water condensation and equipped with a filter (either in-stack or heated out-stack) to remove particulate matter. A plug of glass wool, inserted into the end of the probe, is a satisfactory filter.

3.1.2 Impingers. Two midget impingers, each with 30 ml capacity, or equivalent.

3.1.3 Ice Bath. Container and ice, to aid in condensing moisture in impingers.

3.1.4 Drying Tube. Tube packed with new or regenerated 6- to 16-mesh indicating-type silica gel (or equivalent desiccant), to dry the sample gas and to protect the meter and pump.

3.1.5 Valve. Needle valve, to regulate the sample gas flow rate.

3.1.6 Pump. Leak-free, diaphragm type, or equivalent, to pull the gas sample through the train.

3.1.7 Volume meter. Dry gas meter, sufficiently accurate to measure the sample volume within 2%, and calibrated over the range of flow rates and conditions actually encountered during sampling.

3.1.8 Rate Meter. Rotameter, to measure the flow range from 0 to 3 lpm (0 to 0.11 cfm).

3.1.9 Graduated Cylinder. 25 ml.

3.1.10 Barometer. Mercury, aneroid, or other barometer, as described in Section 2.1.5 above.

3.1.11 Vacuum Gauge. At least 760 mm Hg (30 in. Hg) gauge, to be used for the sampling leak check.

3.2 Procedure.

3.2.1 Place exactly 5 ml distilled water in each impinger. Leak check the sampling train as follows: Temporarily insert a vacuum gauge at or near the probe inlet; then, plug the probe inlet and pull a vacuum of at least 250 mm Hg (10 in. Hg). Note, the time rate of change of the dry gas meter dial; alternatively, a rotameter (0–40 cc/min) may be temporarily attached to the dry gas meter outlet to determine the leakage rate. A leak rate not in excess of 2 percent of the average sampling rate is acceptable.

NOTE.—Carefully release the probe inlet plug before turning off the pump.

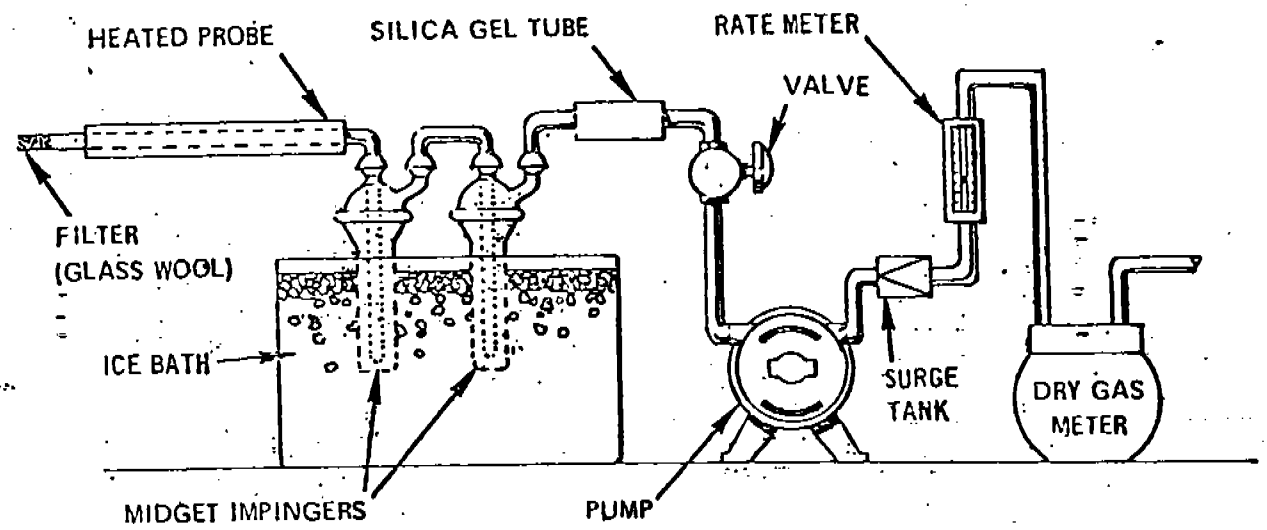

Figure 4-4. Moisture sampling train - approximation method.

LOCATION _____ COMMENTS

TEST _____

DATE _____

OPERATOR _____

BAROMETRIC PRESSURE _____

CLOCK TIME	GAS VOLUME THROUGH METER, (Vm), m^3 (ft^3)	RATE METER SETTING m^3/min. (ft^3/min.)	METER TEMPERATURE, °C (°F)

Figure 4-5. Field moisture determination - approximation method.

3.2.2 Connect the probe, insert it into the stack, and sample at a constant rate of 2 lpm (0.071 cfm). Continue sampling until the dry gas meter registers about 30 liters (1.1 ft³) or until visible liquid droplets are carried over from the first impinger to the second. Record temperature, pressure, and dry gas meter readings as required by Figure 4-5.

3.2.3 After collecting the sample, combine the contents of the two impingers and measure the volume to the nearest 0.5 ml.

3.3 Calculations. The calculation method presented is designed to estimate the moisture in the stack gas; therefore, other data, which are only necessary for accurate moisture determinations, are not collected. The following equations adequately estimate the moisture content, for the purpose of determining isokinetic sampling rate settings.

3.3.1 Nomenclature.

B_{wo} = Approximate proportion, by volume, of water vapor in the gas stream leaving the second impinger, 0.025.

B_{ws} = Water vapor in the gas stream, proportion by volume.

M_w = Molecular weight of water, 18.0 g/g-mole (18.0 lb/lb-mole)

P_m = Absolute pressure (for this method, same as barometric pressure) at the dry gas meter.

P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).

R = Ideal gas constant, 0.06236 (mm Hg) (m³)/(g-mole) (°K) for metric units and 21.85 (in. Hg) (ft³)/lb-mole) (°R) for English units.

T_m = Absolute temperature at meter, °K (°R)

T_{std} = Standard absolute temperature, 293° K (528° R)

V_f = Final volume of impinger contents, ml.

V_i = Initial volume of impinger contents, ml.

V_m = Dry gas volume measured by dry gas meter, dcm (dcf).

$V_{m(std)}$ = Dry gas volume measured by dry gas meter, corrected to standard conditions, dscm (dscf).

$V_{wc(std)}$ = Volume of water vapor condensed, corrected to standard conditions, scm (scf).

ρ_w = Density of water, 0.9982 g/ml (0.002201 lb/ml).

Y = Dry gas meter calibration factor.

3.3.2 Volume of water vapor collected.

$$V_{wc} = \frac{(V_f - V_i)\rho_w R T_{std}}{P_{std} M_w} = K_1 (V_f - V_i)$$

Equation 4-5

where:

K_1 = 0.001333 m³/ml for metric units
= 0.04707 ft³/ml for English units.

$$V_{m(std)} = V_m Y \left(\frac{P_m}{P_{std}}\right)\left(\frac{T_{std}}{T_m}\right) = K_2 Y \frac{V_m P_m}{T_m}$$

Equation 4-6

where:

K_2 = 0.3858 °K/mm Hg for metric units
= 17.64 °R/in. Hg for English units

3.3.4 Approximate moisture content.

$$B_{ws} = \frac{V_{wc(std)}}{V_{wc(std)} + V_{m(std)}} + B_{wo} = \frac{V_{wc(std)}}{V_{wc(std)} + V_{m(std)}} + (0.025)$$

Equation 4-7

4. *Calibration*

4.1 For the reference method, calibrate equipment as specified in the following sections of Method 5: Section 5.3 (metering system); Section 5.5 (temperature gauges); and Section 5.7 (barometer). The recommended leak check of the metering system (Section 5.6 of Method 5) also applies to the reference method. For the approximation method, use the procedures outlined in Section 5.1.1 of Method 6 to calibrate the metering system, and the procedure of Method 5, Section 5.7 to calibrate the barometer.

5. *Bibliography*

1. Air Pollution Engineering Manual (Second Edition). Danielson, J. A. (ed.). U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, N.C. Publication No. AP-40. 1973.

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

3. 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 collected on a glass fiber filter maintained at a temperature in the range of 120±14° C (248±25° F) or such other temperature as specified by an applicable subpart of the standards or approved by the Administrator, U.S. Environmental Protection Agency, for a particular application. The particulate mass, which includes any material that condenses at or above the filtration temperature, is determined gravimetrically after removal of uncombined water.

1.2 Applicability. This method is applicable for the determination of particulate emissions from stationary sources.

2. *Apparatus*

2.1 Sampling Train. A schematic of the sampling train used in this method is shown in Figure 5-1. Complete construction details are given in APTD-0581 (Citation 2 in Section 7); commercial models of this train are also available. For changes from APTD-0581 and for allowable modifications of the train shown in Figure 5-1, see the following subsections.

The operating and maintenance procedures for the sampling train are described in APTD-0576 (Citation 3 in Section 7). Since correct usage is important in obtaining valid results, all users should read APTD-0576 and adopt the operating and maintenance procedures outlined in it, unless otherwise specified herein. The sampling train consists of the following components:

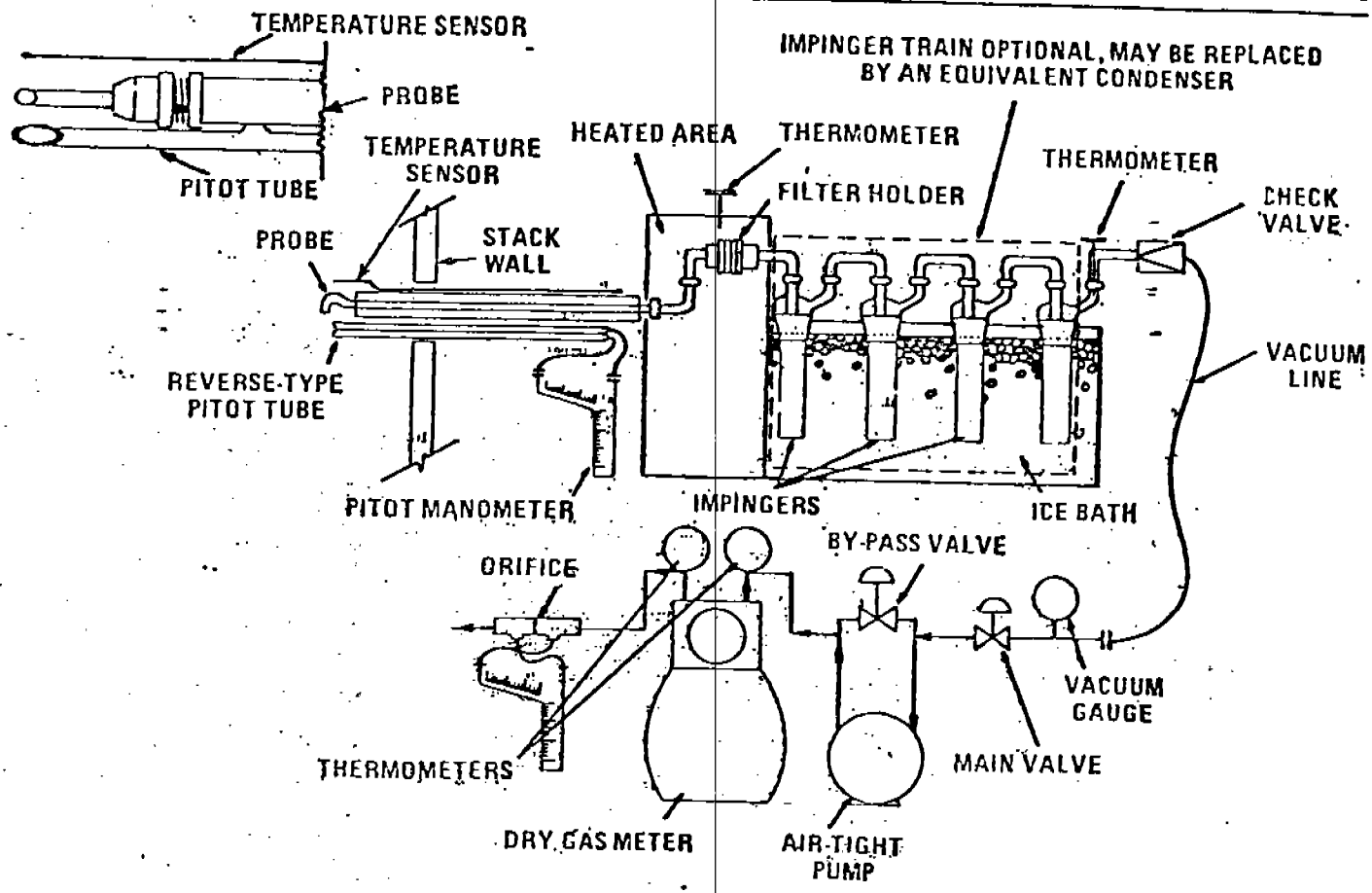

Figure 5 1. Particulate-sampling train.

2.1.1 Probe Nozzle. Stainless steel (316) or glass with sharp, tapered leading edge. The angle of taper shall be ≤30° and the taper shall be on the outside to preserve a constant internal diameter. The probe nozzle shall be of the button-hook or elbow design, unless otherwise specified by the Administrator. If made of stainless steel, the nozzle shall be constructed from seamless tubing; other materials of construction may be used, subject to the approval of the Administrator.

A range of nozzle sizes suitable for isokinetic sampling should be available, e.g., 0.32 to 1.27 cm (⅛ to ½ in.)—or larger if higher volume sampling trains are used—inside diameter (ID) nozzles in increments of 0.16 cm (1/16 in.). Each nozzle shall be calibrated according to the procedures outlined in Section 5.

2.1.2 Probe Liner. Borosilicate or quartz glass tubing with a heating system capable of maintaining a gas temperature at the exit end during sampling of 120±14° C (248±25° F), or such other temperature as specified by an applicable subpart of the standards or approved by the Administrator for a particular application. (The tester may opt to operate the equipment at a temperature lower than that specified.) Since the actual temperature at the outlet of the probe is not usually monitored during sampling, probes constructed according to APTD-0581 and utilizing the calibration curves of APTD-0576 (or calibrated according to the procedure outlined in APTD-0576) will be considered acceptable.

Either borosilicate or quartz glass probe liners may be used for stack temperatures up to about 480° C (900° F); quartz liners shall be used for temperatures between 480 and 900° C (900 and 1,650° F). Both types of liners may be used at higher temperatures than specified for short periods of time, subject to the approval of the Administrator. The softening temperature for borosilicate is 820° C (1,508° F), and for quartz it is 1,500° C (2,732° F).

Whenever practical, every effort should be made to use borosilicate or quartz glass probe liners. Alternatively, metal liners (e.g., 316 stainless steel, Incoloy 825,[3] or other corrosion resistant metals) made of seamless tubing may be used, subject to the approval of the Administrator.

2.1.3 Pitot Tube. Type S, as described in Section 2.1 of Method 2, or other device approved by the Administrator. The pitot tube shall be attached to the probe (as shown in Figure 5-1) to allow constant monitoring of the stack gas velocity. The impact (high pressure) opening plane of the pitot tube shall be even with or above the nozzle entry plane (see Method 2, Figure 2-6b) during sampling. The Type S pitot tube assembly shall have a known coefficient, determined as outlined in Section 4 of Method 2.

2.1.4 Differential Pressure Gauge. Inclined manometer or equivalent device (two), as described in Section 2.2 of Method 2. One manometer shall be used for velocity head (Δp) readings, and the other, for orifice differential pressure readings.

2.1.5 Filter Holder. Borosilicate glass, with a glass frit filter support and a silicone rubber gasket. Other materials of construction (e.g., stainless steel, Teflon, Viton) may be used, subject to approval of the Administrator. The holder design shall provide a positive seal against leakage from the outside or around the filter. The holder shall be attached immediately at the outlet of the probe (or cyclone, if used).

2.1.6 Filter Heating System. Any heating system capable of maintaining a temperature around the filter holder during sampling of 120±14° C (248±25° F), or such other temperature as specified by an applicable subpart of the standards or approved by the Administrator for a particular application. Alternatively, the tester may opt to operate the equipment at a temperature lower than that specified. A temperature gauge capable of measuring temperature to within 3° C (5.4° F) shall be installed so that the temperature around the filter holder can be regulated and monitored during sampling. Heating systems other than the one shown in APTD-0581 may be used.

2.1.7 Condenser. The following system shall be used to determine the stack gas moisture content: Four impingers connected in series with leak-free ground glass fittings or any similar leak-free non-contaminating fittings. The first, third, and fourth impingers shall be of the Greenburg-Smith design, modified by replacing the tip with 1.3 cm (½ in.) ID glass tube extending to about 1.3 cm (½ in.) from the bottom of the flask. The second impinger shall be of the Greenburg-Smith design with the standard tip. Modifications (e.g., using flexible connections between the impingers, using materials other than glass, or using flexible vacuum lines to connect the filter holder to the condenser) may be used, subject to the approval of the Administrator. The first and second impingers shall contain known quantities of water (Section 4.1.3), the third shall be empty, and the fourth shall contain a known weight of silica gel, or equivalent desiccant. A thermometer, capable of measuring temperature to within 1° C (2° F) shall be placed at the outlet of the fourth impinger for monitoring purposes.

Alternatively, any system that cools the sample gas stream and allows measurement of the water condensed and moisture leaving the condenser, each to within 1 ml or 1 g may be used, subject to the approval of the Administrator. Acceptable means are to measure the condensed water either gravimetrically or volumetrically and to measure the moisture leaving the condenser by: (1) monitoring the temperature and pressure at the exit of the condenser and using Dalton's law of partial pressures; or (2) passing the sample gas stream through a tared silica gel (or equivalent desiccant) trap with exit gases kept below 20° C (68° F) and determining the weight gain.

If means other than silica gel are used to determine the amount of moisture leaving the condenser, it is recommended that silica gel (or equivalent) still be used between the condenser system and pump to prevent moisture condensation in the pump and metering devices and to avoid the need to make corrections for moisture in the metered volume.

NOTE.—If a determination of the particulate matter collected in the impingers is desired in addition to moisture content, the impinger system described above shall be used, without modification. Individual States or control agencies requiring this information shall be contacted as to the sample recovery and analysis of the impinger contents.

2.1.8 Metering System. Vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 3° C (5.4° F), dry gas meter capable of measuring volume to within 2 percent, and related equipment, as shown in Figure 5-1. Other metering systems capable of maintaining sampling rates within 10 percent of isokinetic and of determining sample volumes to within 2 percent may be used, subject to the approval of the Administrator. When the metering system is used in conjunction with a pitot tube, the system shall enable checks of isokinetic rates.

Sampling trains utilizing metering systems designed for higher flow rates than that described in APTD-0581 or APTD-0576 may be used provided that the specifications of this method are met.

2.1.9 Barometer. Mercury, aneroid, or other barometer capable of measuring atmospheric pressure to within 2.5 mm Hg (0.1 in. Hg). In many cases, the barometric reading may be obtained from a nearby national weather service station, in which case the station value (which is

[3] Mention of trade names or specific products does not constitute endorsement by the Environmental Protection Agency.

the absolute barometric pressure) shall be requested and an adjustment for elevation differences between the weather station and sampling point shall be applied at a rate of minus 2.5 mm Hg (0.1 in. Hg) per 30 m (100 ft) elevation increase or vice versa for elevation decrease.

2.1.10 Gas Density Determination Equipment. Temperature sensor and pressure gauge, as described in Sections 2.3 and 2.4 of Method 2, and gas analyzer, if necessary, as described in Method 3. The temperature sensor shall, preferably, be permanently attached to the pitot tube or sampling probe in a fixed configuration, such that the tip of the sensor extends beyond the leading edge of the probe sheath and does not touch any metal. Alternatively, the sensor may be attached just prior to use in the field. Note, however, that if the temperature sensor is attached in the field, the sensor must be placed in an interference-free arrangement with respect to the Type S pitot tube openings (see Method 2, Figure 2-7). As a second alternative, if a difference of not more than 1 percent in the average velocity measurement is to be introduced, the temperature gauge need not be attached to the probe or pitot tube. (This alternative is subject to the approval of the Administrator.)

2.2 Sample Recovery. The following items are needed:

2.2.1 Probe-Liner and Probe-Nozzle Brushes. Nylon bristle brushes with stainless steel wire handles. The probe brush shall have extensions (at least as long as the probe) of stainless steel, Nylon, Teflon, or similarly inert material. The brushes shall be properly sized and shaped to brush out the probe liner and nozzle.

2.2.2 Wash Bottles—Two. Glass wash bottles are recommended; polyethylene wash bottles may be used at the option of the tester. It is recommended that acetone not be stored in polyethylene bottles for longer than a month.

2.2.3 Glass Sample Storage Containers. Chemically resistant, borosilicate glass bottles, for acetone washes, 500 ml or 1000 ml. Screw cap liners shall either be rubber-backed Teflon or shall be constructed so as to be leak-free and resistant to chemical attack by acetone. (Narrow mouth glass bottles have been found to be less prone to leakage.) Alternatively, polyethylene bottles may be used.

2.2.4 Petri Dishes. For filter samples, glass or polyethylene, unless otherwise specified by the Administrator.

2.2.5 Graduated Cylinder and/or Balance. To measure condensed water to within 1 ml or 1 g. Graduated cylinders shall have subdivisions no greater than 2 ml. Most laboratory balances are capable of weighing to the nearest 0.5 g or less. Any of these balances is suitable for use here and in Section 2.3.4.

2.2.6 Plastic Storage Containers. Air-tight containers to store silica gel.

2.2.7 Funnel and Rubber Policeman. To aid in transfer of silica gel to container; not necessary if silica gel is weighed in the field.

2.2.8 Funnel. Glass or polyethlene, to aid in sample recovery.

2.3 Analysis. For analysis, the following equipment is needed.

2.3.1 Glass Weighing Dishes.

2.3.2 Desiccator.

2.3.3 Analytical Balance. To measure to within 0.1 mg.

2.3.4 Balance. To measure to within 0.5 g.

2.3.5 Beakers. 250 ml.

2.3.6 Hygrometer. To measure the relative humidity of the laboratory environment.

2.3.7 Temperature Gauge. To measure the temperature of the laboratory environment.

3. *Reagents*

3.1 Sampling. The reagents used in sampling are as follows:

3.1.1 Filters. Glass fiber filters, without organic binder, exhibiting at least 99.95 percent efficiency (≤0.05 percent penetration) on 0.3-micron dioctyl phthalate smoke particles. The filter efficiency test shall be conducted in accordance with ASTM standard method D 2986-71. Test data from the supplier's quality control program are sufficient for this purpose.

3.1.2 Silica Gel. Indicating type, 6 to 16 mesh. If previously used, dry at 175° C (350° F) for 2 hours. New silica gel may be used as received. Alternatively, other types of desiccants (equivalent or better) may be used, subject to the approval of the Administrator.

3.1.3 Water. When analysis of the material caught in the impingers is required, distilled water shall be used. Run blanks prior to field use to eliminate a high blank on test samples.

3.1.4 Crushed Ice.

3.1.5 Stopcock Grease. Acetone-insoluble, heat-stable silicone grease. This is not necessary if screw-on connectors with Teflon sleeves, or similar, are used. Alternatively, other types of stopcock grease may be used, subject to the approval of the Administrator.

3.2 Sample Recovery. Acetone—reagent grade, ≤0.001 percent residue, in glass bottles—is required. Acetone from metal containers generally has a high residue blank and should not be used. Sometimes, suppliers transfer acetone to glass bottles from metal containers; thus, acetone blanks shall be run prior to field use and only acetone with low blank values (≤0.001 percent) shall be used. In no case shall a blank value of greater than 0.001 percent of the weight of acetone used be subtracted from the sample weight.

3.3 Analysis. Two reagents are required for the analysis:

3.3.1 Acetone. Same as 3.2.

3.3.2 Desiccant. Anhydrous calcium sulfate, indicating type. Alternatively, other types of desiccants may be used, subject to the approval of the Administrator.

4. *Procedure*

4.1 Sampling. The complexity of this method is such that, in order to obtain reliable results, testers should be trained and experienced with the test procedures.

4.1.1 Pretest Preparation. All the components shall be maintained and calibrated according to the procedure described in APTD-0576, unless otherwise specified herein.

Weigh several 200 to 300 g portions of silica gel in air-tight containers to the nearest 0.5 g. Record the total weight of the silica gel plus container, on each container. As an alternative, the silica gel need not be preweighed, but may be weighed directly in its impinger or sampling holder just prior to train assembly.

Check filters visually against light for irregularities and flaws or pinhole leaks. Label filters of the proper diameter on the back side near the edge using numbering machine ink. As an alternative, label the shipping containers (glass or plastic petri dishes) and keep the filters in these containers at all times except during sampling and weighing.

Desiccate the filters at 20±5.6° C (68±10° F) and ambient pressure for at least 24 hours and weigh at intervals of at least 6 hours to a constant weight, i.e., <0.5 mg change from previous weighing; record results to the nearest 0.1 mg. During each weighing the filter must not be exposed to the laboratory atmosphere for a period greater than 2 minutes and a relative humidity above 50 percent. Alternatively (unless otherwise specified by the Administrator), the filters may be oven dried at 105° C (220° F) for 2 to 3 hours, desiccated for 2 hours, and weighed. Procedures other than those described, which account for relative humidity effects, may be used, subject to the approval of the Administrator.

4.1.2 Preliminary Determinations. Select the sampling site and the minimum number of sampling points according to Method 1 or as specified by the Administrator. Determine the stack pressure, temperature, and the range of velocity heads using Method 2; it is recommended that a leak-check of the pitot lines (see Method 2, Section 3.1) be performed. Determine the moisture content using Approximation Method 4 or its alternatives for the purpose of making isokinetic sampling rate settings. Determine the stack gas dry molecular weight, as described in Method 2, Section 3.6; if integrated Method 3 sampling is used for molecular weight determination, the integrated bag sample shall be taken simultaneously with, and for the same total length of time as, the particulate sample run.

Select a nozzle size based on the range of velocity heads, such that it is not necessary to change the nozzle size in order to maintain isokinetic sampling rates. During the run, do not change the nozzle size. Ensure that the proper differential pressure gauge is chosen for the range of velocity heads encountered (see Section 2.2 of Method 2).

Select a suitable probe liner and probe length such that all traverse points can be sampled. For large stacks, consider sampling from opposite sides of the stack to reduce the length of probes.

Select a total sampling time greater than or equal to the minimum total sampling time specified in the test procedures for the specific industry such that (1) the sampling time per point is not less than 2 min (or some greater time interval as specified by the Administrator), and (2) the sample volume taken (corrected to standard conditions) will exceed the required minimum total gas sample volume. The latter is based on an approximate average sampling rate.

It is recommended that the number of minutes sampled at each point be an integer or an integer plus one-half minute, in order to avoid timekeeping errors. The sampling time at each point shall be the same.

In some circumstances, e.g., batch cycles, it may be necessary to sample for shorter times at the traverse points and to obtain smaller gas sample volumes. In these cases, the Administrator's approval must first be obtained.

4.1.3 Preparation of Collection Train. During preparation and assembly of the sampling train, keep all openings where contamination can occur covered until just prior to assembly or until sampling is about to begin.

Place 100 ml of water in each of the first two impingers, leave the third impinger empty, and transfer approximately 200 to 300 g of preweighed silica gel from its container to the fourth impinger. More silica gel may be used, but care should be taken to ensure that it is not entrained and carried out from the impinger during sampling. Place the container in a clean place for later use in the sample recovery. Alternatively, the weight of the silica gel plus impinger may be determined to the nearest 0.5 g and recorded.

Using a tweezer or clean disposable surgical gloves, place a labeled (identified) and weighed filter in the filter holder. Be sure that the filter is properly centered and the gasket properly placed so as to prevent the sample gas stream from circumventing the filter. Check the filter for tears after assembly is completed.

When glass liners are used, install the selected nozzle using a Viton A O-ring when stack temperatures are less than 260° C (500° F) and an asbestos string gasket when temperatures are higher. See APTD-0576 for details. Other connecting systems using either 316 stainless steel or Teflon ferrules may be used. When metal liners are used, install the nozzle as above or by a leak-free direct mechanical connection. Mark the probe with heat resistant tape or by some other method to denote the proper distance into the stack or duct for each sampling point.

Set up the train as in Figure 5-1, using (if necessary) a very light coat of silicone grease on all ground glass joints, greasing only the outer portion (see APTD-0576) to avoid possibility of contamination by the silicone grease. Subject to the approval of the Administrator, a glass cyclone may be used between the probe and filter holder when the total particulate catch is expected to exceed 100 mg or when water droplets are present in the stack gas.

Place crushed ice around the impingers.

4.1.4 Leak-Check Procedures.

4.1.4.1 Pretest Leak-Check. A pretest leak-check is recommended, but not required. If the tester opts to conduct the pretest leak-check, the following procedure shall be used.

After the sampling train has been assembled, turn on and set the filter and probe heating systems at the desired operating temperatures. Allow time for the temperatures to stabilize. If a Viton A O-ring or other leak-free connection is used in assembling the probe nozzle to the probe liner, leak-check the train at the sampling site by plugging the nozzle and pulling a 380 mm Hg (15 in. Hg) vacuum.

NOTE.—A lower vacuum may be used, provided that it is not exceeded during the test.

If an asbestos string is used, do not connect the probe to the train during the leak-check. Instead, leak-check the train by first plugging the inlet to the filter holder (cyclone, if applicable) and pulling a 380 mm Hg (15 in. Hg) vacuum (see Note immediately above). Then connect the probe to the train and leak-check at about 25 mm Hg (1 in. Hg) vacuum; alternatively, the probe may be leak-checked with the rest of the sampling train, in one step, at 380 mm Hg (15 in. Hg) vacuum. Leakage rates in excess of 4 percent of the average sampling rate or 0.00057 m³/min (0.02 cfm), whichever is less, are unacceptable.

The following leak-check instructions for the sampling train described in APTD-0576 and APTD-0581 may be helpful. Start the pump with bypass valve fully open and coarse adjust valve completely closed. Partially open the coarse adjust valve and slowly close the bypass valve until the desired vacuum is reached. Do not reverse direction of bypass valve; this will cause water to back up into the filter holder. If the desired vacuum is exceeded, either leak-check at this higher vacuum or end the leak check as shown below and start over.

When the leak-check is completed, first slowly remove the plug from the inlet to the probe, filter holder, or cyclone (if applicable) and immediately turn off the vacuum pump. This prevents the water in the impingers from being forced backward into the filter holder and silica gel from being entrained backward into the third impinger.

4.1.4.2 Leak-Checks During Sample Run. If, during the sampling run, a component (e.g., filter assembly or impinger) change becomes necessary, a leak-check shall be conducted immediately before the change is made. The leak-check shall be done according to the procedure outlined in Section 4.1.4.1 above, except that it shall be done at a vacuum equal to or greater than the maximum value recorded up to that point in the test. If the leakage rate is found to be no greater than 0.00057 m³/min (0.02 cfm) or 4 percent of the average sampling rate (whichever is less), the results are acceptable, and no correction will need to be applied to the total volume of dry gas metered; if, however, a higher leakage rate is obtained, the tester shall either record the leakage rate and plan to correct the sample volume as shown in Section 6.3 of this method, or shall void the sampling run.

Immediately after component changes, leak-checks are optional; if such leak-checks are done, the procedure outlined in Section 4.1.4.1 above shall be used.

4.1.4.3 Post-test Leak-Check. A leak-check is mandatory at the conclusion of each sampling run. The leak-check shall be done in accordance with the procedures outlined in Section 4.1.4.1, except that it shall be conducted at a vacuum equal to or greater than the maximum value reached during the sampling run. If the leakage rate is found to be no greater than 0.00057 m³/min (0.02 cfm) or 4 percent of the average sampling rate (whichever is less), the results are acceptable, and no correction need be applied to the total volume of dry gas metered. If, however, a higher leakage rate is obtained, the tester shall either record the leakage rate and correct the sample volume as shown in Section 6.3 of this method, or shall void the sampling run.

4.1.5 Particulate Train Operation. During the sampling run, maintain an isokinetic sampling rate (within 10 percent of true isokinetic unless otherwise specified by the Administrator) and a temperature around the filter of 120±14° C (248±25° F), or such other temperature as specified by an applicable subpart of the standards or approved by the Administrator.

For each run, record the data required on a data sheet such as the one shown in Figure 5-2. Be sure to record the initial dry gas meter reading. Record the dry gas meter readings at the beginning and end of each sampling time increment, when changes in flow rates are made, before and after each leak check, and when sampling is halted;

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Take other readings required by Figure 5-2 at least once at each sample point during each time increment and additional readings when significant changes (20 percent variation in velocity head readings) necessitate additional adjustments in flow rate. Level and zero the manometer. Because the manometer level and zero may drift due to vibrations and temperature changes, make periodic checks during the traverse.

Clean the portholes prior to the test run to minimize the chance of sampling deposited material. To begin sampling, remove the nozzle cap, verify that the filter and probe heating systems are up to temperature, and that the pitot tube and probe are properly positioned. 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. Nomographs are available, which aid in the rapid adjustment of the isokinetic sampling rate without excessive computations. These nomographs are designed for use when the Type S pitot tube coefficient is 0.85±0.02, and the stack gas equivalent density (dry molecular weight) is equal to 29±4. APTD-0576 details the procedure for using the nomographs. If C_p and M_s are outside the above stated ranges do not use the nomographs unless appropriate steps (see Citation 7 in Section 7) are taken to compensate for the deviations.

PLANT _____

LOCATION _____

OPERATOR _____

DATE _____

RUN NO. _____

SAMPLE BOX NO. _____

METER BOX NO. _____

METER ΔH@ _____

C FACTOR _____

PITOT TUBE COEFFICIENT, C_p _____

SCHEMATIC OF STACK CROSS SECTION

AMBIENT TEMPERATURE _____

BAROMETRIC PRESSURE _____

ASSUMED MOISTURE, % _____

PROBE LENGTH, m (ft) _____

NOZZLE IDENTIFICATION NO. _____

AVERAGE CALIBRATED NOZZLE DIAMETER, cm (in.) _____

PROBE HEATER SETTING _____

LEAK RATE, m^3/min. (cfm) _____

PROBE LINER MATERIAL _____

STATIC PRESSURE, mm Hg (in. Hg) _____

FILTER NO. _____

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	VACUUM mm Hg (in. Hg)	STACK TEMPERATURE (T_S) °C (°F)	VELOCITY HEAD (ΔP_S), mm(in.)H_2O	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER mm H_2O (in. H_2O)	GAS SAMPLE VOLUME m^3 (ft^3)	GAS SAMPLE TEMPERATURE AT DRY GAS METER		FILTER HOLDER TEMPERATURE, °C (°F)	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER, °C (°F)
							INLET °C (°F)	OUTLET °C (°F)		
TOTAL							Avg.	Avg.		
AVERAGE							Avg.			

Figure 5-2. Particulate field data.

When the stack is under significant negative pressure (height of impinger stem), take care to close the coarse adjust valve before inserting the probe into the stack to prevent water from backing into the filter holder. If necessary, the pump may be turned on with the coarse adjust valve closed.

When the probe is in position, block off the openings around the probe and porthole to prevent unrepresentative dilution of the gas stream.

Traverse the stack cross-section, as required by Method 1 or as specified by the Administrator, being careful not to bump the probe nozzle into the stack walls when sampling near the walls or when removing or inserting the probe through the portholes; this minimizes the chance of extracting deposited material.

During the test run, make periodic adjustments to keep the temperature around the filter holder at the proper level; add more ice and, if necessary, salt to maintain a temperature of less than 20° C (68° F) at the condenser/silica gel outlet. Also, periodically check the level and zero of the manometer.

If the pressure drop across the filter becomes too high, making isokinetic sampling difficult to maintain, the filter may be replaced in the midst of a sample run. It is recommended that another complete filter assembly be used rather than attempting to change the filter itself. Before a new filter assembly is installed, conduct a leak-check (see Section 4.1.4.2). The total particulate weight shall include the summation of all filter assembly catches.

A single train shall be used for the entire sample run, except in cases where simultaneous sampling is required in two or more separate ducts or at two or more different locations within the same duct, or, in cases where equipment failure necessitates a change of trains. In all other situations, the use of two or more trains will be subject to the approval of the Administrator.

Note that when two or more trains are used, separate analyses of the front-half and (if applicable) impinger catches from each train shall be performed, unless identical nozzle sizes were used on all trains, in which case, the front-half catches from the individual trains may be combined (as may the impinger catches) and one analysis of front-half catch and one analysis of impinger catch may be performed. Consult with the Administrator for details concerning the calculation of results when two or more trains are used.

At the end of the sample run, turn off the coarse adjust valve, remove the probe and nozzle from the stack, turn off the pump, record the final dry gas meter reading, and conduct a post-test leak-check, as outlined in Section 4.1.4.3. Also, leak-check the pitot lines as described in Method 2, Section 3.1; the lines must pass this leak-check, in order to validate the velocity head data.

4.1.6 Calculation of Percent Isokinetic. Calculate percent isokinetic (see Calculations, Section 6) to determine whether the run was valid or another test run should be made. If there was difficulty in maintaining isokinetic rates due to source conditions, consult with the Administrator for possible variance on the isokinetic rates.

4.2 Sample Recovery. Proper cleanup procedure begins as soon as the probe is removed from the stack at the end of the sampling period. Allow the probe to cool.

When the probe can be safely handled, wipe off all external particulate matter near the tip of the probe nozzle and place a cap over it to prevent losing or gaining particulate matter. Do not cap off the probe tip tightly while the sampling train is cooling down as this would create a vacuum in the filter holder, thus drawing water from the impingers into the filter holder.

Before moving the sample train to the cleanup site, remove the probe from the sample train, wipe off the silicone grease, and cap the open outlet of the probe. Be careful not to lose any condensate that might be present. Wipe off the silicone grease from the filter inlet where the probe was fastened and cap it. Remove the umbilical cord from the last impinger and cap the impinger. If a flexible line is used between the first impinger or condenser and the filter holder, disconnect the line at the filter holder and let any condensed water or liquid drain into the impingers or condenser. After wiping off the silicone grease, cap off the filter holder outlet and impinger inlet. Either ground-glass stoppers, plastic caps, or serum caps may be used to close these openings.

Transfer the probe and filter-impinger assembly to the cleanup area. This area should be clean and protected from the wind so that the chances of contaminating or losing the sample will be minimized.

Save a portion of the acetone used for cleanup as a blank. Take 200 ml of this acetone directly from the wash bottle being used and place it in a glass sample container labeled "acetone blank."

Inspect the train prior to and during disassembly and note any abnormal conditions. Treat the samples as follows:

Container No. 1. Carefully remove the filter from the filter holder and place it in its identified petri dish container. Use a pair of tweezers and/or clean disposable surgical gloves to handle the filter. If it is necessary to fold the filter, do so such that the particulate cake is inside the fold. Carefully transfer to the petri dish any particulate matter and/or filter fibers which adhere to the filter holder gasket, by using a dry Nylon bristle brush and/or a sharp-edged blade. Seal the container.

Container No. 2. Taking care to see that dust on the outside of the probe or other exterior surfaces does not get into the sample, quantitatively recover particulate matter or any condensate from the probe nozzle, probe

fitting, probe liner, and front half of the filter holder by washing these components with acetone and placing the wash in a glass container. Distilled water may be used instead of acetone when approved by the Administrator and shall be used when specified by the Administrator; in these cases, save a water blank and follow the Administrator's directions on analysis. Perform the acetone rinses as follows:

Carefully remove the probe nozzle and clean the inside surface by rinsing with acetone from a wash bottle and brushing with a Nylon bristle brush. Brush until the acetone rinse shows no visible particles, after which make a final rinse of the inside surface with acetone.

Brush and rinse the inside parts of the Swagelok fitting with acetone in a similar way until no visible particles remain.

Rinse the probe liner with acetone by tilting and rotating the probe while squirting acetone into its upper end so that all inside surfaces will be wetted with acetone. Let the acetone drain from the lower end into the sample container. A funnel (glass or polyethylene) may be used to aid on transferring liquid washes to the container. Follow the acetone rinse with a probe brush. Hold the probe in an inclined position, squirt acetone into the upper end as the probe brush is being pushed with a twisting action through the probe; hold a sample container underneath the lower end of the probe, and catch any acetone and particulate matter which is brushed from the probe. Run the brush through the probe three times or more until no visible particulate matter is carried out with the acetone or until none remains in the probe liner on visual inspection. With stainless steel or other metal probes, run the brush through in the above prescribed manner at least six times since metal probes have small crevices in which particulate matter can be entrapped. Rinse the brush with acetone, and quantitatively collect these washings in the sample container. After the brushing, make a final acetone rinse of the probe as described above.

It is recommended that two people be used to clean the probe to minimize sample losses. Between sampling runs, keep brushes clean and protected from contaminations.

After ensuring that all joints have been wiped clean of silicone grease, clean the inside of the front half of the filter holder by rubbing the surfaces with a Nylon bristle brush and rinsing with acetone. Rinse each surface three times or more if needed to remove visible particulate. Make a final rinse of the brush and filter holder. Carefully rinse out the glass cyclone, also (if applicable). After all acetone washings and particulate matter have been collected in the sample container, tighten the lid on the sample container so that acetone will not leak out when it is shipped to the laboratory. Mark the height of the fluid level to determine whether or not leakage occured during transport. Label the container to clearly identify its contents.

Container No. 3. Note the color of the indicting silica gel to determine if it has been completely spent and make a notation of its condition. Transfer the silica gel from the fourth impinger to its original container and seal. A funnel may make it easier to pour the silica gel without spilling. A rubber policeman may be used as an aid in removing the silica gel from the impinger. It is not necessary to remove the small amount of dust particles that may adhere to the impinger wall and are difficult to remove. Since the gain in weight is to be used for moisture calculations, do not use any water or other liquids to transfer the silica gel. If a balance is available in the field, follow the procedure for container No. 3 in Section 4.3.

Impinger Water. Treat the impingers as follows; Make a notation of any color or film in the liquid catch. Measure the liquid which is in the first three impingers to within ± 1 ml by using a graduated cylinder or by weighing it to within ± 0.5 g by using a balance (if one is available). Record the volume or weight of liquid present. This information is required to calculate the moisture content of the effluent gas.

Discard the liquid after measuring and recording the volume or weight, unless analysis of the impinger catch is required (see Note, Section 2.1.7).

If a different type of condenser is used, measure the amount of moisture condensed either volumetrically or gravimetrically.

Whenever possible, containers should be shipped in such a way that they remain upright at all times.

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

Container No. 1. Leave the contents in the shipping container or transfer the filter and any loose particulate from the sample container to a tared glass weighing dish. Desiccate for 24 hours in a desiccator containing anhydrous calcium sulfate. Weigh to a constant weight and report the results to the nearest 0.1 mg. For purposes of this Section, 4.3, the term "constant weight" means a difference of no more than 0.5 mg or 1 percent of total weight less tare weight, whichever is greater, between two consecutive weighings, with no less than 6 hours of desiccation time between weighings.

Plant _____

Date _____

Run No. _____

Filter No. _____

Amount liquid lost during transport _____

Acetone blank volume, ml _____

Acetone wash volume, ml _____

Acetone blank concentration, mg/mg (equation 5-4) _____

Acetone wash blank, mg (equation 5-5) _____

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED, mg		
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
1			
2			
TOTAL			
		Less acetone blank	
		Weight of particulate matter	

	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 (1g/ml):

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

Figure 5-3. Analytical data.

Alternatively, the sample may be oven dried at 105° C (220° F) for 2 to 3 hours, cooled in the desiccator, and weighed to a constant weight, unless otherwise specified by the Administrator. The tester may also opt to oven dry the sample at 105° C (220° F) for 2 to 3 hours, weigh the sample, and use this weight as a final weight.

Container No. 2. Note the level of liquid in the container and confirm on the analysis sheet whether or not leakage occurred during transport. If a noticeable amount of leakage has occurred, either void the sample or use methods, subject to the approval of the Administrator, to correct the final results. Measure the liquid in this container either volumetrically to ±1 ml or gravimetrically to ±0.5 g. Transfer the contents to a tared 250-ml beaker and evaporate to dryness at ambient temperature and pressure. Desiccate for 24 hours and weigh to a constant weight. Report the results to the nearest 0.1 mg.

Container No. 3. Weigh the spent silica gel (or silica gel plus impinger) to the nearest 0.5 g using a balance. This step may be conducted in the field.

"Acetone Blank" Container. Measure acetone in this container either volumetrically or gravimetrically. Transfer the acetone to a tared 250-ml beaker and evaporate to dryness at ambient temperature and pressure. Desiccate for 24 hours and weigh to a constant weight. Report the results to the nearest 0.1 mg.

NOTE.—At the option of the tester, the contents of Container No. 2 as well as the acetone blank container may be evaporated at temperatures higher than ambient. If evaporation is done at an elevated temperature, the temperature must be below the boiling point of the solvent; also, to prevent "bumping," the evaporation process must be closely supervised, and the contents of the beaker must be swirled occasionally to maintain an even temperature. Use extreme care, as acetone is highly flammable and has a low flash point.

5. *Calibration*

Maintain a laboratory log of all calibrations.

5.1 Probe Nozzle. Probe nozzles shall be calibrated before their initial use in the field. Using a micrometer, measure the inside diameter of the nozzle to the nearest 0.025 mm (0.001 in.). Make three separate measurements using different diameters each time, and obtain the average of the measurements. The difference between the high and low numbers shall not exceed 0.1 mm (0.004 in.). When nozzles become nicked, dented, or corroded, they shall be reshaped, sharpened, and recalibrated before use. Each nozzle shall be permanently and uniquely identified.

5.2 Pitot Tube. The Type S pitot tube assembly shall be calibrated according to the procedure outlined in Section 4 of Method 2.

5.3 Metering System. Before its initial use in the field, the metering system shall be calibrated according to the procedure outlined in APTD-0576. Instead of physically adjusting the dry gas meter dial readings to correspond to the wet test meter readings, calibration factors may be used to mathematically correct the gas meter dial readings to the proper values. Before calibrating the metering system, it is suggested that a leak-check be conducted. For metering systems having diaphragm pumps, the normal leak-check procedure will not detect leakages within the pump. For these cases the following leak-check procedure is suggested: make a 10-minute calibration run at 0.00057 m³/min (0.02 cfm); at the end of the run, take the difference of the measured wet test meter and dry gas meter volumes; divide the difference by 10, to get the leak rate. The leak rate should not exceed 0.00057 m³/min (0.02 cfm).

After each field use, the calibration of the metering system shall be checked by performing three calibration runs at a single, intermediate orifice setting (based on the previous field test), with the vacuum set at the maximum value reached during the test series. To adjust the vacuum, insert a valve between the wet test meter and the inlet of the metering system. Calculate the average value of the calibration factor. If the calibration has changed by more than 5 percent, recalibrate the meter over the full range of orifice settings, as outlined in APTD-0576.

Alternative procedures, e.g., using the orifice meter coefficients, may be used, subject to the approval of the Administrator.

NOTE.—If the dry gas meter coefficient values obtained before and after a test series differ by more than 5 percent, the test series shall either be voided, or calculations for the test series shall be performed using whichever meter coefficient value (i.e., before or after) gives the lower value of total sample volume.

5.4 Probe Heater Calibration. The probe heating system shall be calibrated before its initial use in the field according to the procedure outlined in APTD-0576. Probes constructed according to APTD-0581 need not be calibrated if the calibration curves in APTD-0576 are used.

5.5 Temperature Gauges. Use the procedure in Section 4.3 of Method 2 to calibrate in-stack temperature gauges. Dial thermometers, such as are used for the dry gas meter and condenser outlet, shall be calibrated against mercury-in-glass thermometers.

5.6 Leak Check of Metering System Shown in Figure 5-1. That portion of the sampling train from the pump to the orifice meter should be leak checked prior to initial use and after each shipment. Leakage after the pump will result in less volume being recorded than is actually sampled. The following procedure is suggested (see Figure 5-4): Close the main valve on the meter box. Insert a one-hole rubber stopper with rubber tubing attached into the orifice exhaust pipe. Disconnect and vent the low side of the orifice manometer. Close off the low side orifice tap. Pressurize the system to 13 to 18 cm (5 to 7 in.) water column by blowing into the rubber tubing. Pinch off the tubing and observe the manometer for one minute. A loss of pressure on the manometer indicates a leak in the meter box; leaks, if present, must be corrected.

5.7 Barometer. Calibrate against a mercury barometer.

6. *Calculations*

Carry out calculations, retaining at least one extra decimal figure beyond that of the acquired data. Round off figures after the final calculation. Other forms of the equations may be used as long as they give equivalent results.

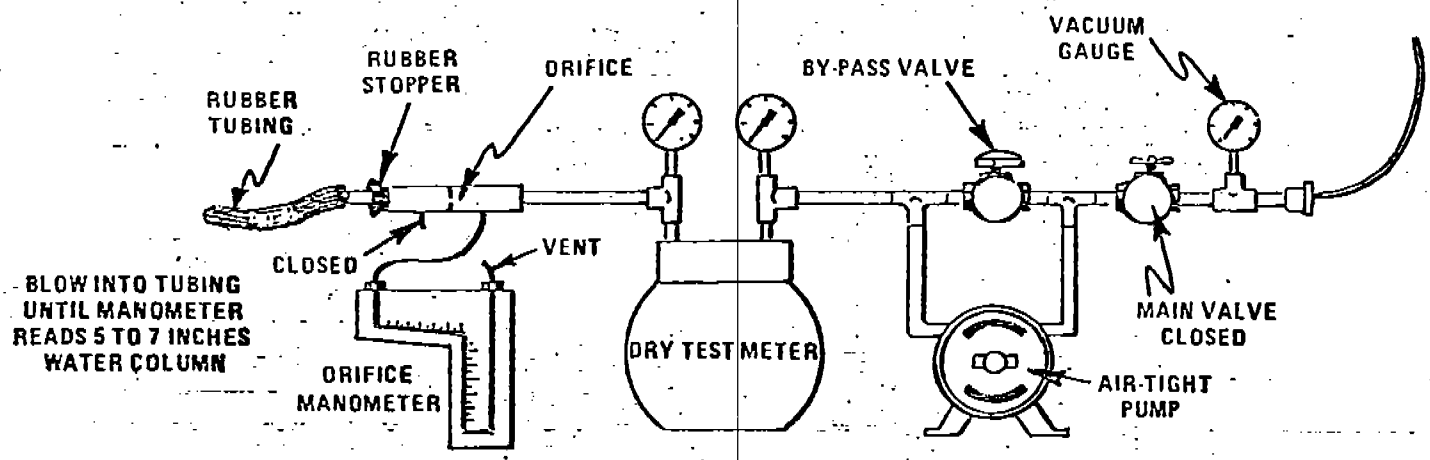

Figure 5-4. Leak check of meter box.

6.1 Nomenclature

A_n = Cross-sectional area of nozzle, m² (ft²).

B_{ws} = Water vapor in the gas stream, proportion by volume.

C_a = Acetone blank residue concentration, mg/g.

c_s = Concentration of particulate matter in stack gas, dry basis, corrected to standard conditions, g/dscm (g/dscf).

I = Percent of isokinetic sampling.

L_a = Maximum acceptable leakage rate for either a pretest leak check or for a leak check following a component change; equal to 0.00057 m³/min (0.02 cfm) or 4 percent of the average sampling rate, whichever is less.

L_i = Individual leakage rate observed during the leak check conducted prior to the "i^{th}" component change (i=1, 2, 3 . . . . n), m³/min (cfm).

L_p = Leakage rate observed during the post-test leak check, m³/min (cfm).

m_a = Total amount of particulate matter collected, mg.

M_w = Molecular weight of water, 18.0 g/g-mole (18.0 lb/lb-mole).

m_s = Mass of residue of acetone after evaporation, mg.

P_{bar} = Barometric pressure at the sampling site, mm Hg (in. Hg).

P_s = Absolute stack gas pressure, mm Hg (in. Hg).

P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).

R = Ideal gas constant, 0.06236 mm Hg-m³/°K-g-mole (21.85 in. Hg-ft³/°R-lb-mole).

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

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

T_{std} = Standard absolute temperature, 293° K (528° R).

V_a = Volume of acetone blank, ml.

V_{aw} = Volume of acetone used in wash, ml.

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

V_m = Volume of gas sample as measured by dry gas meter, dcm (dcf).

$V_{m(std)}$ = Volume of gas sample measured by the dry gas meter, corrected to standard conditions, dscm (dscf).

$V_{w(std)}$ = Volume of water vapor in the gas sample, corrected to standard conditions, scm (scf).

V_s = Stack gas velocity, calculated by Method 2, Equation 2-9, using data obtained from Method 5, m/sec (ft/sec).

W_a = Weight of residue in acetone wash, mg.

Y = Dry gas meter calibration factor.

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

ρ_a = Density of acetone, mg/ml (see label on bottle).

ρ_w = Density of water, 0.9982 g/ml (0.00220 lb/ml).

θ = Total sampling time, min.

θ_i = Sampling time interval, from the beginning of a run until the first component change, min.

θ_i = Sampling time interval, between two successive component changes, beginning with the interval between the first and second changes, min.

θ_p = Sampling time interval, from the final (n^{th}) component change until the end of the sampling run, min.

13.6 = Specific gravity of mercury.

60 = Sec/min.

100 = Conversion to percent.

6.2 Average dry gas meter temperature and average orifice pressure drop. See data sheet (Figure 5-2).

6.3 Dry Gas Volume. Correct the sample volume measured by the dry gas meter to standard conditions (20° C, 760 mm Hg or 68° F, 29.92 in. Hg) by using Equation 5-1.

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

$$= K_1 V_m Y \frac{P_{bar} + (\Delta H/13.6)}{T_m}$$

Equation 5-1

where:
$K_1 = 0.3858$ °K/mm Hg for metric units
$= 17.64$ °R/in. Hg for English units

NOTE.—Equation 5-1 can be used as written unless the leakage rate observed during any of the mandatory leak checks (i.e., the post-test leak check or leak checks conducted prior to component changes) exceeds L_a. If L_p or L_i exceeds L_a, Equation 5-1 must be modified as follows:

(a) Case I. No component changes made during sampling run. In this case, replace V_m in Equation 5-1 with the expression:

$$V_m - (L_p - L_a)\theta]$$

(b) Case II. One or more component changes made during the sampling run. In this case, replace V_m in Equation 5-1 by the expression:

$$\left[V_m - (L_1 - L_a)\theta_1 - \sum_{i=2}^{n} (L_i - L_a)\theta_i - (L_p - L_a)\theta_p\right]$$

and substitute only for those leakage rates (L_i or L_p) which exceed L_a.

6.4 Volume of water vapor.

$$V_w\,(\text{std}) = V_{1c}\left(\frac{\rho_w}{M_w}\right)\left(\frac{RT_{\text{std}}}{P_{\text{std}}}\right) = K_2 V_{1c}$$

Equation 5-2

where:
$K_2 = 0.001333\,m^3/ml$ for metric units
$= 0.04707\,ft^3/ml$ for English units.

6.5 Moisture Content.

$$B_{ws} = \frac{V_w\,(\text{std})}{V_m\,(\text{std}) + V_w\,(\text{std})}$$

Equation 5-3

NOTE.—In saturated or water droplet-laden gas streams, two calculations of the moisture content of the stack gas shall be made, one from the impinger analysis (Equation 5-3), and a second from the assumption of saturated conditions. The lower of the two values of B_w shall be considered correct. The procedure for determining the moisture content based upon assumption of saturated conditions is given in the Note of Section 1.2 of Method 4. For the purposes of this method, the average stack gas temperature from Figure 5-2 may be used to make this determination, provided that the accuracy of the in-stack temperature sensor is ±1° C (2° F).

$$I = \frac{100 T_s\,[K_3 V_{1c} + (V_m/T_m)(P_{bar} + \Delta H/13.6)]}{60\,\theta v_s P_s A_n}$$

Equation 5-7

where:
$K_3 = 0.003454$ mm Hg—m^3/ml—°K for metric units.
$= 0.002669$ in. Hg—ft^3/ml—°R for English units.

6.11.2 Calculation From Intermediate Values.

$$I = \frac{T_s V_m\,(\text{std})\,P_{\text{std}}\,100}{T_{\text{std}} v_s \theta\, A_n P_s\, 60(1 - B_{ws})}$$

$$= K_4 \frac{T_s V_m\,(\text{std})}{P_s V_s A_n \theta\,(1 - B_{ws})}$$

Equation 5-8

where:
$K_4 = 4.320$ for metric units
$= 0.09450$ for English units.

6.12 Acceptable Results. If 90 percent $\leq I \leq$ 110 percent, the results are acceptable. If the results are low in comparison to the standard and I is beyond the acceptable range, or if I is less than 90 percent, the Administrator may opt to accept the results.

6.6 Acetone Blank Concentration.

$$C_a = \frac{m_a}{V_a \rho_a}$$

Equation 5-4

6.7 Acetone Wash Blank.

$$W_a = C_a V_{aw} \rho_a$$

Equation 5-5

6.8 Total Particulate Weight. Determine the total particulate catch from the sum of the weights obtained from containers 1 and 2 less the acetone blank (see Figure 5-3). NOTE.—Refer to Section 4.1.5 to assist in calculation of results involving two or more filter assemblies or two or more sampling trains.

6.9 Particulate Concentration.

$$c_s = (0.001\ g/mg)\,(m_n/V_m\,(\text{std}))$$

Equation 5-6

6.10 Conversion Factors:

From	To	Multiply by
scf	m^3	0.02832
g/ft^3	gr/ft^3	15.43
g/ft^3	lb/ft^3	2.205×10^{-3}
g/ft^3	g/m^3	35.31

6.11 Isokinetic Variation.

6.11.1 Calculation From Raw Data.

Use Citation 4 to make judgments. Otherwise, reject the results and repeat the test.

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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. The sulfuric acid mist (including sulfur trioxide) and the sulfur dioxide are separated. 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. The minimum detectable limit of the method has been determined to be 3.4 milligrams (mg) of SO_3/m^3 (2.12×10^{-7} lb/ft^3). Although no upper limit has been established, tests have shown that concentrations as high as 80,000 mg/m^3 of SO_2 can be collected efficiently in two midget impingers, each containing 15 milliliters of 3 percent hydrogen peroxide, at a rate of 1.0 lpm for 20 minutes. Based on theoretical calculations, the upper concentration limit in a 20-liter sample is about 93,300 mg/m3.

Possible interferents are free ammonia, water-soluble cations, and fluorides. The cations and fluorides are removed by glass wool filters and an isopropanol bubbler, and hence do not affect the SO_3 analysis. When samples are being taken from a gas stream with high concentrations of very fine metallic fumes (such as in inlets to control devices), a high-efficiency glass fiber filter must be used in place of the glass wool plug (i.e., the one in the probe) to remove the cation interferents.

Free ammonia interferes by reacting with SO_2 to form particulate sulfite and by reacting with the indicator. If free ammonia is present (this can be determined by knowledge of the process and noticing white particulate matter in the probe and isopropanol bubbler), alternative methods, subject to the approval of the Administrator, U.S. Environmental Agency, are required.

2. *Apparatus*

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APPENDIX THREE

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