Background Report Reference

AP-42 Section Number: 12.15

Background Chapter: 4

Reference Number: 13

Title: Source Sampling Report for Johnson Controls, Inc., Louisville, Kentucky, Automatic Post Burner Lines 1 and 2

Environmental Testing, Inc.

1989

environmental testing inc.

(1)

SOURCE SAMPLING REPORT

FOR

JOHNSON CONTROLS, INC.

Louisville, Kentucky

Automatic Post Burner Lines 1 & 2

Reviewed by:
ENVIRONMENTAL TESTING, INC.
Charlotte, North Carolina

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December 1989

Performed by:
ENVIRONMENTAL TESTING, INC.
Charlotte, North Carolina

Richard B. McCain, III
December 1989

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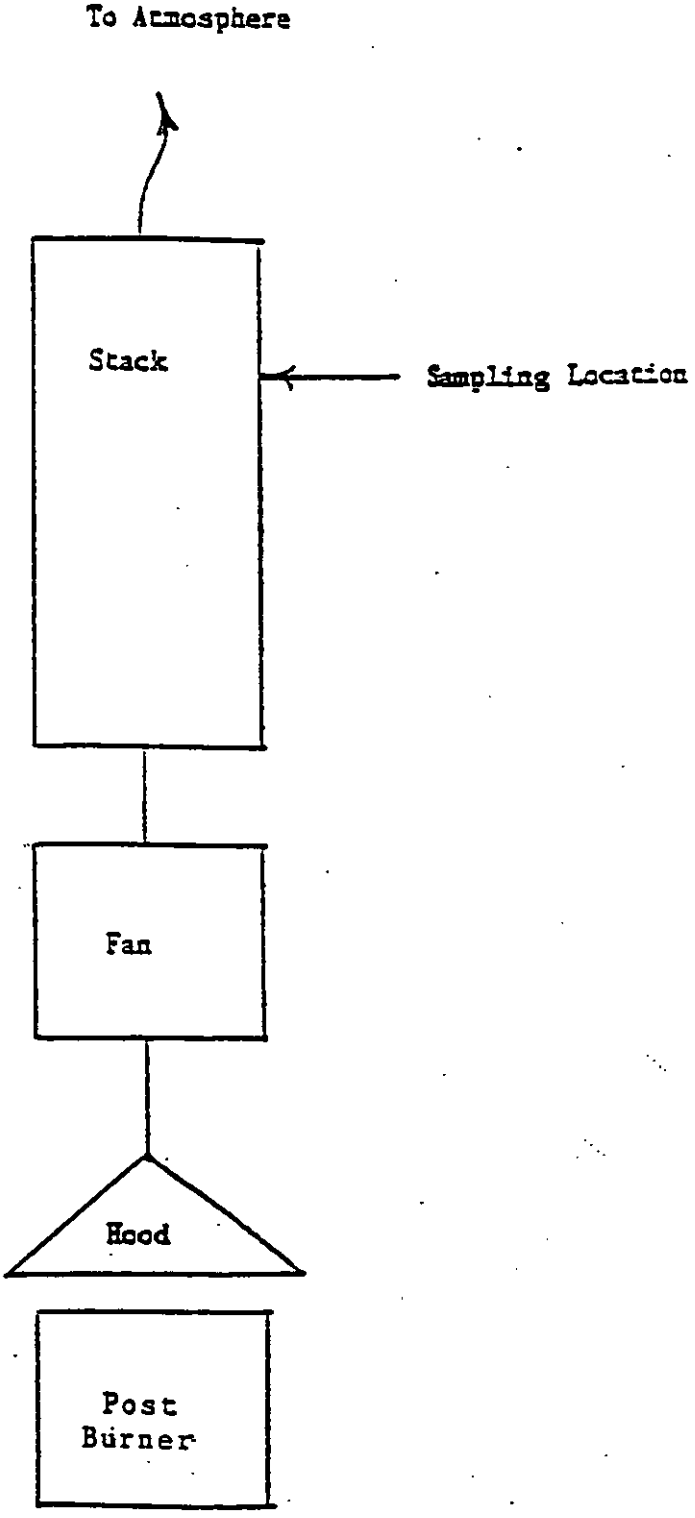
INTRODUCTION

Source sampling was performed at the Johnson Controls, Inc., Louisville, Kentucky, plant to determine lead emissions from Automatic Post Burner Lines 1 and 2 stack. Three one-hour sampling runs were made on December 12, 1989. A typical sampling location is shown in Figure 1.

The measurements of stack gas flow rate and pollutant concentrations were made according to U.S. Environmental Protection Agency and the Jefferson County Air Pollution Control District recommendations. Mr. Paul Costagno, a representative from the Jefferson County Air Pollution Control District, was present to observe the test proceedings.

The following sections of the report detail the summary of results, the process and its operation, the location of the sampling points and the sampling and analytical procedures used.

Automatic Post Burner Lines 1 & 2



FLOW DIAGRAM

Figure 1

SUMMARY OF RESULTS

Table Number 1 presents the summary of results from the lead sampling. The mean lead concentration from Automatic Post Burner Lines 1 and 2 stack was 0.646 x 10^{-5} grains per dry standard cubic foot. The mean lead emission rate was 0.000003 pounds per hour.

Based on the results of the Method 12 sampling the Johnson Controls, Inc., Louisville, Kentucky plant was in compliance with the allowable emission rate for Automatic Post Burner Lines 1 and 2 stack which had an allowable emission rate of 0.00044 grains per dry standard cubic foot based on the regulations in 40CFR60, Subpart KK, "Standards of Performance for Lead-Acid Battery Manufacturing Plants," Section 60.372, Paragraph (a)(6).

TABLE 1

SUMMARY OF RESULTS, LEAD SAMPLING

AUTOMATIC POST BURNER LINES 1 AND 2

Run Number	1	2	3
Date	12/12/89	12/12/89	12/12/89
% Isokinetic	92.73	91.76	93.75
Volume of Gas Sampled, SCF * Dry	47.305	47.292	46.900
Stack Gas Flow Rate, SCFM * Dry	53.8	54.5	53.1
Stack Gas Flow Rate, ACFM	61.0	62.3	60.8
Lead:			
Catch, mgrams	0.0186	0.0149	0.0258
Concentration, grains/ SCF * Dry	0.00000606	0.00000485	0.00000847
Emission Rate, lbs/hr	0.00000279	0.00000227	0.00000386

*68°F, 29.92 in. Hg
**Nozzle, probe, filter, impingers

PROCESS DESCRIPTION AND OPERATION

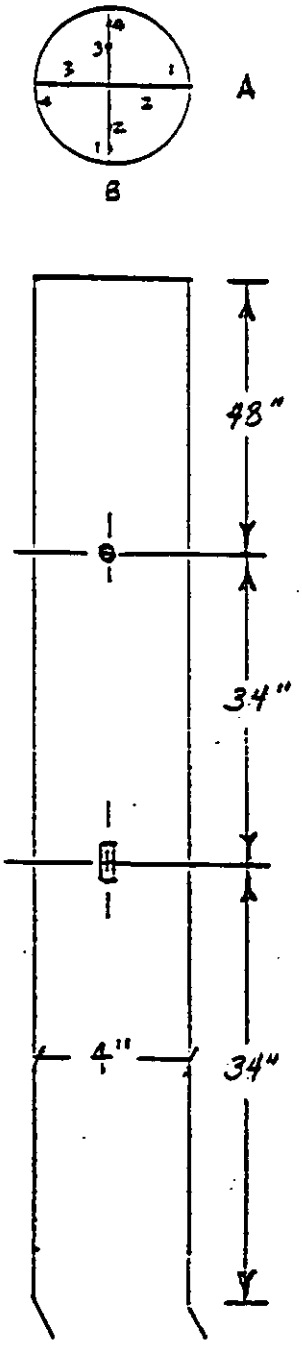
The Johnson Controls, Inc., Louisville, Kentucky, plant has an Automatic Post Burner operation that utilizes electrical current to form battery posts automatically. No new lead is introduced during this process. The emissions from Post Burner Lines 1 & 2 are exhausted through a single stack to the atmosphere.

No unusual conditions were noted during sampling. Sampling was coordinated with plant personnel to ensure a representative sample was collected. The process was operated in a normal manner.

LOCATION OF SAMPLING POINTS

The dimensions of the stack and the location of the sampling points are shown in Figure 2. The stack cross section was divided into 8 equal areas. The ports were labeled A and B. Each point was sampled for a period of 7.5 minutes per point which yielded a total test time of 60 minutes per run. The number of sampling points was determined by the distance from the last disturbance in the gas flow as outlined in Method 1, Federal Register, Volume 48, No. 191, 30 September 1983.

Automatic Post Burner Lines 1 & 2



LOCATION OF SAMPLING PORTS AND POINTS

Figure 2

SAMPLING AND ANALYTICAL PROCEDURES

All sampling and analytical procedures used were those recommended by the U.S. Environmental Protection Agency and the FDER. Complete details are found in Appendix F which is a copy of the Federal Register, Volume 42, Number 160, dated 18 August 1977, the Federal Register, Volume 48, No. 191, 30 September 1983, the Federal Register, Volume 54, No. 58, 28 March 1989 (Methods 1 - 4), 40 CFR Ch. 1, Pt. 60, Appendix A, Method 12, dated 01 July 1987 (Method 12), and the Perkin Elmer Corporation Manual (Citation 9.4). To insure the results were free of all chemical interferences the Method of Standard Additions procedure was used as the method of analysis for all samples as outlined in the Federal Register Method 12 section 5.4.2.

Sample point locations and velocity measurements were made by Methods 1 and 2. Gas composition was determined by Fyrite and Method 3 on continuous bag samples. Method 12 was used for the lead concentration determination.

APPENDICES

APPENDIX A

Summary of Results

Appendix A

Summary of Method 12 Lead Results

Johnson Controls Inc. Louisville Kentucky Automatic Post Burner Lines No. 1 and

Run Number		1	2	3
Date		12/12/89	12/12/89	12/12/89
DN	Sample nozzle dia., in.	0.504	0.503	0.502
TT	Net time of test	60	60	60
PB	Barometric pressure, in. Hg.	29.58	29.58	29.58
PM	Average orifice pressure drop, in. H2O	1.980	2.049	1.960
VM	Volume of dry gas sampled, cu. ft. at meter conditions	44.95	45.64	44.69
TM	Average gas meter temp. in degrees F.	38.25	46.13	39.63
VMSTD	Volume of dry gas sampled at standard conditions*, SCF	47.305	47.292	46.900
VW	Total water collected in impingers + silica gel, ML.	12.4	11.0	13.5
VMV	Volume of water vapor at standard conditions*, SCF	0.584	0.518	0.636
PMV	Percent moisture by volume	1.219	1.083	1.337
MD	Mole fraction dry gas	0.9878	0.9892	0.9866
PCO2	Percent CO2 by volume, dry	0.00	0.00	0.00
PO2	Percent O2 by volume, dry	20.90	20.80	20.90
PCO	Percent CO by volume, dry	0.00	0.00	0.00
PN2	Percent N2 by volume, dry	79.10	79.20	79.10
MWD	Molecular weight-dry stack gas	28.836	28.832	28.836
MW	Molecular weight-stack gas	28.704	28.715	28.691
CP	Pitot tube coefficient	0.84	0.84	0.84
DPS	Average velocity head of stack gas, inches water	0.1946	0.1979	0.1933
TS	Average stack temperature, F	124.38	129.13	129.38

PSI	Static pressure of stack gas, inches Hg.	-0.000	-0.000	-0.000
PS	Stack pressure, absolute	29.580	29.580	29.580
VS	Average stack velocity, FPM	695.5	710.2	694.2
AS	Stack area, inches sqrd.	12.6	12.6	12.6
QS	Stack flow rate, dry, standard conditions, DSCFM	53.8	54.5	53.1
QSW	Stack flow rate, wet, standard conditions, WSCFM	54.4	55.1	53.9
QA	Actual stack flow rate, ACFM	61.0	62.3	60.8
PERI	Percent isokinetic	92.73	91.76	93.75
FMF	Lead, Mg.	0.0186	0.0149	0.0258
CAN	Lead, GR/DSCF	0.606E-05	0.485E-05	0.847E-05
CAM	Lead, GR/WSCF	0.613E-05	0.491E-05	0.859E-05
CAT	Lead, GR/ACF	0.534E-05	0.425E-05	0.740E-05
CAW	Lead, LB/HR	0.279E-05	0.227E-05	0.386E-05
FNP	Net sampling points	8	8	8

*68 Degrees F. 29.92 Inches Hg.

Method 12 Lead Calculations Test Number 1

Johnson Controls Inc. Louisville Kentucky Automatic Post Burner Lines No. 1 and

Volume of Dry Gas Sampled at Standard Conditions

$$VMSTD = \frac{17.64 * VM * (PB + PM / 13.6)}{TM + 460} = 47.305$$

Volume of Water Vapor at Standard Conditions

$$VMV = 0.04709 * VW = 0.584$$

Percent Moisture in Stack Gas

$$PMV = \frac{100 * VMV}{VMSTD + VMV} = 1.219$$

Mole Fraction of Dry Gas

$$MD = \frac{100 - PMV}{100} = 0.9878$$

Average Molecular Weight of Dry Stack Gas

$$MWD = 0.44 * PCO2 + 0.32 * PO2 + 0.28 * (PN2+PCO) = 28.836$$

Molecular Weight of Stack Gas

$$MW = MWD * MD + 18 * (1-MD) = 28.704$$

Stack Gas Velocity at Stack Conditions

$$VS = 5129.4 * CP * DPS * SQRT(TS + 460)/(PS * MW) = 695.5$$

Stack Gas Volumetric Flow at Standard Conditions, Dry

$$QS = \frac{0.123 * VS * AS * PS * MD}{TS + 460} = 53.8$$

Stack Gas Volumetric Flow at Stack Conditions

$$QA = \frac{QS * (TS + 460)}{17.64 * PS * MD} = 61.0$$

Percent Isokinetic

$$PERI = \frac{1039 * (TS + 460) * VMSTD}{VS * TT * PS * MD * DN * DN} = 92.73$$

Lead Loading -- Probe, Cyclone, Filter, Impingers
(At Standard Conditions)

$$CAN = 0.0154 * FMF / VMSTD = 0.606E-05$$

Lead Loading -- Probe, Cyclone, Filter, Impingers
(At Stack Conditions)

$$CAT = \frac{17.64 * CAN * PS * MD}{TS + 460} = 0.534E-05$$

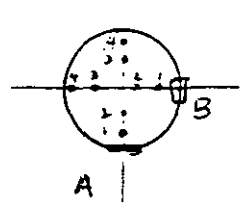
Lead Lb/Hr -- Probe, Cyclone, Filter, Impingers
(At Standard Conditions)

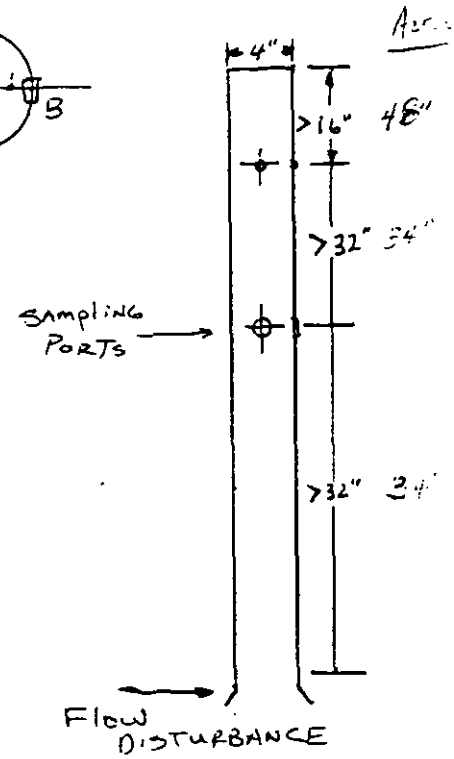
$$CAW = 0.00857 * CAN * QS = 0.279E-05$$

APPENDIX B

Field Data

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS





Plant Johnson Controls Louisville Kentucky

Date Dec 12, 1989

Sampling location Auto Post Burner #1 & 2 STACK

Inside of far wall to outside of nipple (I) 4"

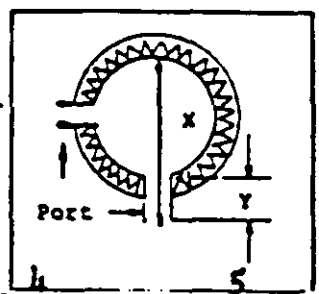
Inside of near wall to outside of nipple (nipple length) (I) 0.0

Stack I.D. (I-I) 4"

Nearest upstream disturbance >8.0 dd

Nearest downstream disturbance >8.0 dd

Calculated by JAB



SCHEMATIC OF SAMPLING LOCATION

1	2	3	4	5
TRAVERSE POINT NUMBER	FRACTION OF STACK I.D.	STACK I.D.	PRODUCT OF COLUMNS 2 AND 3 (TO NEAREST 1/8 INCH)	NIPPLE LENGTH	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5)
1	0.067	4"	0.268 → asec	0	0.500
2	0.250	↓	1.000	↓	1.000
3	0.750	↓	3.000	↓	3.000
4	0.933	↓	3.732 → 3.5cc	↓	3.500

METHOD 2 GAS VELOCITY AND CYCLONIC FLOW DETERMINATION

Plant and City Johnson Controls Inc Louisville KY Run Date 12/12/89

Sampling Location Automatic Post Burner lines 1+2 Stack Clock Time 0915

Run Number 1 Operator JAB/RBM Amb. Temp., °F 25

Bar. Press., in. Hg 29.58 Static Press., in. H_2O -0.005

Stack Press., in. Hg 29.5796 Static Press., in. Hg -0.0004

Stack Dimension, in. - Diam. or side 1 4" side 2 —

Pitot Tube (C_p) 0.99 Pitot Tube Leak Check <0.1 @ 4.1 in. H_2O

Field data

Traverse point number	Position, in.	Velocity head (Δp_s), in. H_2O		Stack temp., °F		Cyclonic flow determination: Δp_s at 0° reference		Cyclonic flow determination: Angle (α) which yields a null Δp	
		A	B	A	B	A	B	A	B
1	0.500	0.020	0.030	125	125	0.0	0.0	0	0
2	1.000	0.025	0.035	125	125	0.0	0.0	0	0
3	3.000	0.030	0.045	125	125	0.0	0.0	0	0
4	3.500	0.028	0.050	125	125	0.0	0.0	0	0

Average angle (α)[a] 0

[a] Average of (α) must be < 10 degrees to be acceptable. ✓

NOMAGRAPH DATA

1401

$\Delta H_@$ 1.86 T_m 60 %M 2% P_s/P_m 0.999 C 1.08 D_b 125

0.99 $\overline{\Delta p}$ 0.033 T_s 125 DN_c 0.490 DN_a 0.504 Ref. Δp 0.035 W_b 63

0.84 0.039 0.503 D/ 62

0.502

METHOD 12 LEAD FIELD DATA

Plant JOHNSONControls Inc Louisville Kentucky
Run No. 1
Location Auto Post Burner #1&2
Date 12-12-99
Operator TAB/BAM
Sample Box No. 1
Meter Box No. 1401
Filter No. M12-1
Probe No. 3
Pilot Tube Cp 0.99 / 0.84

Very Important — Fill In All Blanks
Leak Checks: Beg. @ 15" 0.006
End @ 6" 0.002
Pilot Tube: Pitot @ 4.2 "H2O
Pitot @ 3.9 "H2O
Static Pressure: -0.005 "H2O
Start: 10:56
Finish: 12:15
Observer Paul Cartwright Agency ARCO

Bar. Press. "Hg 29.58
Meter Box ΔH@ 1.66 Y = 1.00
Assumed Tm, °F 60
Dry Bulb, °F 125
Wet Bulb, °F 63
Db - Wb, °F 62
Assumed Moisture % 2%
Ps/Pm 0.999
C Factor 1.03

Ambient Temp., °F 78
Heater Box Setting, °F 250
Probe Tip Dia., in. 0.504
Probe Length 3' GLASS LINED
Probe Heater Setting 85%
Average Δp 0.039 Δp 0.035
Average ΔH 2.03 ΔH Rel
Process Weight NA
Steam Load NA
Steam Pressure NA

0.99 0.84

Point	Clock Time	Dry Gas Meter, Cu Ft	Pitot Manometer (Δp) in H_2O	Pitot Manometer (Δp) in H_2O	Orifice Manometer (ΔH) in H_2O Desired	Orifice Manometer (ΔH) in H_2O Actual	Dry Gas Temp °F Inlet	Dry Gas Temp °F Outlet	Pump Vacuum in Hg Gauge	Box Temp. °F	Impinger Temp °F	Stack Temp. °F	% CO_2	% O_2
A1	0	528.90	0.020	0.024	1.20	1.28	32	29	3.5	260	34	129		
2	7½	533.53	0.025	0.029	1.32	1.32	40	29	3.6	265	34	124		
3	15	538.16	0.030	0.035	1.65	1.65	44	31	4.3	265	34	125		
4	22½	543.50	0.032	0.033	1.70	1.70	49	32	4.2	259	36	121		
B1	30	548.86	0.030	0.035	1.85	1.85	42	32	4.3	245	35	123		
2	7½	554.45	0.035	0.041	2.12	2.12	48	34	4.6	244	35	125		
3	15	560.31	0.045	0.053	2.72	2.72	52	36	4.9	250	35	123		
4	22½	566.94	0.050	0.059	3.00	3.00	45	38	6.0	250	35	125		
	30	573.85												
		44.95												

Downtime 1125 - 1204

Power Outage

METHOD 12 LEAD FIELD DATA

Plant: Johnson Controls Inc Louisville Kentucky
Run No.: 2
Location: A-16 Post Burner 1&2
Date: 12-12-06
Operator: J.W.S/J.S.M
Sample Box No.: 2
Meter Box No.: 1401
Filter No.: A12-2
Probe No.: 4
Pilot Tube Cp: 0.84 | 0.84

Very Important — Fill In All Blanks
Leak Checks: Beg. @ 15": 0.007
End @ 60": 0.004
Pilot Tube: Pre Test @ 4.7 "H2O
Leak at @ 3.9 "H2O
Static Pressure: -0.005 "H2O
Start: 12:35
Finish: 13:35
Observer: P&I Testing Agency HPCD

Bar. Press. "Hg: 29.58
Meter Box ΔH@: 1.86 Y = 1.01
Assumed Tm, °F: 120
Dry Bulb, °F: 125
Wet Bulb, °F: 63
Db - Wb, °F: 62
Assumed Moisture %: 2%
Ps/Pm: 0.999
C Factor: 1.00

Ambient Temp., °F: 30
Heater Box Setting, °F: 250
Probe Tip Dia., in.: 0.503
Probe Length: 3' Class I.Wed
Probe Heater Setting: 85%
Average Δp: 0.039 Δp: 0.345
Average ΔH: 1.05 ΔH: Rel
Process Weight: N/A
Steam Load: N/A
Steam Pressure: N

0.84 0.84

Point	Clock Time	Dry Gas Meter, Cu Ft	Pilot Manometer (Δp) in H2O	Pilot Manometer (Δp) in H2O	Orifice Manometer (ΔH) in H2O Desired	Orifice Manometer (ΔH) in H2O Actual	Dry Gas Temp °F Inlet	Dry Gas Temp °F Outlet	Pump Vacuum in Hg Gauge	Box Temp. °F	Impinger Temp. °F	Stack Temp. °F	% CO2	% O2
A-1	0	574.11	0.021	0.025	1.29	1.29	40	33	2.3	246	32	127		
2	7½	578.71	0.035	0.039	1.32	1.32	48	34	2.6	242	32	129		
3	15	583.66	0.032	0.038	2.00	2.00	54	37	3.8	250	32	130		
4	22½	589.18	0.030	0.035	1.85	1.85	56	40	4.0	246	33	131		
B-1	30	594.75	0.032	0.038	2.00	2.00	52	40	4.1	250	32	130		
2	7½	600.49	0.036	0.042	2.21	2.21	57	44	4.8	251	34	131		
3	15	606.57	0.045	0.053	2.72	2.72	58	43	5.2	251	34	128		
4	22½	612.95	0.050	0.059	3.00	3.00	59	43	6.0	250	32	127		
	30	619.75												
		45.64												

METHOD 12 LEAD FIELD DATA

Plant Johnson Controls Inc. Louisville Kentucky
Run No. 3
Location Auto Post Burner #2
Date 12-17-91
Operator JAB/ABM
Sample Box No. 3
Meter Box No. 1401
Filter No. M12-3
Probe No. 3
Pilot Tube Cp 0.84 1.03*

Very Important — Fill In All Blanks
Leak Checks: Beg. @ 15" 0.009
End @ 8" 0.004
Pilot Tube: Inlet @ 4.7 "H2O
Outlet @ 2.4 "H2O
Static Pressure 0.05 "H2O
Start: 1500
Finish: 1602
Observer Paul Gallagher Agency MACO

Bar. Press. "Hg 29.58
Meter Box ΔH@ 1.80 Y = 1.00
Assumed Tm. °F 60
Dry Bulb, °F 72
Wet Bulb, °F 62
Db - Wb, °F 62
Assumed Moisture % 2%
Ps/Pm 0.995
C Factor 1.00

Ambient Temp., °F 32
Heater Box Setting, °F 250
Probe Tip Dia., in. 0.402
Probe Length 3' GLASS LINED
Probe Heater Setting 255
Average Δp 0.034 Δp 0.035
Average ΔH 0.05 ΔH Rel
Process Weight N/A
Steam Load N/A
Steam Pressure N/A

Point	Clock Time	Dry Gas Meter, Cu Ft.	Pitot Manometer (Δp) in H_2O	Pitot Manometer (Δp) in H_2O	Orifice Manometer (ΔH) in H_2O Desired	Orifice Manometer (ΔH) in H_2O Actual	Dry Gas Temp °F Inlet	Dry Gas Temp °F Outlet	Pump Vacuum in Hg Gauge	Box Temp. °F	Impinger Temp. °F	Stack Temp. °F	% CO_2	% O_2
A 1	0	620.30	0.030	0.024	1.28	1.28	30	30	2.4	260	30	131		
2	7½	624.80	0.035	0.034	1.38	1.32	30	30	2.4	256	30	132		
3	15	629.35	0.030	0.035	1.35	1.35	37	30	4.6	259	30	130		
4	22½	634.86	0.029	0.034	1.82	1.82	50	32	4.7	259	30	131		
B 1	30	640.33	0.030	0.035	1.35	1.35	50	34	4.9	260	31	130		
2	7½	646.04	0.035	0.041	2.12	2.12	52	34	4.9	260	31	126		
3	15	651.61	0.045	0.053	2.72	2.72	54	36	5.4	263	32	129		
4	22½	658.25	0.045	0.053	2.72	2.72	60	37	5.7	262	34	126		
	30	664.99												
		44.69												

environmental testing inc.

METHOD 3 - ORSAT AND DRY MOLECULAR WEIGHT DETERMINATION

Plant Johnson Controls Inc. Louisville Kentucky Sample Location Automatic Post Burner Lines 1 + 2 Stack

Sample Type - Continuous ✓ Pump Leakfree @ 10" ? NA

Oxygen Check 20.9% ± 0.1% ✓ Fuel Type None

Orsat Leak Check @ 4 min.: Pipet Levels - Leakfree ? ✓

Buret 13.5 - 13.5 = <0.2 ml ? ✓

Run No. 1 Sample Date 12/12/89 Ambient Temp. °F 70

Sampling Time (24 - hr clock) 1036 - 1215 Analysis By RBM

Gas \ Run	1 Actual	1 Net	2 Actual	2 Net	3 Actual	3 Net	Avg. %	Mult.	Molecular Wt. Dry lb/lb mole
CO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.00	~~.44~~	0.000
O_2	20.9	20.9	20.9	20.9	20.9	20.9	20.90	.32	6.688
CO	20.9	0.0	20.9	0.0	20.9	0.0	0.00	.28	0.000
N_2	100	79.1	100	79.1	100	79.1	79.10	.28	22.148
								Total	28.836

$F_o = \frac{20.9 - \%O_2}{\%CO_2} = NA$

Run No. 2 Sample Date 12/12/89 Ambient Temp. °F 70

Sampling Time (24 - hr clock) 1225 - 1328 Analysis By RBM

Gas \ Run	1 Actual	1 Net	2 Actual	2 Net	3 Actual	3 Net	Avg. %	Mult.	Molecular Wt. Dry lb/lb mole
CO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.00	~~.44~~	0.000
O_2	20.8	20.8	20.8	20.8	20.8	20.8	20.80	.32	6.656
CO	20.8	0.0	20.8	0.0	20.8	0.0	0.00	.28	0.000
N_2	100	79.2	100	79.2	100	79.2	79.20	.28	22.176
								Total	28.832

$F_o = \frac{20.9 - \%O_2}{\%CO_2} = NA$

Run No. 3 Sample Date 12/12/89 Ambient Temp. °F 70

Sampling Time (24 - hr clock) 1500 - 1602 Analysis By RBM

Gas \ Run	1 Actual	1 Net	2 Actual	2 Net	3 Actual	3 Net	Avg. %	Mult.	Molecular Wt. Dry lb/lb mole
CO_2	0.0	0.0	0.0	0.0	0.0	0.0	0.00	~~.44~~	0.000
O_2	20.9	20.9	20.9	20.9	20.9	20.9	20.90	.32	6.688
CO	20.9	0.0	20.9	0.0	20.9	0.0	0.00	.28	0.0000
N_2	100	79.1	100	79.1	100	79.1	79.10	.28	22.148
								Total	28.836

Fuel type	F_o range
Coal:	
Anthracite and lignite	1.016–1.130
Bituminous	1.083–1.230
Wood	1.000–1.120
Wood bark	1.003–1.130

$F_o = \frac{20.9 - \%O_2}{\%CO_2} = NA$

environmental testing inc.

METHOD 12 SAMPLE RECOVERY AND INTEGRITY SHEET

Plant Johnson Controls Louisville Kentucky Recovered By JAB/RBM
Sample Location Auto Post Burn #1 Stack Recovery Date 12-12-89

Run Number	1	2	3
Sample Date	12-12-89	12-12-89	12-12-89
Sample Box Number	1	2	3
Probe Number	3	4	3

MOISTURE DETERMINATION AND SAMPLE RECOVERY - IMPINGERS

Impingers Cont. Number	M12-1	M12-2	M12-3
Description of Water	Clear	Clear	Clear
Liquid Level Marked	✓	✓	✓
Final Volume (wt.), ml	205.0	204.0	205.0
Initial Volume (wt.), ml	200.0	200.0	200.0
Net Volume (wt.), ml (g)	5.0	4.0	5.0
Silica Gel Cont. Number	M12-1	M12-2	M12-3
Silica Gel % Spent	30%	30%	30%
Final Weight, g	207.4	207.0	208.5
Initial Weight, g	200.0	200.0	200.0
Net Weight, g	7.4	7.0	8.5
Total Moisture, g	12.4	11.0	13.5

SAMPLE RECOVERY - FILTER

Filter Cont. Number	M12-1	M12-2	M12-3
Particulate Description	None Visible	None Visible	None Visible
Filter Cont. Sealed	✓	✓	✓
Probe Rinse Cont. Number	M12-1	M12-2	M12-3
Liquid Level Marked	✓	✓	✓

SAMPLE WEIGHT CALCULATION

Run #	Conc., mg/l	x	Vol., l	-	Blank, mg	=	Total mg Lead
1	0.0742	x	0.250	-	<0.010	=	0.0186
2	0.0596	x	0.250	-	<0.010	=	0.0149
3	0.1033	x	0.250	-	<0.010	=	0.0258

BLANK CALCULATIONS

Conc., mg/l	x	Volume, l	=	Total mg	
<0.050	x	0.100	=	<0.005	Filter Blank
<0.050	x	0.100	=	<0.005	Filter Blank
<0.050	x	0.100	=	<0.005	HNO_3 Blank
				<0.010	Total Blank

LABORATORY CUSTODY

Received By: JAB/RBM Date Received: 12/15/89
Stored and Locked: ✓ Remarks: NONE

APPENDIX C

Laboratory Data

METHOD 12 ATOMIC ABSORPTION

QUALITY ASSURANCE DATA

All analyses were performed by the Method of Standard Additions to ascertain that the sample matrix did not cause erroneous analytical results. The Method of Additions procedure used was that recommended by the Perkin - Elmer Corporation Manual of Analytical Methods for Atomic Absorption Spectrophotometry Section 9.4, January 1982 (Cited in the Federal Register for Method 12 Section 5.4.2). The laboratory data for all the sample runs will follow this sheet.

A spiked filter with a known amount of lead was used to determine recovery and accuracy of the analytical data. The spike was identified as ETI 1-5. ETI 1-5 was spiked with 0.1000 mg of lead. The recovery was 0.0953 mg of lead. This yielded a 95.3% recovery.

Blanks were carried throughout the analytical procedure to monitor for any possible contamination. Two filter blanks and one 0.1N HNO_3 acid blank were used for this purpose. Filter Blank A and Filter Blank B were found to contain <0.050 mg/l of lead. The 0.1N HNO_3 acid blank was also found to contain <0.050 mg/l of lead.

Element File: MSAM12PB.GEL Element: Pb
Date: 12/26/89 Time: 16:02
Data Storage File: 891226.DAT ID/Weight File: M12.A60
Technique: HGA Calibration Type: Meth. of Add.
Remark 1: Last Edited October 3, 1989

ID: Blank Seq. No.: 00001 A/S Pos.: 0 Date: 12/26/8

uL dispensed: 10 from 0, 5 from 36, 10 from 0
Replicate 1 (Peak Stored) Time: 16:04
Peak Area (A-s): 0.013 Peak Height (A): 0.029
Background Pk Area (A-s): 0.192 Background Pk Height (A): 0.080
Blank Corrected Pk Area (A-s): 0.013

uL dispensed: 10 from 0, 5 from 36, 10 from 0
Replicate 2 (Peak Stored) Time: 16:07
Peak Area (A-s): 0.012 Peak Height (A): 0.027
Background Pk Area (A-s): 0.193 Background Pk Height (A): 0.081
Blank Corrected Pk Area (A-s): 0.012

Mean Pk Area (A-s): 0.012 SD: 0.0014 RSD(%): 10.90

Auto-zero performed.

ID: HNO3 Blank Seq. No.: 00002 A/S Pos.: 3 Date: 12/26/8

uL dispensed: 10 from 0, 5 from 36, 10 from 3
Replicate 1 (Peak Stored) Time: 16:10
Peak Area (A-s): 0.020 Peak Height (A): 0.036
Background Pk Area (A-s): 0.190 Background Pk Height (A): 0.079
Blank Corrected Pk Area (A-s): 0.007

uL dispensed: 10 from 0, 5 from 36, 10 from 3
Replicate 2 (Peak Stored) Time: 16:13
Peak Area (A-s): 0.020 Peak Height (A): 0.038
Background Pk Area (A-s): 0.185 Background Pk Height (A): 0.078
Blank Corrected Pk Area (A-s): 0.008

Mean Pk Area (A-s): 0.007 SD: 0.0003 RSD(%): 4.16

ID: Addition 1 Seq. No.: 00003 A/S Pos.: 3 Date: 12/26/8

uL dispensed: 5 from 36, 10 from 1, 10 from 3
Replicate 1 (Peak Stored) Time: 16:16
Peak Area (A-s): 0.087 Peak Height (A): 0.160
Background Pk Area (A-s): 0.139 Background Pk Height (A): 0.056
Blank Corrected Pk Area (A-s): 0.075

uL dispensed: 5 from 36, 10 from 1, 10 from 3
Replicate 2 (Peak Stored) Time: 16:19
Peak Area (A-s): 0.093 Peak Height (A): 0.165
Background Pk Area (A-s): 0.143 Background Pk Height (A): 0.057
Blank Corrected Pk Area (A-s): 0.081

Mean Pk Area (A-s): 0.078 SD: 0.0042 RSD(%): 5.44

ID: Addition 2 Seq. No.: 00004 A/S Pos.: 3 Date: 12/26/8

uL dispensed: 5 from 36, 10 from 2, 10 from 3
Replicate 1 (Peak Stored) Time: 16:21
Peak Area (A-s): 0.160 Peak Height (A): 0.279
Background Pk Area (A-s): 0.152 Background Pk Height (A): 0.061
Blank Corrected Pk Area (A-s): 0.147

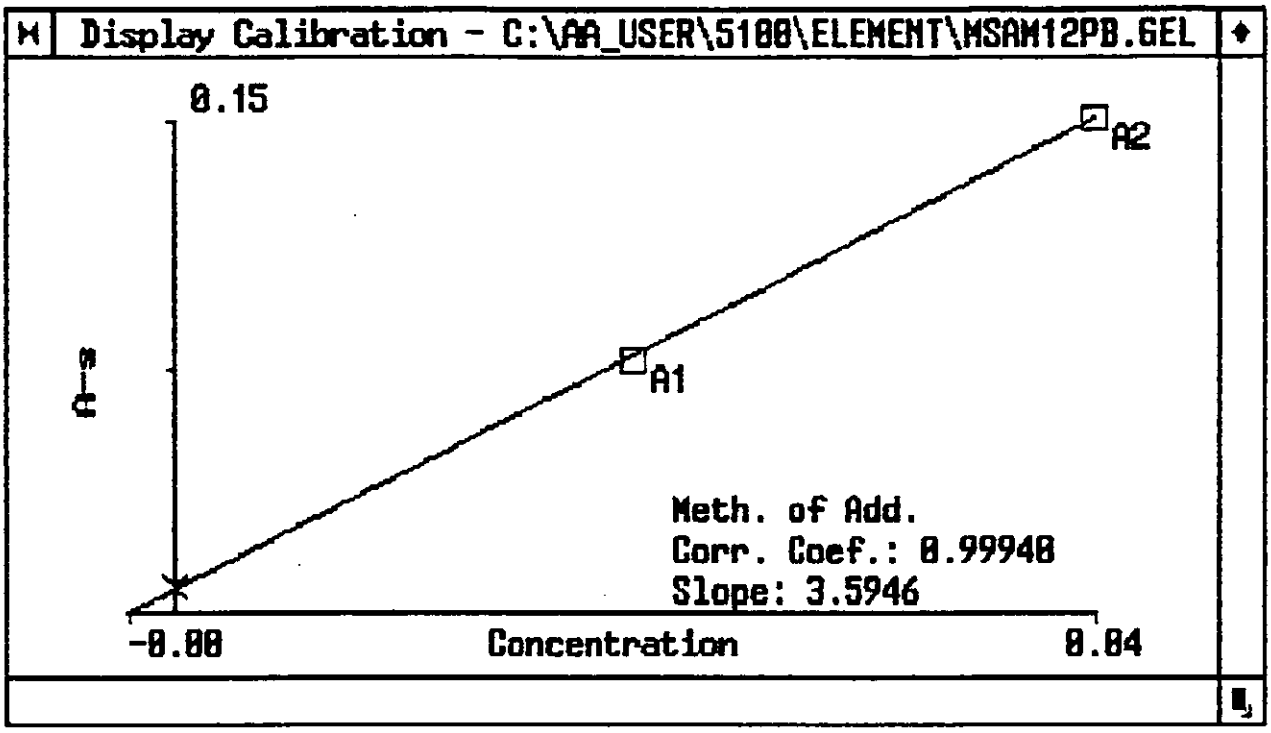
uL dispensed: 5 from 36, 10 from 2, 10 from 3
Replicate 2 (Peak Stored) Time: 16:24
Peak Area (A-s): 0.169 Peak Height (A): 0.292
Background Pk Area (A-s): 0.158 Background Pk Height (A): 0.063
Blank Corrected Pk Area (A-s): 0.156

Mean Pk Area (A-s): 0.152 SD: 0.0064 RSD(%): 4.18

ID: HNO3 Blank Seq. No.: 00002 A/S Pos.: 3 Date: 12/26/8

Concentration (mg/L): 0.0021

Correlation coefficient: 0.99940 Slope: 3.5946


Display Calibration - C:\AA_USER\5100\ELEMENT\MSAM12PB.GEL
0.15
A2
A1
Meth. of Add.
Corr. Coef.: 0.99948
Slope: 3.5946
-0.00
Concentration
0.04

~~~~~~

ID: Filter A Blank Seq. No.: 00005 A/S Pos.: 4 Date: 12/26/9

uL dispensed: 10 from 0, 5 from 36, 10 from 4
Replicate 1 (Peak Stored) Time: 16:28
Peak Area (A-s): 0.108 Peak Height (A): 0.202
Background Pk Area (A-s): 0.313 Background Pk Height (A): 0.122
Blank Corrected Pk Area (A-s): 0.095

uL dispensed: 10 from 0, 5 from 36, 10 from 4
Replicate 2 (Peak Stored) Time: 16:31
Peak Area (A-s): 0.091 Peak Height (A): 0.164
Background Pk Area (A-s): 0.322 Background Pk Height (A): 0.129
Blank Corrected Pk Area (A-s): 0.078

Mean Pk Area (A-s): 0.087 SD: 0.0121 RSD(%): 13.92

ID: Addition 1 Seq. No.: 00006 A/S Pos.: 4 Date: 12/26/9

uL dispensed: 5 from 36, 10 from 1, 10 from 4
Replicate 1 (Peak Stored) Time: 16:34
Peak Area (A-s): 0.155 Peak Height (A): 0.297
Background Pk Area (A-s): 0.256 Background Pk Height (A): 0.096
Blank Corrected Pk Area (A-s): 0.143

uL dispensed: 5 from 36, 10 from 1, 10 from 4
Replicate 2 (Peak Stored) Time: 16:37
Peak Area (A-s): 0.158 Peak Height (A): 0.302
Background Pk Area (A-s): 0.255 Background Pk Height (A): 0.096
Blank Corrected Pk Area (A-s): 0.145

Mean Pk Area (A-s): 0.144 SD: 0.0017 RSD(%): 1.20

ID: Addition 2 Seq. No.: 00007 A/S Pos.: 4 Date: 12/26/9

uL dispensed: 5 from 36, 10 from 2, 10 from 4
Replicate 1 (Peak Stored) Time: 16:40
Peak Area (A-s): 0.227 Peak Height (A): 0.418
Background Pk Area (A-s): 0.268 Background Pk Height (A): 0.120
Blank Corrected Pk Area (A-s): 0.215

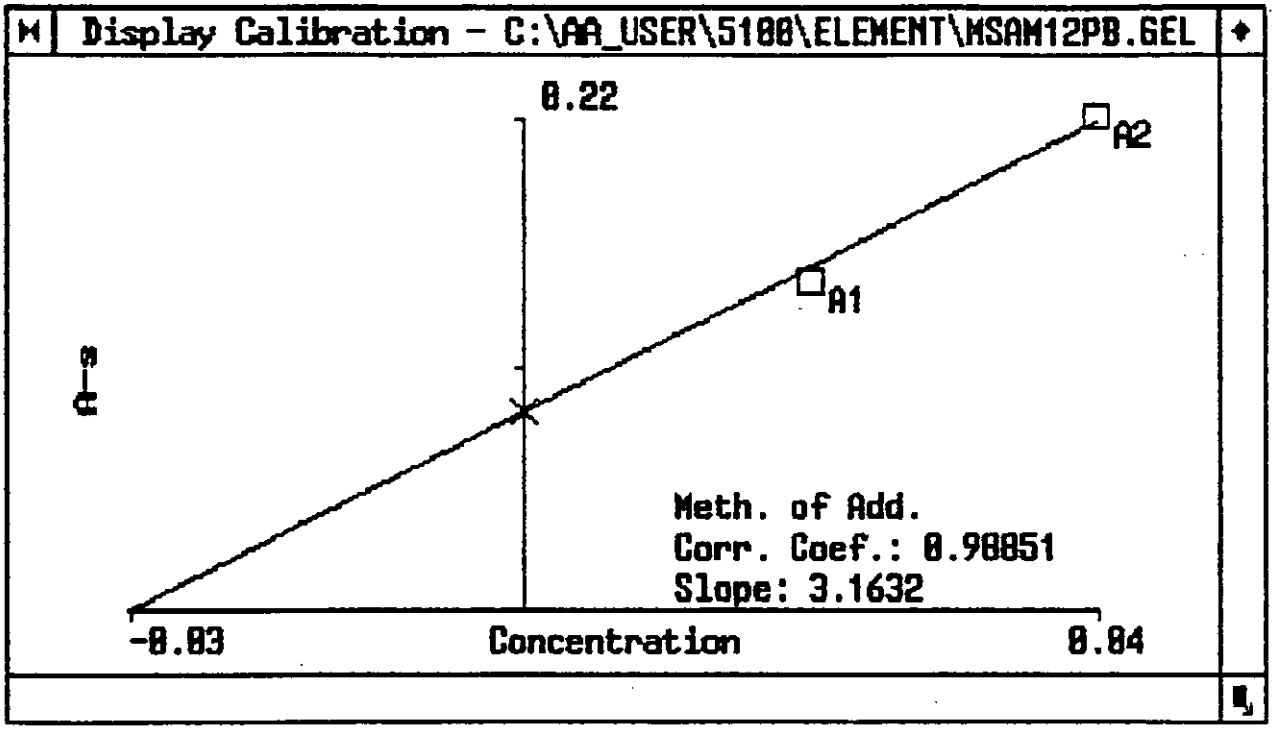
uL dispensed: 5 from 36, 10 from 2, 10 from 4
Replicate 2 (Peak Stored) Time: 16:43
Peak Area (A-s): 0.230 Peak Height (A): 0.429
Background Pk Area (A-s): 0.269 Background Pk Height (A): 0.121
Blank Corrected Pk Area (A-s): 0.217

Mean Pk Area (A-s): 0.216 SD: 0.0017 RSD(%): 0.81

ID: Filter A Blank Seq. No.: 00005 A/S Pos.: 4 Date: 12/26/9

Concentration (mg/L): 0.0275

Correlation coefficient: 0.98851 Slope: 3.1632
~~~~~~


Display Calibration - C:\AA_USER\5100\ELEMENT\MSAM12PB.GEL
0.22
A2
A1
Abs
Meth. of Add.
Corr. Coef.: 0.98851
Slope: 3.1632
-0.03
Concentration
0.04

~~~~~~

ID: Filter B Blank   Seq. No.: 00008   A/S Pos.: 5   Date: 12/26/8

uL dispensed: 10 from 0, 5 from 36, 10 from 5
Replicate 1 (Peak Stored)   Time: 16:47
Peak Area (A-s): 0.051   Peak Height (A): 0.103
Background Pk Area (A-s): 0.297   Background Pk Height (A): 0.121
Blank Corrected Pk Area (A-s): 0.038

uL dispensed: 10 from 0, 5 from 36, 10 from 5
Replicate 2 (Peak Stored)   Time: 16:49
Peak Area (A-s): 0.035   Peak Height (A): 0.070
Background Pk Area (A-s): 0.292   Background Pk Height (A): 0.120
Blank Corrected Pk Area (A-s): 0.022

Mean Pk Area (A-s):   0.030   SD: 0.0113   RSD(%): 37.19

ID: Addition 1   Seq. No.: 00009   A/S Pos.: 5   Date: 12/26/8

uL dispensed: 5 from 36, 10 from 1, 10 from 5
Replicate 1 (Peak Stored)   Time: 16:52
Peak Area (A-s): 0.104   Peak Height (A): 0.209
Background Pk Area (A-s): 0.236   Background Pk Height (A): 0.092
Blank Corrected Pk Area (A-s): 0.092

uL dispensed: 5 from 36, 10 from 1, 10 from 5
Replicate 2 (Peak Stored)   Time: 16:55
Peak Area (A-s): 0.108   Peak Height (A): 0.217
Background Pk Area (A-s): 0.235   Background Pk Height (A): 0.095
Blank Corrected Pk Area (A-s): 0.096

Mean Pk Area (A-s):   0.094   SD: 0.0030   RSD(%): 3.16

ID: Addition 2   Seq. No.: 00010   A/S Pos.: 5   Date: 12/26/8

uL dispensed: 5 from 36, 10 from 2, 10 from 5
Replicate 1 (Peak Stored)   Time: 16:58
Peak Area (A-s): 0.180   Peak Height (A): 0.357
Background Pk Area (A-s): 0.248   Background Pk Height (A): 0.105
Blank Corrected Pk Area (A-s): 0.168

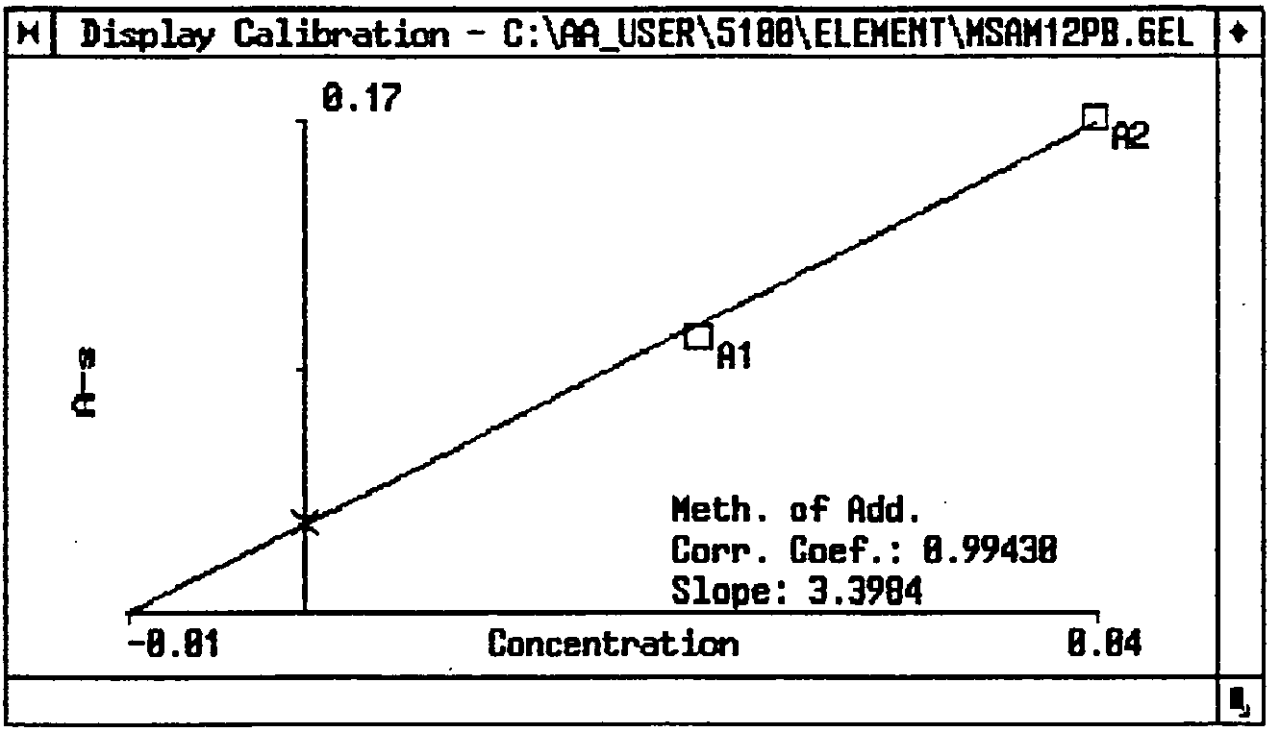
uL dispensed: 5 from 36, 10 from 2, 10 from 5
Replicate 2 (Peak Stored)   Time: 17:01
Peak Area (A-s): 0.181   Peak Height (A): 0.360
Background Pk Area (A-s): 0.249   Background Pk Height (A): 0.109
Blank Corrected Pk Area (A-s): 0.169

Mean Pk Area (A-s):   0.168   SD: 0.0007   RSD(%): 0.43

ID: Filter B Blank   Seq. No.: 00008   A/S Pos.: 5   Date: 12/26/89

Concentration (mg/L):   0.0089

Correlation coefficient: 0.99430   Slope: 3.3984
~~~~~~


Display Calibration - C:\AA_USER\5100\ELEMENT\MSAM12PB.GEL
0.17
A2
A1
Abs
Meth. of Add.
Corr. Coef.: 0.99438
Slope: 3.3984
-0.01
Concentration
0.04

~~~~~~

ID: Sample 1 Seq. No.: 00011 A/S Pos.: 6 Date: 12/26/8

uL dispensed: 10 from 0, 5 from 36, 10 from 6
Replicate 1 (Peak Stored) Time: 17:05
Peak Area (A-s): 0.234 Peak Height (A): 0.473
Background Pk Area (A-s): 0.270 Background Pk Height (A): 0.114
Blank Corrected Pk Area (A-s): 0.221

uL dispensed: 10 from 0, 5 from 36, 10 from 6
Replicate 2 (Peak Stored) Time: 17:08
Peak Area (A-s): 0.220 Peak Height (A): 0.435
Background Pk Area (A-s): 0.268 Background Pk Height (A): 0.112
Blank Corrected Pk Area (A-s): 0.208

Mean Pk Area (A-s): 0.214 SD: 0.0097 RSD(%): 4.54

ID: Addition 1 Seq. No.: 00012 A/S Pos.: 6 Date: 12/26/8

uL dispensed: 5 from 36, 10 from 1, 10 from 6
Replicate 1 (Peak Stored) Time: 17:11
Peak Area (A-s): 0.280 Peak Height (A): 0.514
Background Pk Area (A-s): 0.223 Background Pk Height (A): 0.123
Blank Corrected Pk Area (A-s): 0.267

uL dispensed: 5 from 36, 10 from 1, 10 from 6
Replicate 2 (Peak Stored) Time: 17:14
Peak Area (A-s): 0.281 Peak Height (A): 0.546
Background Pk Area (A-s): 0.224 Background Pk Height (A): 0.133
Blank Corrected Pk Area (A-s): 0.269

Mean Pk Area (A-s): 0.268 SD: 0.0013 RSD(%): 0.47

ID: Addition 2 Seq. No.: 00013 A/S Pos.: 6 Date: 12/26/8

uL dispensed: 5 from 36, 10 from 2, 10 from 6
Replicate 1 (Peak Stored) Time: 17:17
Peak Area (A-s): 0.342 Peak Height (A): 0.662
Background Pk Area (A-s): 0.233 Background Pk Height (A): 0.168
Blank Corrected Pk Area (A-s): 0.330

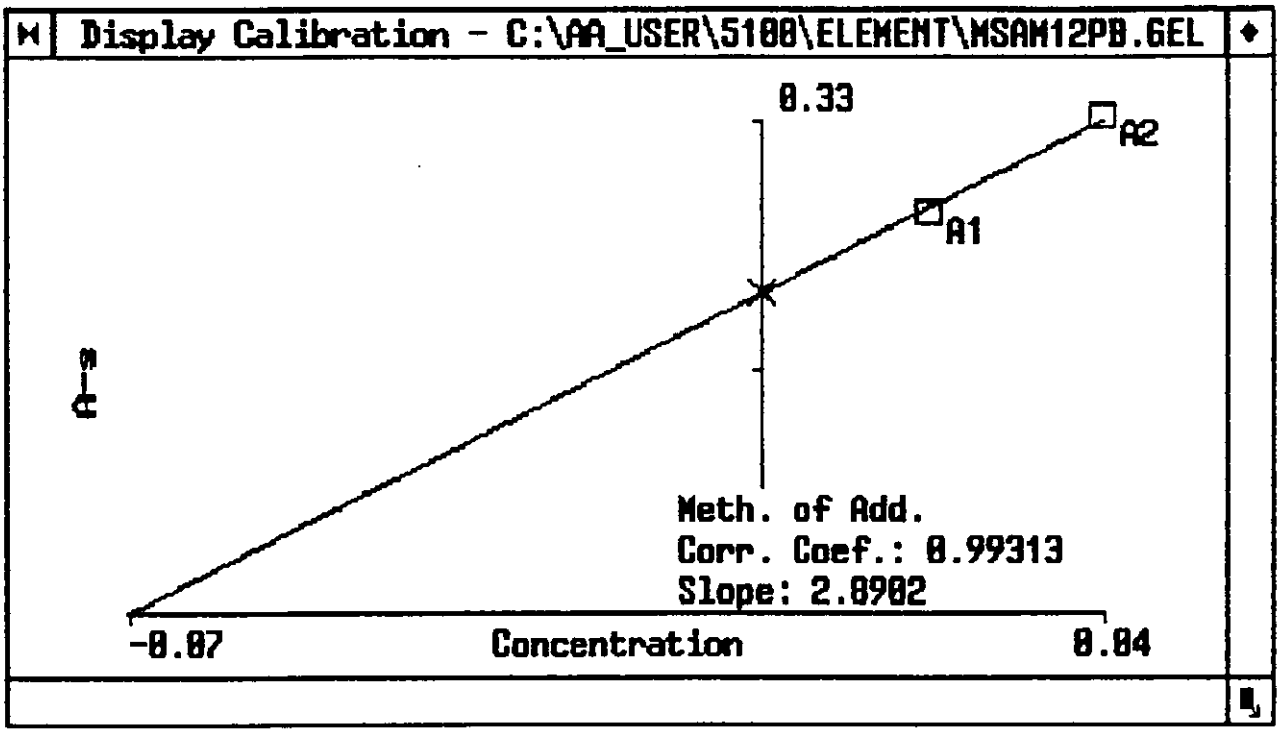
uL dispensed: 5 from 36, 10 from 2, 10 from 6
Replicate 2 (Peak Stored) Time: 17:20
Peak Area (A-s): 0.347 Peak Height (A): 0.665
Background Pk Area (A-s): 0.245 Background Pk Height (A): 0.165
Blank Corrected Pk Area (A-s): 0.334

Mean Pk Area (A-s): 0.332 SD: 0.0031 RSD(%): 0.95

ID: Sample 1 Seq. No.: 00011 A/S Pos.: 6 Date: 12/26/8

Concentration (mg/L): 0.0742

Correlation coefficient: 0.99313 Slope: 2.8902
~~~~~~


Display Calibration - C:\AA_USER\5100\ELEMENT\MSAM12PB.GEL
0.33
A2
A1
Abs
Meth. of Add.
Corr. Coef.: 0.99313
Slope: 2.8902
-0.07
Concentration
0.04

ID: Sample 2 Seq. No.: 00014 A/S Pos.: 7 Date: 12/26/8

uL dispensed: 10 from 0, 5 from 36, 10 from 7
Replicate 1 (Peak Stored) Time: 17:24
Peak Area (A-s): 0.199 Peak Height (A): 0.372
Background Pk Area (A-s): 0.272 Background Pk Height (A): 0.101
Blank Corrected Pk Area (A-s): 0.187

uL dispensed: 10 from 0, 5 from 36, 10 from 7
Replicate 2 (Peak Stored) Time: 17:27
Peak Area (A-s): 0.186 Peak Height (A): 0.375
Background Pk Area (A-s): 0.273 Background Pk Height (A): 0.102
Blank Corrected Pk Area (A-s): 0.174

Mean Pk Area (A-s): 0.180 SD: 0.0094 RSD(%): 5.20

ID: Addition 1 Seq. No.: 00015 A/S Pos.: 7 Date: 12/26/8

uL dispensed: 5 from 36, 10 from 1, 10 from 7
Replicate 1 (Peak Stored) Time: 17:30
Peak Area (A-s): 0.249 Peak Height (A): 0.486
Background Pk Area (A-s): 0.222 Background Pk Height (A): 0.118
Blank Corrected Pk Area (A-s): 0.236

uL dispensed: 5 from 36, 10 from 1, 10 from 7
Replicate 2 (Peak Stored) Time: 17:33
Peak Area (A-s): 0.252 Peak Height (A): 0.463
Background Pk Area (A-s): 0.225 Background Pk Height (A): 0.114
Blank Corrected Pk Area (A-s): 0.240

Mean Pk Area (A-s): 0.238 SD: 0.0026 RSD(%): 1.08

ID: Addition 2 Seq. No.: 00016 A/S Pos.: 7 Date: 12/26/8

uL dispensed: 5 from 36, 10 from 2, 10 from 7
Replicate 1 (Peak Stored) Time: 17:36
Peak Area (A-s): 0.312 Peak Height (A): 0.558
Background Pk Area (A-s): 0.236 Background Pk Height (A): 0.139
Blank Corrected Pk Area (A-s): 0.300

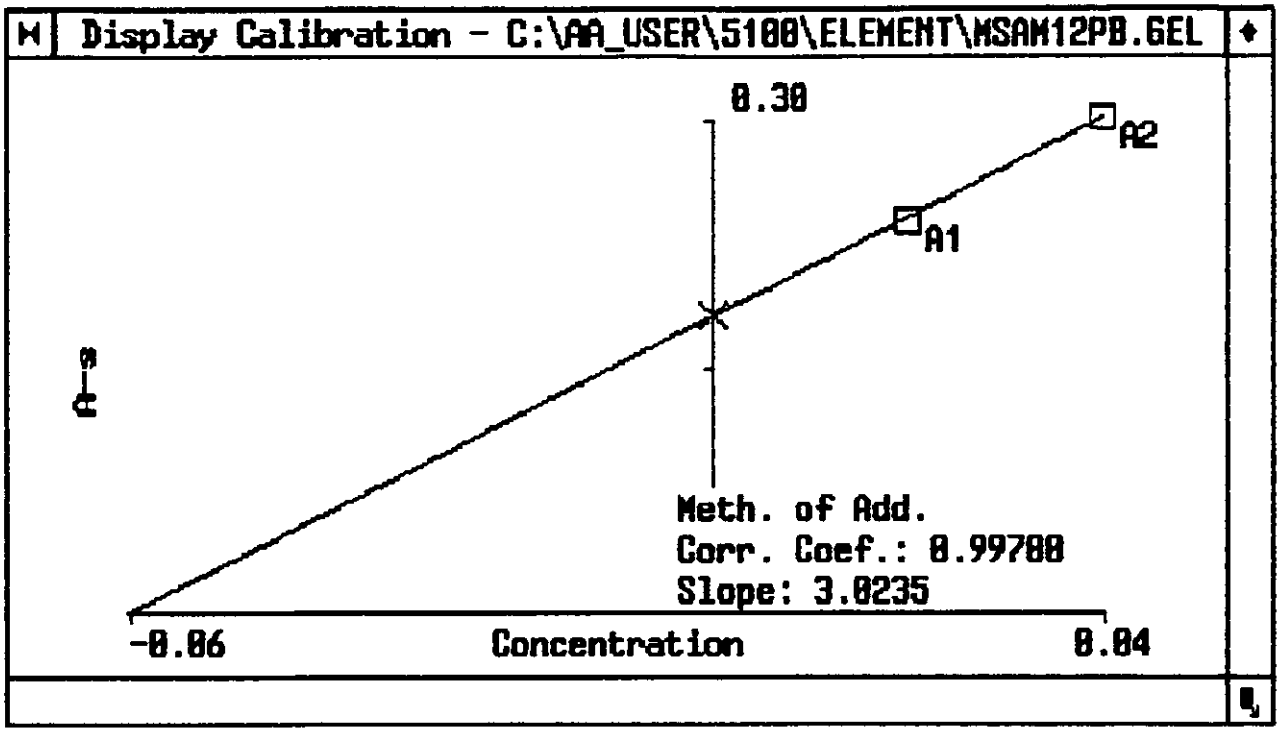
uL dispensed: 5 from 36, 10 from 2, 10 from 7
Replicate 2 (Peak Stored) Time: 17:38
Peak Area (A-s): 0.317 Peak Height (A): 0.585
Background Pk Area (A-s): 0.240 Background Pk Height (A): 0.149
Blank Corrected Pk Area (A-s): 0.305

Mean Pk Area (A-s): 0.302 SD: 0.0034 RSD(%): 1.11

ID: Sample 2 Seq. No.: 00014 A/S Pos.: 7 Date: 12/26/8

Concentration (mg/L): 0.0596

Correlation coefficient: 0.99780 Slope: 3.0235


Display Calibration - C:\AA_USER\5100\ELEMENT\MSAM12PB.GEL
0.30
A2
A1
Abs
Meth. of Add.
Corr. Coef.: 0.99788
Slope: 3.0235
-0.06
Concentration
0.04

ID: Sample 3 Seq. No.: 00017 A/S Pos.: 8 Date: 12/26/8

uL dispensed: 10 from 0, 5 from 36, 10 from 8
Replicate 1 (Peak Stored) Time: 17:42
Peak Area (A-s): 0.295 Peak Height (A): 0.583
Background Pk Area (A-s): 0.271 Background Pk Height (A): 0.148
Blank Corrected Pk Area (A-s): 0.282

uL dispensed: 10 from 0, 5 from 36, 10 from 8
Replicate 2 (Peak Stored) Time: 17:45
Peak Area (A-s): 0.290 Peak Height (A): 0.497
Background Pk Area (A-s): 0.276 Background Pk Height (A): 0.126
Blank Corrected Pk Area (A-s): 0.278

Mean Pk Area (A-s): 0.280 SD: 0.0029 RSD(%): 1.03

ID: Addition 1 Seq. No.: 00018 A/S Pos.: 8 Date: 12/26/8

uL dispensed: 5 from 36, 10 from 1, 10 from 8
Replicate 1 (Peak Stored) Time: 17:48
Peak Area (A-s): 0.340 Peak Height (A): 0.623
Background Pk Area (A-s): 0.236 Background Pk Height (A): 0.161
Blank Corrected Pk Area (A-s): 0.328

uL dispensed: 5 from 36, 10 from 1, 10 from 8
Replicate 2 (Peak Stored) Time: 17:51
Peak Area (A-s): 0.343 Peak Height (A): 0.659
Background Pk Area (A-s): 0.239 Background Pk Height (A): 0.173
Blank Corrected Pk Area (A-s): 0.330

Mean Pk Area (A-s): 0.329 SD: 0.0018 RSD(%): 0.54

ID: Addition 2 Seq. No.: 00019 A/S Pos.: 8 Date: 12/26/8

uL dispensed: 5 from 36, 10 from 2, 10 from 8
Replicate 1 (Peak Stored) Time: 17:54
Peak Area (A-s): 0.403 Peak Height (A): 0.747
Background Pk Area (A-s): 0.251 Background Pk Height (A): 0.201
Blank Corrected Pk Area (A-s): 0.391

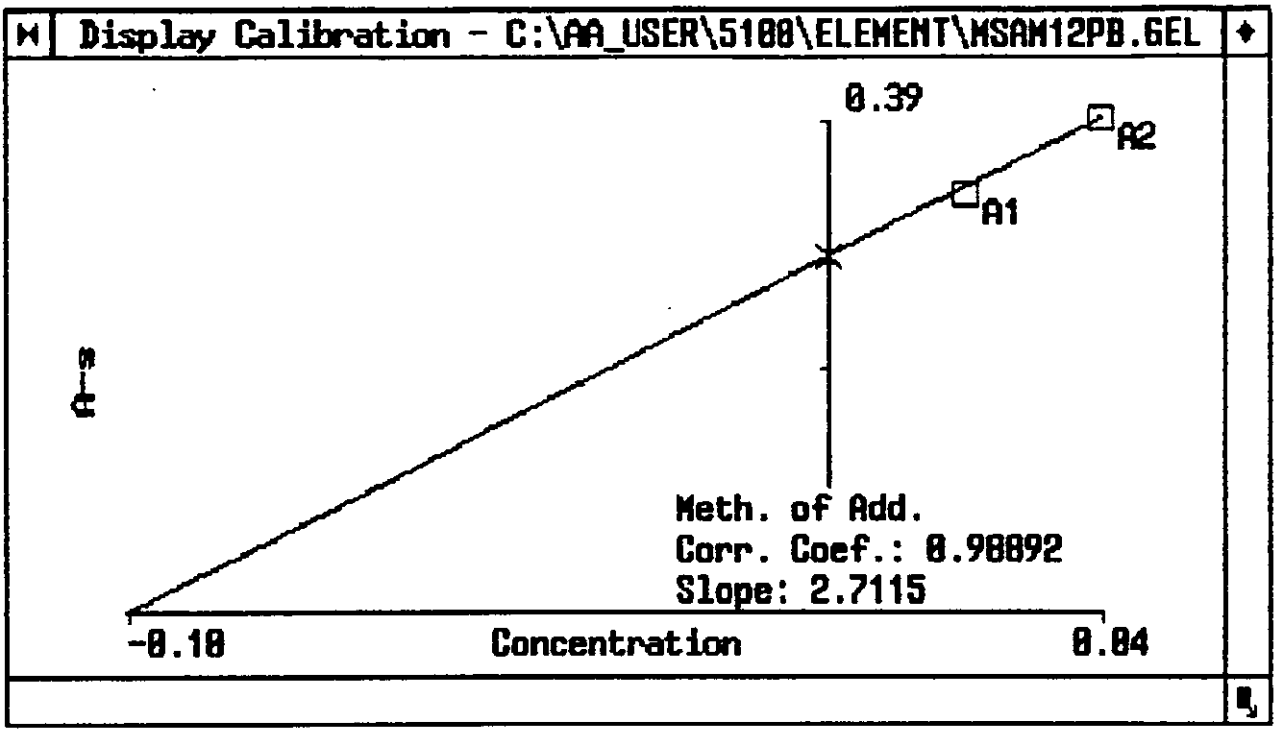
uL dispensed: 5 from 36, 10 from 2, 10 from 8
Replicate 2 (Peak Stored) Time: 17:57
Peak Area (A-s): 0.403 Peak Height (A): 0.762
Background Pk Area (A-s): 0.250 Background Pk Height (A): 0.202
Blank Corrected Pk Area (A-s): 0.391

Mean Pk Area (A-s): 0.391 SD: 0.0001 RSD(%): 0.02

ID: Sample 3 Seq. No.: 00017 A/S Pos.: 8 Date: 12/26/89

Concentration (mg/L): 0.1033

Correlation coefficient: 0.98892 Slope: 2.7115


Display Calibration - C:\AA_USER\5100\ELEMENT\MSAM12PB.GEL
0.39
A2
A1
Abs
Meth. of Add.
Corr. Coef.: 0.98892
Slope: 2.7115
-0.10
Concentration
0.04

ID: ETI 1-5 Seq. No.: 00059 A/S Pos.: 18 Date: 12/26/8

uL dispensed: 10 from 0, 5 from 36, 10 from 18
Replicate 1 (Peak Stored) Time: 20:51
Peak Area (A-s): 0.157 Peak Height (A): 0.312
Background Pk Area (A-s): 0.221 Background Pk Height (A): 0.085
Blank Corrected Pk Area (A-s): 0.145

uL dispensed: 10 from 0, 5 from 36, 10 from 18
Replicate 2 (Peak Stored) Time: 20:54
Peak Area (A-s): 0.140 Peak Height (A): 0.230
Background Pk Area (A-s): 0.247 Background Pk Height (A): 0.092
Blank Corrected Pk Area (A-s): 0.127

Mean Pk Area (A-s): 0.136 SD: 0.0125 RSD(%): 9.18

ID: Addition 1 Seq. No.: 00060 A/S Pos.: 18 Date: 12/26/8

uL dispensed: 5 from 36, 10 from 1, 10 from 18
Replicate 1 (Peak Stored) Time: 20:57
Peak Area (A-s): 0.212 Peak Height (A): 0.367
Background Pk Area (A-s): 0.216 Background Pk Height (A): 0.091
Blank Corrected Pk Area (A-s): 0.200

uL dispensed: 5 from 36, 10 from 1, 10 from 18
Replicate 2 (Peak Stored) Time: 21:00
Peak Area (A-s): 0.214 Peak Height (A): 0.376
Background Pk Area (A-s): 0.223 Background Pk Height (A): 0.090
Blank Corrected Pk Area (A-s): 0.202

Mean Pk Area (A-s): 0.201 SD: 0.0015 RSD(%): 0.73

ID: Addition 2 Seq. No.: 00061 A/S Pos.: 18 Date: 12/26/8

uL dispensed: 5 from 36, 10 from 2, 10 from 18
Replicate 1 (Peak Stored) Time: 21:03
Peak Area (A-s): 0.293 Peak Height (A): 0.492
Background Pk Area (A-s): 0.242 Background Pk Height (A): 0.120
Blank Corrected Pk Area (A-s): 0.281

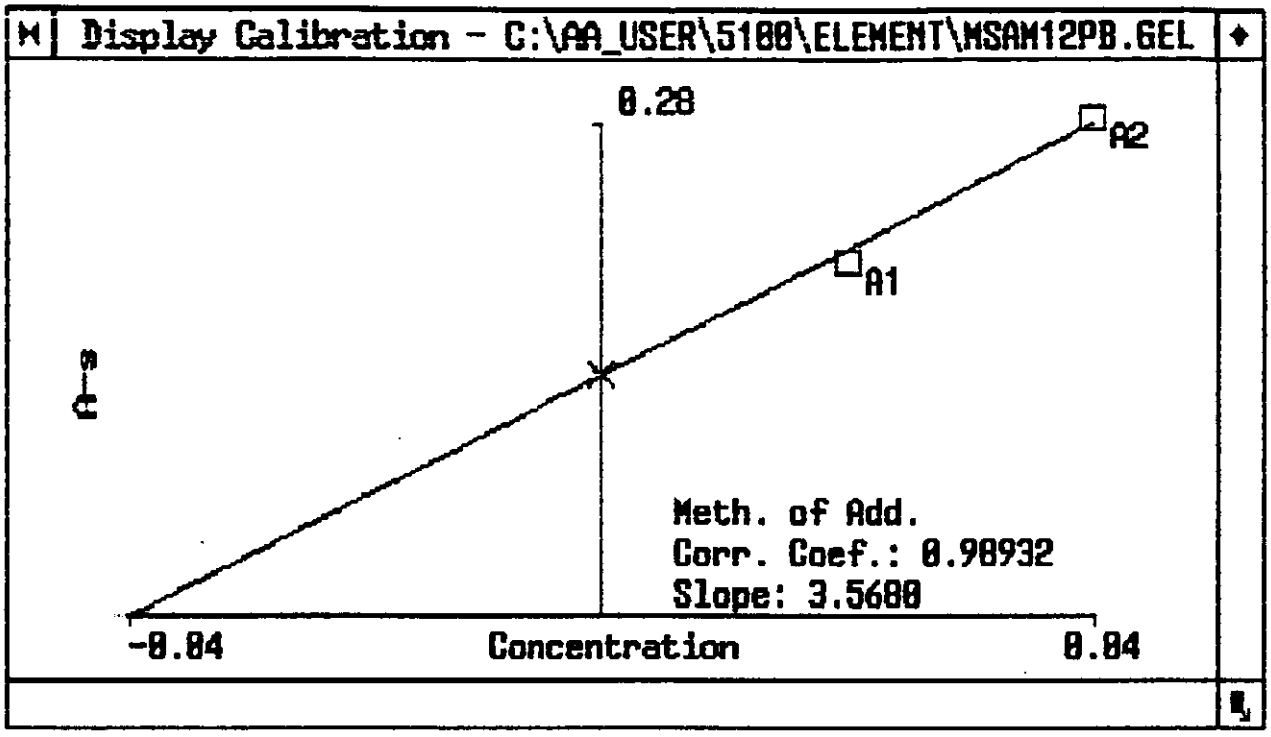
uL dispensed: 5 from 36, 10 from 2, 10 from 18
Replicate 2 (Peak Stored) Time: 21:06
Peak Area (A-s): 0.295 Peak Height (A): 0.509
Background Pk Area (A-s): 0.240 Background Pk Height (A): 0.122
Blank Corrected Pk Area (A-s): 0.282

Mean Pk Area (A-s): 0.282 SD: 0.0010 RSD(%): 0.37

ID: ETI 1-5 Seq. No.: 00059 A/S Pos.: 18 Date: 12/26/8

Concentration (mg/L): 0.0381 Corrected Conc (mg/L): 0.381

Correlation coefficient: 0.98932 Slope: 3.5680


Display Calibration - C:\AA_USER\5100\ELEMENT\MSAM12PB.GEL
0.28
A2
A1
Meth. of Add.
Corr. Coef.: 0.98932
Slope: 3.5688
-0.84
Concentration
0.84

APPENDIX D

Process Data

~~N.S.D Battal~~

Battery Mfg. Tests

12/12/89 Johnson Controls, Inc., Louisville KY
by: Environmental Testing, Inc.

REFERENCE #17

Automatic Post Burner (utilizes electrical current to form battery posts); collected by hood and exhausted to atmosphere w/ no controls

Sampling/Analytical: Methods 1-4, 12; all field data sheets and calculations included and complete.
& calibration

Results:	Run	Isokinetic	Lead, lb/HR
	1	92.73%	$.279 \times 10^{-5}$
	2	91.76%	$.227 \times 10^{-5}$
	3	93.75%	$.386 \times 10^{-5}$

avg. = 297×10^{-8}

Production Data: letter from Mark Ishihara, Env. Engineer, Johnson Controls, to Environmental Testing, Inc.: 2811 batteries produced 12/12/89

~~if~~ production steady @ 24 hrs/day, from later tests, this assumption is valid

297×10^{-8} lb/HR / [(2811 batteries/day)(÷ 24 day/hr)] = 25.4×10^{-6} lb / 1000 batteries

RATING = A

Johnson Controls, Inc.
Battery Group
5757 N. Green Bay Avenue
Post Office Box 591
Milwaukee, WI 53201-0591
Tel. 414/228 1200

JOHNSON CONTROLS

Mr. Richard B. McCain
Environmental Testing, Inc.
1700 University Commerical Place
Charlotte, NC 28213

January 5, 1990

Dear Richard:

SUBJECT: Johnson Controls, Inc. - Louisville, KY
Production Data

The production data for the stack tests is listed below.

12/11/89 - 12/13/89 Pasting

1678450 plates sent to Chemset

12/12/89 COS Lines #1 and #2 (APB)

2811 batteries

12/13/89 COS Line (RADCO) Everstart

860 batteries

Thank you for your assistance in this matter.

Sincerely,

JOHNSON CONTROLS, INC.

Mark R. Ishihara
Environmental Engineer

MRI/ajg

APPENDIX E

TEST PARTICIPANTS

Richard B. McCain, III	Source Sampling Supervisor Environmental Testing, Inc.
J. Anthony Blanton	Biologist Environmental Testing, Inc.

APPENDIX F

Sampling and Analytical Procedures

Federal Register

THURSDAY, AUGUST 18, 1977
PART II

ENVIRONMENTAL PROTECTION AGENCY

■

STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES

Revision to Reference Method 1-8

have peroxide impurities that will cause erroneously high sulfuric acid mist measurements, a test for peroxides in isopropanol has been included in the method.

4. The gravimetric technique for moisture content (rather than volumetric) has been specified because a mixture of isopropyl alcohol and water will have a volume less than the sum of the volumes of its content.

5. A closer correspondence has been made between similar parts of Methods 8 and 5.

Miscellaneous

Several commenters questioned the meaning of the term "subject to the approval of the Administrator" in relation to using alternate test methods and procedures. As defined in § 60.2 of subpart A, the "Administrator" includes any authorized representative of the Administrator of the Environmental Protection Agency. Authorized representatives are EPA officials in EPA Regional Offices or State, local, and regional governmental officials who have been delegated the responsibility of enforcing regulations under 40 CFR 60. These officials in consultation with other staff members familiar with technical aspects of source testing will render decisions regarding acceptable alternate test procedure.

In accordance with section 117 of the Act publication of these methods was preceded by consultation with appropriate advisory committees, independent experts, and Federal departments and agencies.

(Secs. 111, 114 and 301(a) of the Clean Air Act, sec. 4(a) of Pub. L. No. 91-604, 84 Stat. 1683; sec. 4(a) of Pub. L. No. 91-604, 84 Stat. 1687; sec. 2 of Pub. L. No. 90-148, 81 Stat. 504 [42 U.S.C. 1857c-6, 1857c-0, 1857g(a)].)

NOTE—The Environmental Protection Agency has determined that this document does not contain a major proposal requiring preparation of an Economic Impact Analysis under Executive Orders 11821 and 11949 and OMB Circular A-107.

Dated: August 10, 1977.

DOUGLAS M. COSTLE,
Administrator.

Part 60 of Chapter I of Title 40 of the Code of Federal Regulations is amended by revising Methods 1 through 8 of Appendix A—Reference Methods as follows:

APPENDIX A—REFERENCE METHODS

The reference methods in this appendix are referred to in § 60.8 (Performance Tests) and § 60.11 (Compliance With standards and Maintenance Requirements) of 40 CFR Part 60, Subpart A (General Provisions). Specific uses of these reference methods are described in the standards of performance contained in the subparts, beginning with subpart D.

Within each standard of performance, a section titled "Test Methods and Procedures" is provided to (1) identify the test methods applicable to the facility subject to the respective standard and (2) identify any special instructions or conditions to be followed when applying a method to the respective facility. Such instructions (for example, establish sampling rate, volumes, or temperatures) are to be used either in addition to, or as a substitute for procedures in a reference method. Similarly, for sources subject to emission monitoring requirements, specific instructions pertaining to any use of a reference method are provided in the subpart or in Appendix B.

Inclusion of methods in this appendix is not intended as an endorsement or denial of their applicability to sources that are not affected by standards of performance. The methods are commonly accepted as valid techniques; however, applicability should be confirmed by careful and appropriate evaluation of the conditions prevalent at each source.

The approach followed in the formulation of the reference methods involves specifications for equipment, procedures, and performance. In general, a performance specification approach would be preferable in all methods because this allows the greatest flexibility to the user. In practice, however, this approach is impractical in most cases because performance specifications cannot be established. Most of the methods described herein, therefore, involve specific equipment specifications and procedures and only a few methods in this appendix rely on performance criteria.

Minor changes in the reference methods should not necessarily affect the validity of the results and it is recognized that alternative and equivalent methods exist. Section 111 provides authority for the Administrator to specify or approve (1) equivalent methods, (2) alternative methods, and (3) minor changes in the methodology of the reference methods. It should be clearly understood that unless otherwise identified all such methods and changes must have prior approval of the Administrator. An owner employing such methods or deviations from the reference methods without obtaining prior approval does so at the risk of subsequent disapproval and retesting with approved methods.

Within the reference methods, certain specific equipment or procedures are recommended as being acceptable or potentially acceptable and are specifically identified in the methods. The items identified as acceptable options may be used without approval but must be identified in the test report. The potentially approvable options are cited as "subject to the approval of the Administrator" or as "or equivalent," Such potentially approvable techniques or alternatives may be used at the discretion of the owner without prior approval. However, detailed descriptions for applying these potentially approvable techniques or alternatives are not provided in the reference methods. Also, the potentially approvable options are not 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 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}) in 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:

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

Dated: September [illegible], 1983.
William D. Ruckelshaus,
Administrator.

PART 60—[AMENDED]

Appendix A of 40 CFR Part 60 is amended by revising Method 1 as follows:

1. By revising Figure 1–1 and Figure 1–2 as shown:

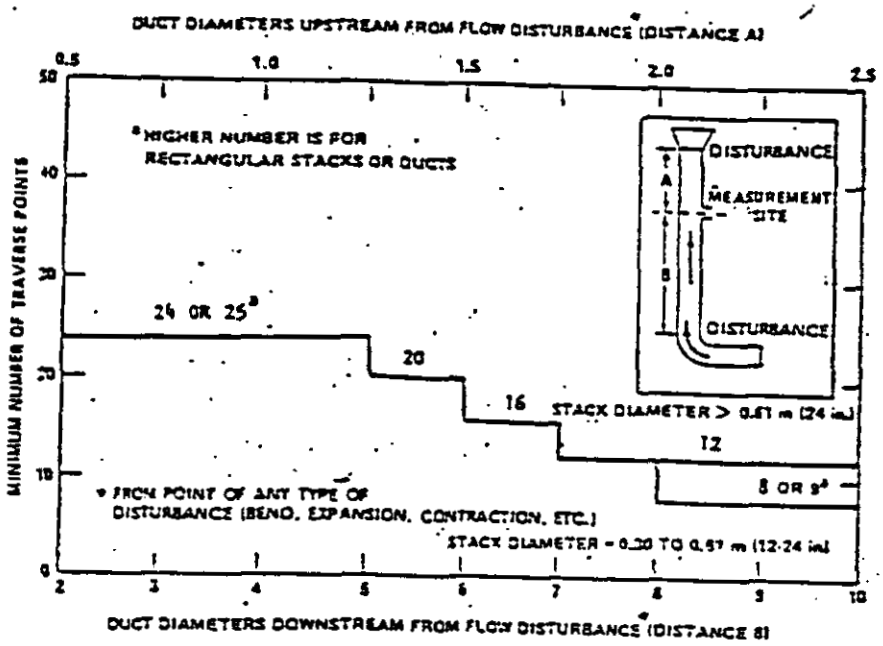


Figure 1-1. Minimum number of traverse points for particulate traverses.

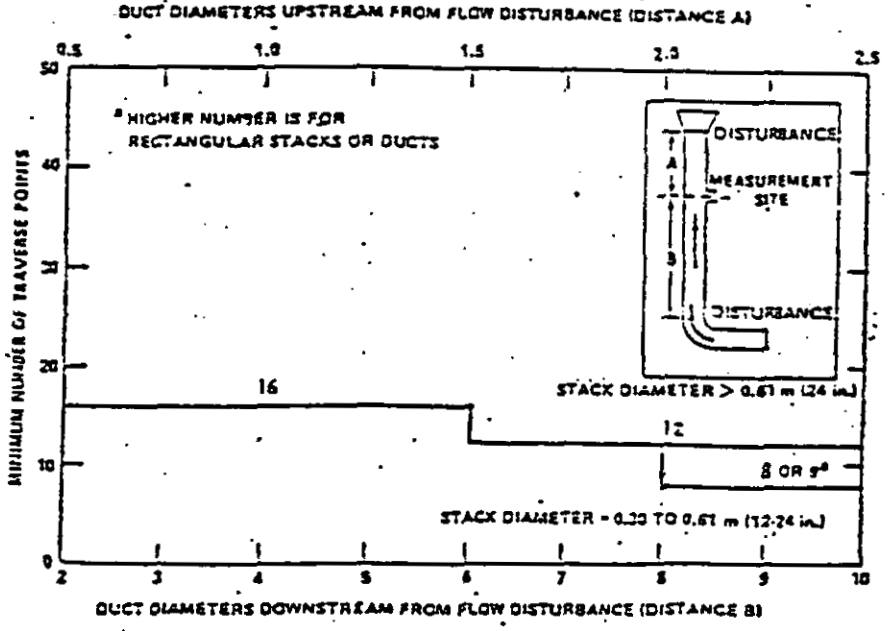


Figure 1-2. Minimum number of traverse points for velocity (nonparticulate) traverses.

2. By adding Citations 7 through 12 to Section 3 (Bibliography) as follows:

Appendix A—Reference Methods

* * * * *

Method 1. Sample and Velocity Traverses for Stationary Sources

* * * * *

3. * * *

7. Hanson, H.A., R.J. Davini, J.K. Morgan, and A.A. Iversen. Particulate Sampling Strategies for Large Power Plants Including Nonuniform Flow. U.S. Environmental Protection Agency, Research Triangle Park, N.C. Publication No. EPA-600/2-76-170. June 1976. 150 p.

8. Brooks, E.F., and R.L. Williams. Flow and Gas Sampling Manual. U.S. Environmental Protection Agency, Research Triangle Park, N.C. Publication No. EPA-600/2-76-203. July 1976. 93 p.

9. Entropy Environmentalists, Inc. Traverse Point Study. EPA Contract No. 68-02-3171. June 1977. 18 p.

10. Brown, J. and K. Yu. Test Report: Particulate Sampling Strategy in Circular Ducts. Emission Measurement Branch, Emission Standards and Engineering Division, U.S. Environmental Protection Agency, Research Triangle Park, N.C. 27711. July 31, 1980. 12 p.

11. Hawksley, P.G.W., S. Badzioch, and [illegible] Blacket. Measurement of Solids in Flue Gases. Leatherhead, England, The British Coal Utilisation Research Association, 1961. p. 129–133.

12. Knapp, K.T. The Number of Sampling Points Needed for Representative Source Sampling. In: Proceedings of the Fourth National Conference on Energy and the Environment. Theodore, L., et al. (ed.). Dayton, Dayton Section of the American Institute of Chemical Engineers, October 3–6, 1976. p. 563–568.

(Secs. 111, 114, and 301(a) of the Clean Air Act, as amended (42 U.S.C. 7411, 7414, and 7601(a)))

[FR Doc. 83-[illegible] Filed 9-[illegible]; 8:45 am]
BILLING CODE 6560-50-M

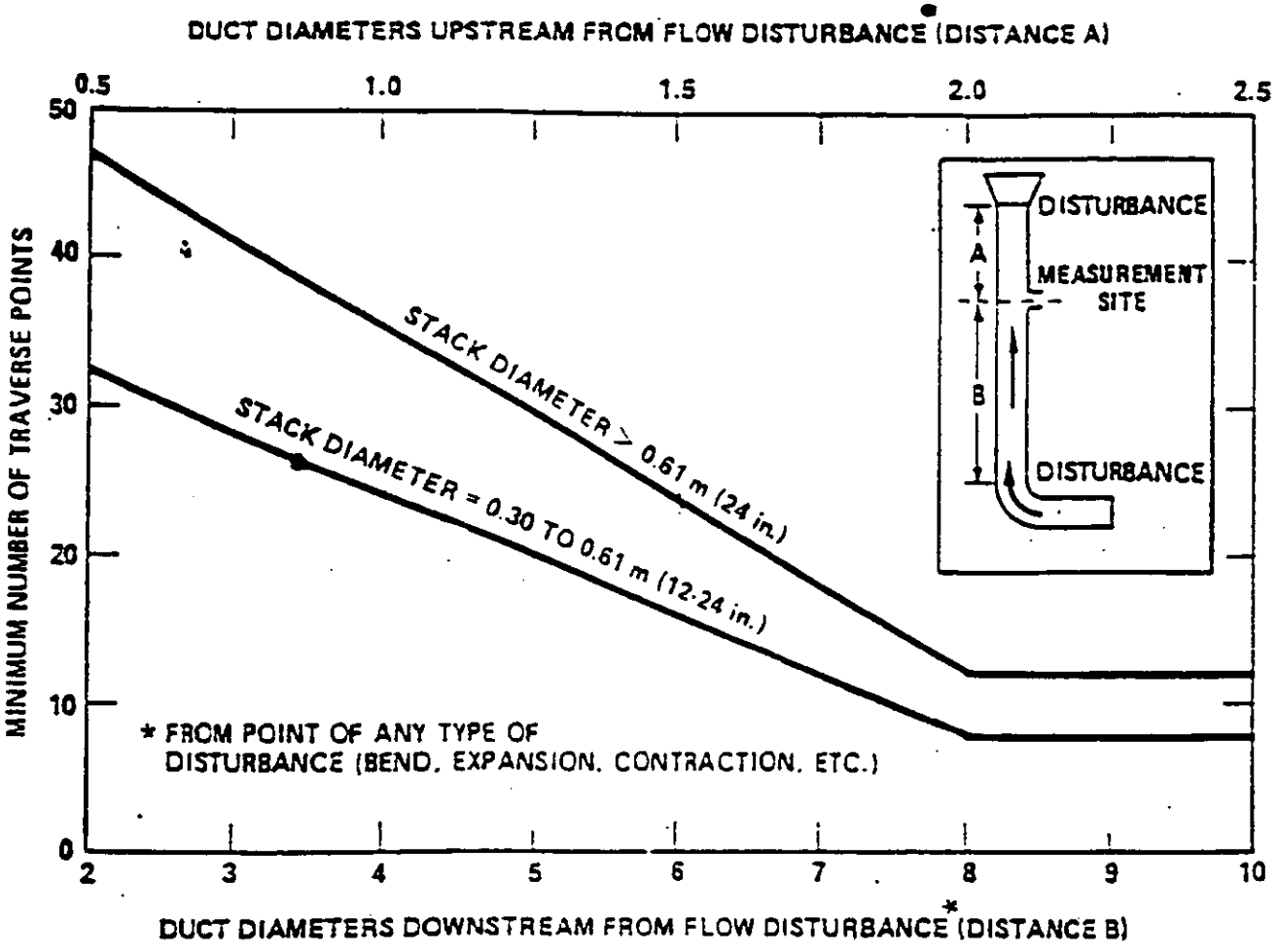


Figure 1-1. Minimum number of traverse points for particulate traverses.

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
12	3x4
16	4x4
20	4x5
25	5x5
30	6x5
36	6x6
42	7x6
49	7x7

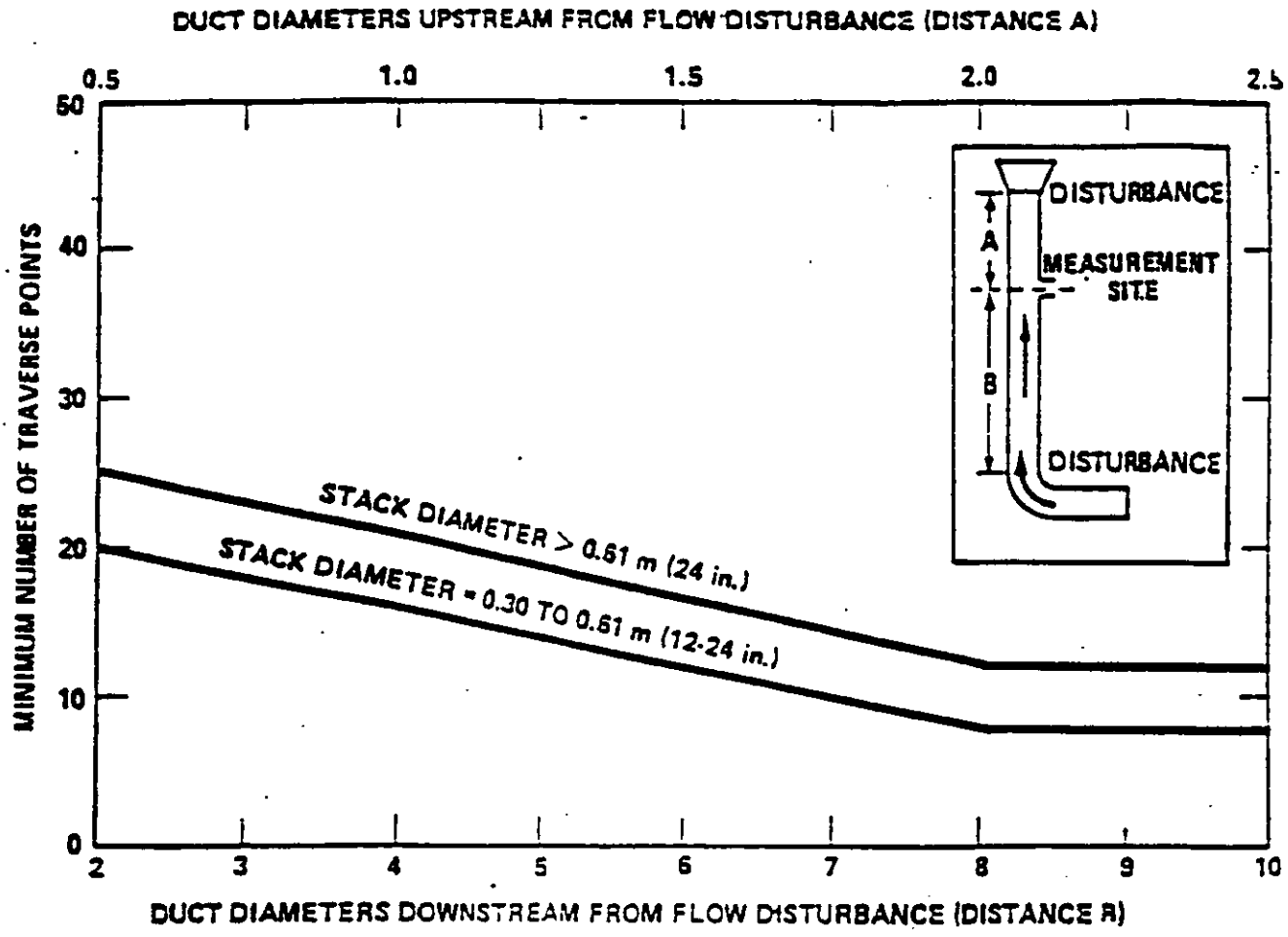


Figure 1-2. Minimum number of traverse points for velocity (nonparticulate) traverses.

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 example, 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 measurements) 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

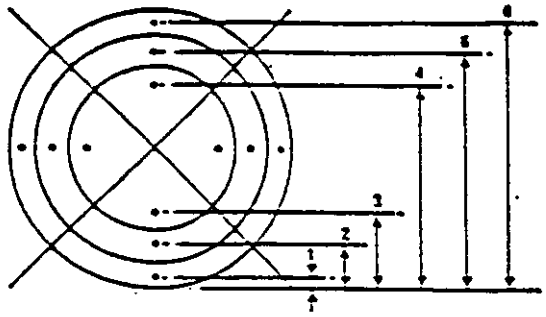


Figure 1-3. Example showing circular stack cross section divided into 12 equal areas, with location of traverse points indicated.

(3) 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.

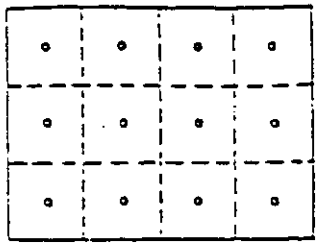


Figure 1-4. Example showing rectangular stack cross section divided into 12 equal areas, with a traverse point at centroid of each area.

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	1.5	1.4	1.3	1.1	1.1
2	85.4	25.0	14.5	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	25.9	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	21.9	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	72.3
16								98.4	92.5	87.1	82.0	77.0
17									95.6	90.3	85.4	80.6
18									98.6	93.1	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

2.1.1.2 Stacks With Diameter Equal to or Less Than 0.61 m (24 in.). Follow the procedure in Section 2.1.1.1, noting only that any "traversed" points should be relocated away from the stack walls to (1) a distance of 1.3 cm (0.50 in.), or (2) a distance equal to the nozzle inside diameter, whichever is larger.

2.1.2 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.

The distance 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.

2.1.3 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

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 or zero 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, calculate the average of the absolute values of α, except α values of 0° or those points for which rotation was required, and include these in the overall average. If the average value of α is greater than 10°, the presence of flow condition in the stack is unacceptable and alternative methodology, subject to the approval of the Administrator, must be used to perform accurate Section and velocity traverses.

3. *Bibliography.*

1. Determining Dust Concentration in a Gas Stream, ASME Performance Test Code No. 27. New York, 1957.

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

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 Strategy for Large Power Plants Including Nonuniform Flow. USEPA, ORD, ESRL, Research Triangle Park, N.C. EPA-650/2-75-170. June 1975.

6. Entropy Environmentalists, Inc. Determination of the Minimum Number of Sampling Points: An Analysis of Method 1 Criteria. Environmental Protection Agency, Research Triangle Park, N.C. EPA Contract No. 68-02-2377, 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 pitot tube.

1.2 Applicability. This method is applicable for the determination 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 flows. 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 relocate the test traverse to a new site which meets the criteria of Method 1, 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.

2.6 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, may be used.

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

2.8 Determine the cross-sectional area of the stack or duct at the sampling location. Whenever possible, physically measure the stack dimensions 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 2-6 or 2-8. The pitot tube shall not be used if it fails to meet these alignment specifications.

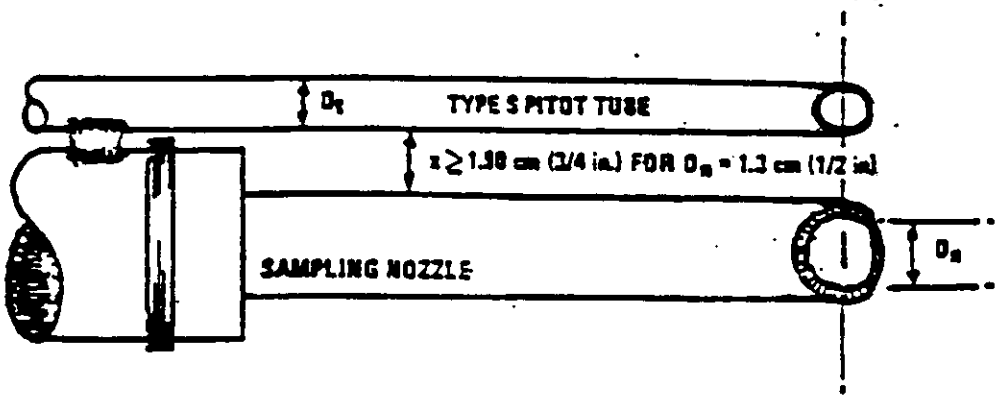
After verifying the face opening alignment, measure and record the following dimensions of the pitot tube: (a) the external tubing diameter (dimension D_t, Figure 2-6b); and (b) the base-to-opening plane distances (dimensions P_A and P_B, Figure 2-6b). If D_t is between 0.48 and 0.95 cm (3/16 and 3/8 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 4.1.3 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 4.1.3 below.

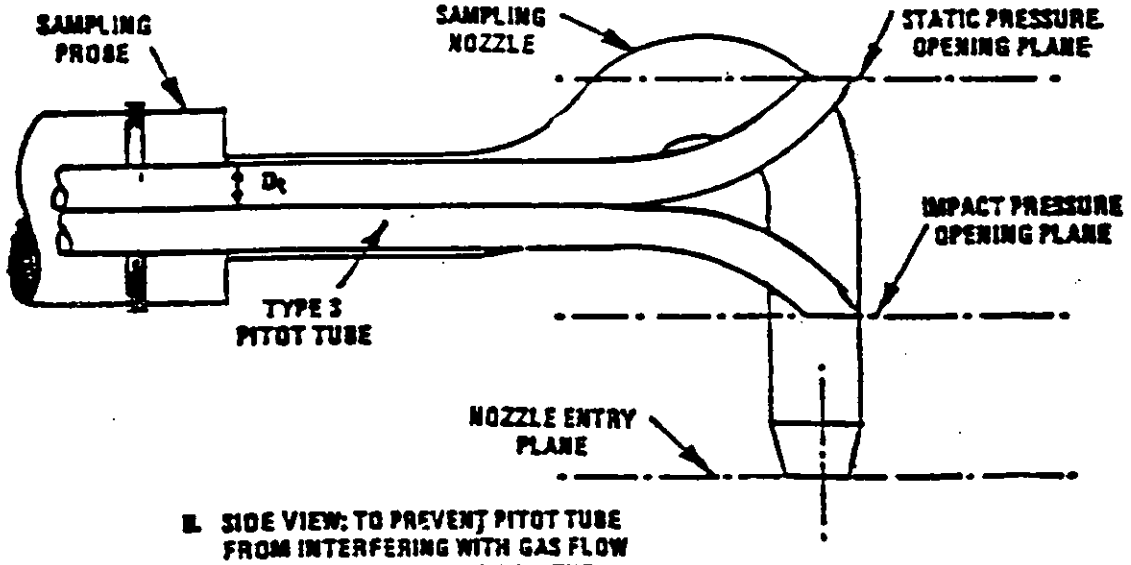
4.1.1 Type S Pitot Tube Assemblies. During sample and velocity traverses, the isolated Type S pitot tube is not always used; in many instances, the pitot tube is used in combination with other source-sampling components (thermocouple, sampling probe, nozzle) as part of an "assembly." The presence of other sampling 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 coefficient value will be altered in any case 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 arrangements for Type S pitot tube 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 4.1.3 below, and prior to calibration, the values of the interspacement spacings (pitot-nozzle, pitot-thermocouple, pitot-probe sheath) shall be measured and recorded.

Note—Do not use any Type S pitot tube assembly which necessitates 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, and the other, 1. 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.).

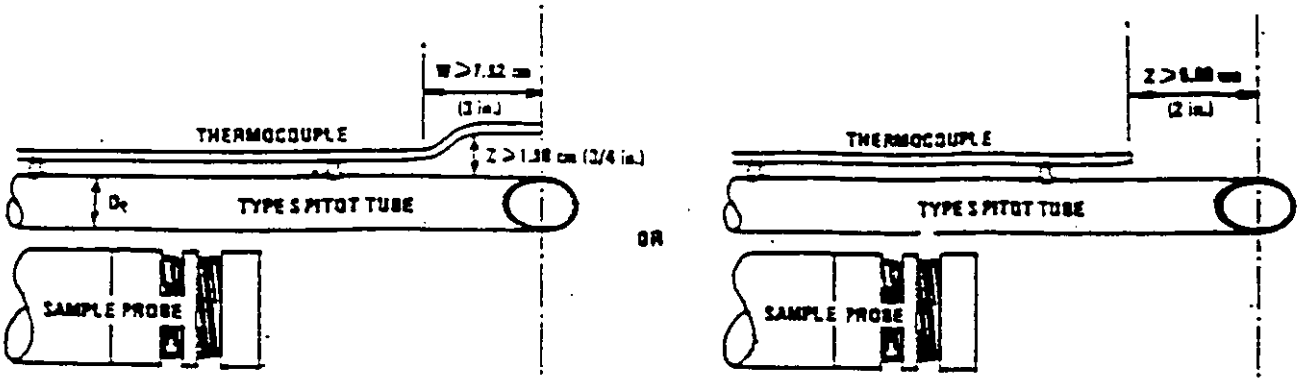


Figure 2-7. Proper thermocouple placement to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

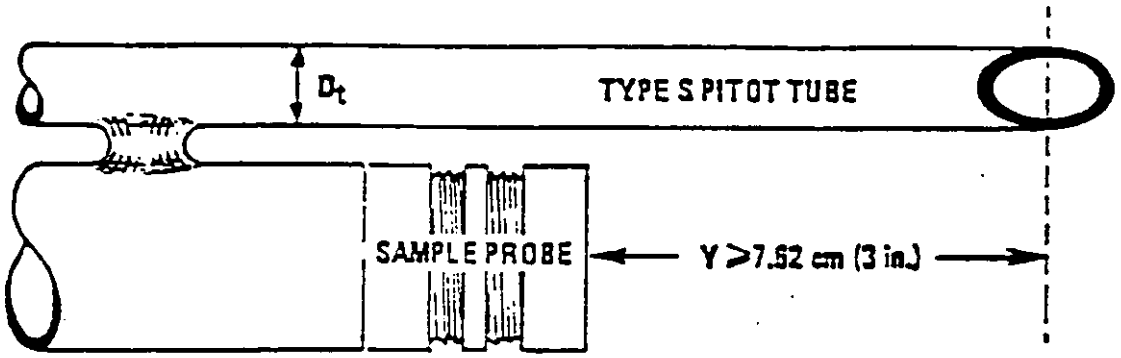


Figure 2-8. Minimum pitot-sample probe separation needed to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

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 disturbance.

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 366 m/min (1,000 ft/min) and to within ±6 to 8 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 the range (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 generic one and must not be used without first referring to the special considerations presented in Section 4.1.4. 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 as 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 4.1.3.1), 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_A 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)		

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

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

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 tube coefficient

$C_{p(std)}$ = 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 3-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:

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

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.

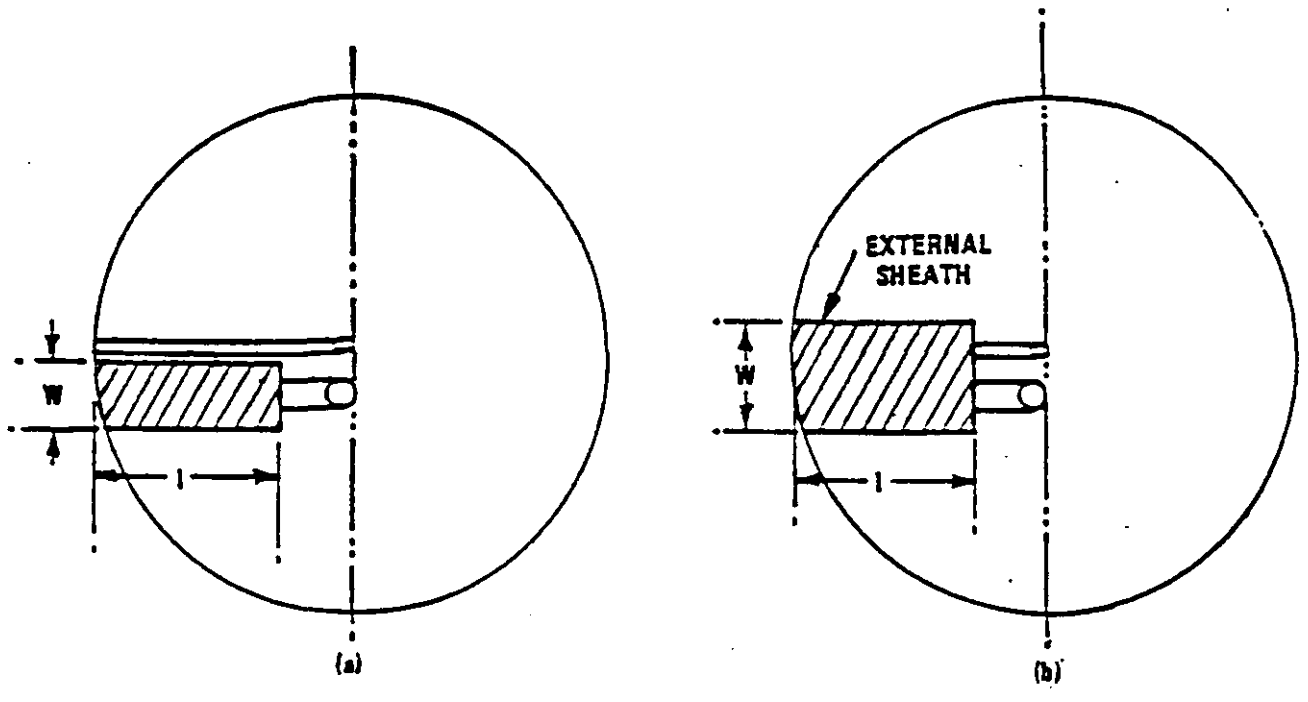
4.1.5.1.1 When an isolated Type S pitot tube is calibrated, select a calibration point at or near the center of the duct, and follow the procedures outlined in Sections 4.1.3 and 4.1.4 above. The Type S pitot coefficients so obtained, i.e., $\bar{C}_p$ (side A) and $\bar{C}_p$ (side B), will be valid, 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 3 percent or less of the duct cross-sectional area for assemblies without external sheaths (Figure 2-10a), and 2 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 fails 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 latter 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 the 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 (or 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 30 in. in diameter), the probe sheath sometimes blocks a significant part of the duct cross-section, causing a reduction in the effective value of $\overline{C}_{avg}$. 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 10 in Section 6).

4.1.6.2 Recalibration.

4.1.6.2.1 Unsealed Pitot Tubes. After each field use, the pitot tube shall be carefully reexamined in top, side, and end views. If the pitot tube 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 Figure 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, m^2 (ft^2).

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,

$$34.97 \frac{m}{sec}\left[\frac{(g/g\text{-mole})(mm\ Hg)}{(°K)(mm\ H_2O)}\right]^{1/2}$$

for the metric system and

$$85.49 \frac{ft}{sec}\left[\frac{(lb/lb\text{-mole})(in.\ Hg)}{(°R)(in.\ H_2O)}\right]^{1/2}$$

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).

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

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).

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

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).

$$= 273 + t_s, \text{ for metric} \qquad \text{Equation 2-7}$$

$$= 460 + t_s, \text{ for English} \qquad \text{Equation 2-8}$$

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

v_s = Average stack gas velocity, meter (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

6. *Bibliography.*

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

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

2. Shigehara, R. T., W. F. Todd, and W. S. Smith. Significance of Errors in Stack Sampling Measurements. U.S. Environmental Protection Agency, Research Triangle Park, N.C. (Presented at the Annual Meeting of the Air Pollution Control Association, St. Louis, Mo., June 14–18, 1970.)

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

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

6. Fluid Meters—Their Theory and Application. American Society of Mechanical Engineers. New York, N.Y. 1959.

7. ASHRAE Handbook of Fundamentals 1972. p. 238.

8. Annual Book of ASTM Standards, Part 26. 1974. p. 648.

9. Vollaro, R. F. Guidelines for Type S Pitot Tube Calibration. U.S. Environmental Protection Agency, Research Triangle Park, N.C. (Presented at 1st Annual Meeting, Source Evaluation Society, Dayton, Ohio, September 18, 1973.)

10. Vollaro, R. F. A Type S Pitot Tube Calibration Study. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, N.C. July 1974.

11. Vollaro, R. F. The Effects of Impact Opening Misalignment on the Value of the Type S Pitot Tube Coefficient. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, N.C. October 1975.

12. Vollaro, R. F. Establishment of a Baseline Coefficient Value for Properly Constructed Type S Pitot Tubes. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, N.C. November 1976.

13. Vollaro, R. F. An Evaluation of Single-Velocity Calibration Techniques as a Means of Determining Type S Pitot Tube Coefficients. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, N.C. August 1975.

14. Vollaro, R. F. The Use of Type S Pitot Tubes for the Measurement of Low Velocities. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, N.C. November 1976.

15. Smith, Marvin L. Velocity Calibration of EPA Type Source Sampling Probe. United Technologies Corporation, Pratt and Whitney Aircraft Division, East Hartford, Conn. 1973.

16. Vollaro, R. F. Recommended Procedure for Sample Traversing in Ducts Smaller than 12 Inches in Diameter. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, N.C. November 1976.

17. Dyer, E. and R. C. Pankhurst. The Measurement of Air Flow, 4th Ed., London, Pergamon Press. 1968.

18. Vollaro, R. F. A survey of Commercially Available Instrumentation for the Measurement of Low-Range Gas Velocities. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, N.C. November 1976. (Unpublished Paper)

19. Gayp, A. W., C. C. St. Pierre, D. S. Smith, D. Mosson, and J. Steiner. An Experimental Investigation of the Effect of Pitot Tube-Sampling Probe Configurations on the Magnitude of the S Type Pitot Tube Coefficient for Commercially Available Source Sampling Probes. Prepared by the University of Windsor for the Ministry of the Environment, Toronto, Canada. February 1975.

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 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 wherein 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) assuming 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.

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.

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

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 60 to 80 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 Analyses. 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 leak-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 3-1. 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 by subtracting the sum of the percent CO 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 3-4.

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] $\%\ DEV = \left(\frac{Q - Q\ avg}{Q\ avg}\right) 100$ (MUST BE ≤ 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. 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; and (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 O_2 and report the results to the nearest 0.1 percent.

4.2.6.3 For percent CO, repeat the analytical procedure until the results of any three analyses differ by no more than 0.5 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 measured, 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-hour, 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 procedure 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 3-1.

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 in the capillary tubing, and then close the pipette stopcocks.

5.1.2 Raise the leveling bulb sufficiently to bring the confining liquid meniscus into 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 stoppers should be checked until the cause of the leak is identified. Leaking stoppers 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, gm/gm-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 latter may not be incurred in the analyses using procedures subject to approval of the Administrator.

7. *Bibliography*

1. Altshuller, A. P. Storage of Gases and Vapors in Plastic Bags. International Journal of Air and Water Pollution. 6:75–81. 1963.

2. Conner, William D. and J. S. Nader. Air Sampling Plastic Bags. Journal of the American Industrial Hygiene Association. 25:291–297. 1964.

3. Burrell Manual for Gas Analysis, Seventh edition. Burrell Corporation, 2223 Fifth Avenue, Pittsburgh, Pa. 15219. 1951.

4. Mitchell, W. J. and M. R. Midgett. Field Reliability of the Orsat Analyzer. Journal of Air Pollution Control Association. 26:491–495. May 1976.

5. Shigeoka, R. T., R. M. Neulicht, and W. S. Smith. Validating Orsat Analysis Data from Fossil Fuel-Fired Units. Stack Sampling News. 4(2):21–28. August, 1976.

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 particulate 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 combined with an isokinetic particulate emission measurement run; when it is, calculation of percent moisture, 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.

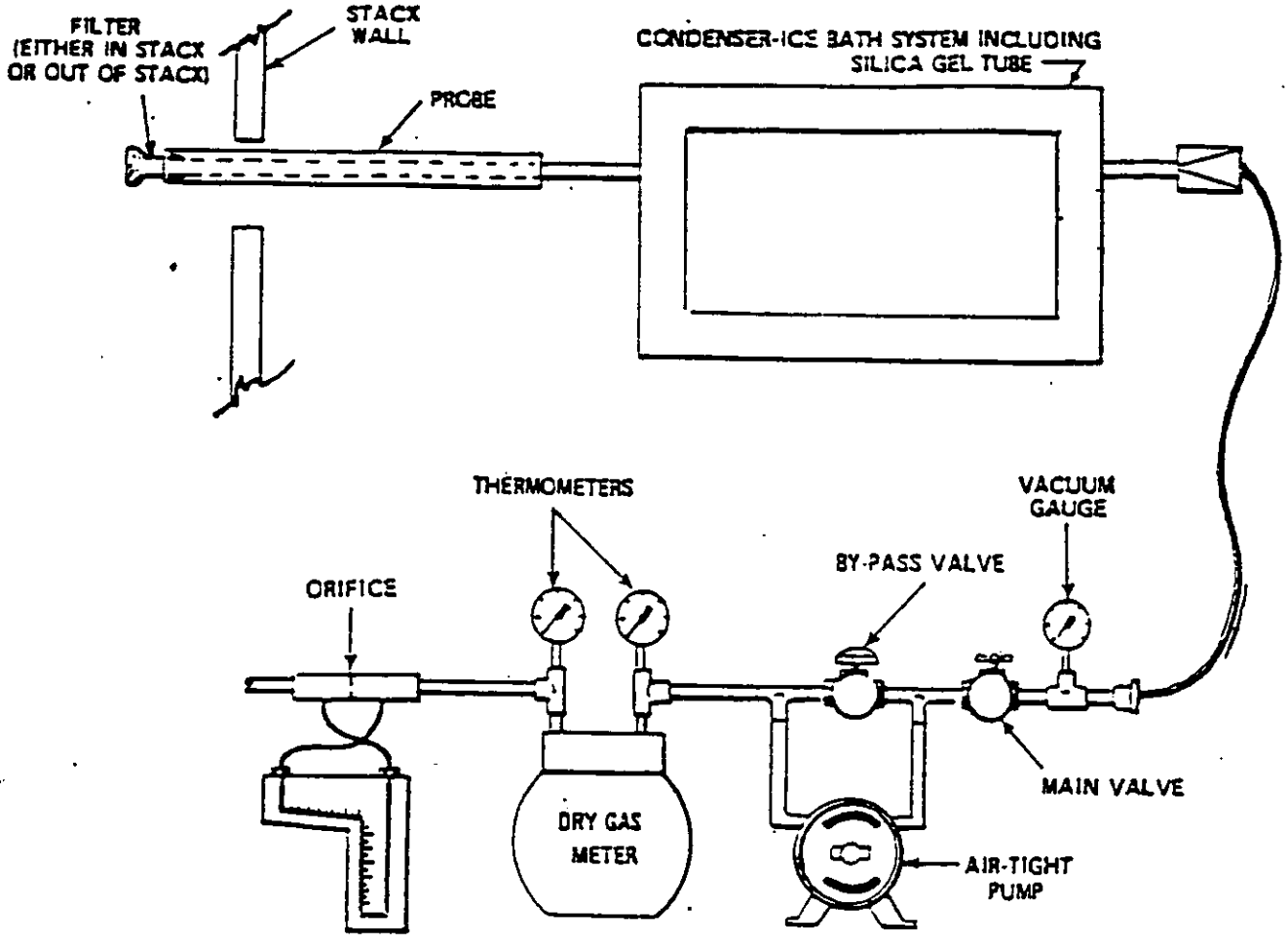

Figure 4-1. Moisture sampling train-reference method.

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.

Where 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 resumed. Take other appropriate readings as 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 report 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 ($T_{m(in)}$), °C (°F)	OUTLET ($T_{m(out)}$), °C (°F)	
TOTAL						Avg.	Avg.	
AVERAGE						Avg.		

Figure 4-2. Field moisture determination-reference method.

	[illegible] VOLUME, ml	SILICA GEL WEIGHT, g
FINAL		
INITIAL		
DIFFERENCE		

Figure 4-2. Analytical data - reference method.

2.2.1 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).

$V_{w(std)}$ = Volume of water vapor condensed corrected to standard conditions, scm (scf).

$V_{w(std)}$ = 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).

2.2.2 Volume of water vapor condensed.

$$V_{w(std)} = \frac{(V_f - V_i)\rho_w R T_{std}}{P_{std} M_w} = K_1 (V_f - V_i)$$

Equation 4-1

where:

K_1 = 0.001333 m³/ml for metric units
= 0.04707 ft³/ml for English units

2.2.3 Volume of water vapor collected in silica gel.

$$V_{w(std)} = \frac{(W_f - W_i) R T_{std}}{P_{std} M_w} = K_2 (W_f - W_i)$$

Equation 4-2

where:

K_2 = 0.001333 m³/g for metric units
= 0.0474 ft³/g for English units

2.2.4 Sample gas volume.

$$V_{m(std)} = V_m Y \frac{(P_m)(T_{std})}{(P_{std})(T_m)} = K_1 Y \frac{V_m P_m}{T_m}$$

Equation 4-3

where:

K_1 = 17.64 °K/mm Hg for metric units
= 528 °R/in. Hg for English units

NOTE.—If the pretest leak rate (Section 2.2.6) exceeds the allowable rate, correct the value of V_m in Equation 4-3, as directed in Section 6.3 of Method 5.

2.2.5 Moisture Content.

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

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.

2.2.6 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 l/pm (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 2.1.3 above.

3.1.11 Vacuum Gauge. At least 760 mm Hg (30 in. Hg) range, to be used for the sampling leak check.

3.2 Procedure.

3.2.1 Place exactly 5 ml distilled water in each impinger. Assemble the apparatus without the probe as shown in Figure 4-4. Leak check the train by placing a vacuum gauge at the inlet to the first impinger and drawing a vacuum of at least 250 mm Hg (10 in. Hg), plugging the outlet of the rotameter, and then turning off the pump. The vacuum shall remain constant for at least one minute. Carefully release the vacuum gauge before unplugging the rotameter end.

2.2.2 Connect the probe, insert it into the stack, and sample at a constant rate of 21 lpm (0.021 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 4-1.

2.2.3 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_{wa} = 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).

$V_{w(std)}$ = Volume of water vapor condensed, corrected to standard conditions, scm (scf).

ρ_w = Density of water, 0.9982 g/ml (0.002201 lb/ml).

3.3.2 Volume of water vapor collected.

$$V_{w(std)} = \frac{(V_f - V_i)\rho_w R T_{std}}{P_{std} M_w}$$

$$= K_1 (V_f - V_i)$$

Equation 4-5

where:

K_1 = 0.001333 m³/ml for metric units
= 0.04707 ft³/ml for English units.

3.3.3 Gas volume.

$$V_{m(std)} = V_m \left(\frac{P_m}{P_{std}}\right)\left(\frac{T_{std}}{T_m}\right)$$

$$= K_2 \frac{V_m P_m}{T_m}$$

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.

$$B_{wa} = \frac{V_w}{V_w + V_{m(std)}} + B_{wa}$$

$$= \frac{V_w}{V_w + V_{m(std)}} + (0.025)$$

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 5.3.1 of Method 5 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:

3-28-89
Vol. 54 No. 58
Pages 12571-12808

Federal Register

Tuesday
March 28, 1989

Briefings on How To Use the Federal Register—
For information on briefings in Washington, DC, Philadelphia, PA, and Salt Lake City, UT, see announcement on the inside cover of this issue.

USEPA is rescinding its January 9, 1989, rulemaking. USEPA will rulemake on the revised I/M Program and the overall Cuyahoga CO plan in future Federal Register notice(s).

EFFECTIVE DATE: Rescission of the January 9, 1989, rulemaking is effective as of March 28, 1989.

FOR FURTHER INFORMATION CONTACT: Maggie Greene, Air and Radiation Branch (5AR-26), U.S. Environmental Protection Agency, 230 South Dearborn Street, Chicago, Illinois 60604, (312) 886-6088.

SUPPLEMENTARY INFORMATION: This rescission of the January 9, 1989 rulemaking is effective as of March 28, 1989. The Administrative Procedure Act (APA), 5 U.S.C. 553(d), permits the effective date of a substantive rule to be less than thirty days after the publication of the rule if the rule "relieves a restriction". Since USEPA's rescission of the January 9, 1989 rulemaking is a substantive rule that relieves the restrictions outlined in that notice (funding and growth sanctions, and CO SIP disapproval), the rescission may be made effective upon signature by the USEPA Administrator.

Beyond that, the APA, 5 U.S.C. 553(b)(B) and (c), permits an agency to forgo the notice-and-comment process that normally attends informal rulemaking, "when the agency for good cause finds (and incorporates the finding and a brief statement of the reasons therefore in the rules issued) that notice and public procedure thereon are impracticable, unnecessary, or contrary to the public interest." USEPA is invoking this exemption as the ground for foregoing additional notice and an opportunity to comment on the agency's rescission of the January 9, 1989 rulemaking. It would make little sense and create needless havoc for USEPA to impose the funding and growth sanctions and CO SIP disapproval after the State had already remedied the inaction that formed the basis for those restrictions. It would thus be contrary to the public interest to open a notice-and-comment process that would allow the restrictions to take effect. (Alternatively, it would have been impracticable for USEPA to complete a notice-and-comment proceeding between the Ohio legislature's action on March 14, 1989 and the March 15, 1989, effective date of the restrictions.) Moreover, the rulemaking leading to the January 9, 1989 notice provided the public ample notice of, and opportunity to comment on, the fact that the restrictions were based solely on the state legislature's previous failure to adopt a tailpipe I/M program. Thus, it is unnecessary for USEPA to open a new notice-and-comment process on whether the Ohio legislature's adoption of that very type of program justifies rescinding the restrictions.

Therefore, USEPA is rescinding its January 9, 1989 rule.

Authority: 42 U.S.C. 7401-7642.

Dated: March 14, 1989.

William K. Reilly,

Administrator.

Accordingly, 40 CFR Part 52 is amended as follows:

PART 52—[AMENDED]

1. The authority citation for Part 52 continues to read as follows:

Authority: 42 U.S.C. 7401-7642.

§ 52.1887 [Amended]

2. Section 52.1887 is amended by removing paragraph (d).

[FR Doc. 89-6981 Filed 3-27-89; 8:45 am]

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40 CFR Part 60

[AD-FRL-3448-3]

Standards of Performance for New Stationary Sources

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final rule.

SUMMARY: On October 21, 1983, among other actions, EPA proposed to add Methods 1A, 2C, and 2D to Appendix A of 40 CFR Part 60 (48 FR 48932). Today's action promulgates those test methods. This promulgation action for Methods 1A, 2C, and 2D is required because on May 30, 1984, EPA promulgated Subpart VV—Standards of Performance for Equipment Leaks of VOC in the Synthetic Organic Chemicals Manufacturing Industry, which specified these methods for potential application for the measurement of stack flows (49 FR 22607).

This addition to Appendix A provides methods needed for sampling in small stacks and ducts. Methods 1A, 2C, and 2D will apply to Subpart VV and other stationary source categories where sampling in small stacks and ducts is necessary.

EFFECTIVE DATE: March 28, 1989.

Under Section 307(b)(1) of the Clean Air Act, judicial review of the actions taken by this notice is available *only* by the filing of a petition for review in the U.S. Court of Appeals for the District of Columbia Circuit within 60 days of today's publication of this notice. Under Section 307(b)(2) of the Clean Air Act, the requirements that are the subject of today's notice may not be challenged later in civil or criminal proceedings brought by EPA to enforce these requirements.

ADDRESSES: *Docket.* A docket, number A-88-15, containing information considered by EPA in development of the promulgated rulemaking, is available for public inspection between 8:00 a.m. and 4:00 p.m., Monday through Friday, at EPA's Central Docket Section (LE-131), South Conference Center, Room 4, 401 M Street SW., Washington, DC 20460. A reasonable fee may be charged for copying.

FOR FURTHER INFORMATION CONTACT: Mr. William Grimley or Mr. Roger T. Shigehara, Emission Measurement Branch, Technical Support Division (MD-19), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, telephone (919) 541-2237.

SUPPLEMENTARY INFORMATION:

I. The Rulemaking

Methods 1A, 2C, and 2D are being added to Appendix A of 40 CFR Part 60 for the sampling and measurement of particulate matter (PM) and flow rates in small stacks and ducts. Subpart VV of Part 60 specifies these methods for potential application in the determination of the exit velocity of a flare, and these methods will also be needed for future source category rulemaking actions.

This rulemaking does not impose emission measurement requirements beyond those specified in the current regulations, nor does it change any emission standard. Rather, the rulemaking would simply add methods for the achievement of emission testing requirements that would apply irrespective of this rulemaking.

II. Public Participation

The proposed amendment to 40 CFR Part 60 that contained proposed Methods 1A, 2C, and 2D was published in the Federal Register on October 21, 1983 (48 FR 48932). Public comments were solicited at the time of proposal. To provide interested persons the opportunity for oral presentation of data, views, or arguments concerning the proposed action, a public hearing was held, as scheduled, on November 15, 1983, beginning at 10:00 a.m. No comments that pertained to the *proposed methods were made* at the public hearing. The public comment period was from October 21, 1983, to January 3, 1984. One comment letter was received that contained two comments

concerning the proposed methods. The two comments have been considered carefully, and, in the instance where it was determined to be appropriate by the Agency, a change has been made to the proposed rulemaking.

III. Comments and Changes to the Proposed Standards

One comment letter was received on the proposed methods from a manufacturer of packaged products. The manufacturer's first comment was that Method 1A should be changed to allow the pitot tube for velocity measurement to be placed upstream of the PM sampling probe in order to place everything within a 12 to 14 diameter-length of suitable duct, rather than an 18 duct diameter-length.

The method presently states "* * * if such locations are not available, select an alternative PM sampling site that is at least 2 equivalent stack or duct diameters downstream and 2½ diameters upstream from any flow disturbance." Thus, the proposed method allows PM sampling to be accomplished within a minimum of a total of 4½ duct diameter-lengths, and the suggested change is, therefore, not necessary.

The manufacturer's second and last comment was that Method 1A should be changed to indicate that when steady-state flow exists, the same sample port could be used for both velocity and PM traverses by preceding and following the PM traverse with velocity traverses that demonstrate steady flow.

The EPA believes this suggested procedure is reasonable if some limit is placed on the allowable variation between the two velocity traverses. Section 2.1.2 of Method 1A has been revised to describe this procedure, with a stipulation that the PM sampling is acceptable if the final flow rate, derived from the final velocity traverse, does not deviate from the initial flow rate by more than 10 percent.

IV. Administrative

The docket is an organized and complete file of all the information considered by EPA in the development of this rulemaking. The docket is a dynamic file, since material is added throughout the rulemaking development. The docketing system is intended to allow members of the public and industries involved to identify readily and locate documents so that they can effectively participate in the rulemaking process. Along with the statement of basis and purpose of the proposed and promulgated methods, and EPA responses to significant comments, the contents of the docket, except for interagency review materials, will serve as the record in case of judicial review (Clean Air Act, Section 307(d)(7)(A)).

Under Executive Order 12291, EPA is required to judge whether a regulation is a "major rule" and, therefore, subject to the requirements of a regulatory impact analysis. The Agency has determined that this regulation would result in none of the adverse economic effects set forth in Section 1 of the Order as grounds for finding a regulation to be a "major rule." The rulemaking does not impose emission measurement requirements beyond those specified in the current regulations, but, instead, provides methods for performing emission measurement requirements that would apply irrespective of this rulemaking. The Agency has, therefore, concluded that this regulation is not a "major rule" under Executive Order 12291.

The Regulatory Flexibility Act of 1980 requires the identification of potentially adverse impacts of Federal regulations upon small business entities. The Act specifically requires the completion of a regulatory flexibility analysis (RFA) in those instances where small business impacts are possible. Because these methods impose no adverse economic impacts, and RFA has not been conducted.

Pursuant to the provisions of 5 U.S.C. 605(b), I hereby certify that the promulgated rule will not have any economic impact on small entities, because the rule does not add either to the existing requirement for flow rate measurements, or increase their associated performance cost.

This rule does not contain any information collection requirements subject to OMB review under the Paperwork Reduction Act of 1980, 44 U.S.C. 3501 *et seq.*

List of Subjects in 40 CFR Part 60

Air pollution control, Intergovernmental relations, Synthetic Organic Chemicals Manufacturing Industry, Reporting and recordkeeping requirements, and Incorporation by reference.

Date: March 20, 1989.

William K. Reilly,

Administrator.

40 CFR Part 60 is amended as follows:

PART 60—[AMENDED]

1. The authority citation for Part 60 continues to read as follows:

Authority: Sections 101, 111, 114, 116, 301 of the Clean Air Act, as amended (42 U.S.C. 7401, 7411, 7414, 7416, 7601).

2. In Appendix A, Test Methods 1A, 2C, and 2D are added to read as follows:

Appendix A

* * * * *

Method 1A—Sample and Velocity Traverses for Stationary Sources with Small Stacks or Ducts

1. Applicability and Principle

1.1 The applicability and principle of this method are identical to Method 1, except this method's applicability is limited to stacks or ducts less than about 0.30 meter (12 in.) in diameter or 0.071 m^2 (113 $in.^2$) in cross-sectional area, but equal to or greater than about 0.10 meter (4 in.) in diameter or 0.0081 m^2 (12.57 $in.^2$) in cross-sectional area.

1.2 In these small diameter stacks or ducts, the conventional Method 5 stack assembly (consisting of a Type S pitot tube attached to a sampling probe, equipped with a nozzle and thermocouple) blocks a significant portion of the cross section of the duct and causes inaccurate measurements. Therefore, for particulate matter (PM) sampling in small stacks or ducts, the gas velocity is measured using a standard pitot tube downstream of the actual emission sampling site. The straight run of duct between the PM sampling and velocity measurement sites allows the flow profile, temporarily disturbed by the presence of the sampling probe, to redevelop and stabilize.

1.3 The cross-sectional layout and location of traverse points and the verification of the absence of cyclonic flow are the same as in Method 1, Sections 2.3 and 2.4, respectively. Differences from Method 1, except as noted, are given below.

2. Procedure

2.1 Selection of Sampling and Measurement Sites.

2.1.1 PM Measurements. Select a PM sampling site located preferably at least 8 equivalent stack or duct diameters downstream and 10 equivalent diameters upstream from any flow disturbances such as bends, expansions, or contractions in the stack, or from a visible flame. Next, locate the velocity measurement site 8 equivalent diameters downstream of the PM sampling site. See Figure 1A–1. If such locations are not available, select an alternative PM sampling site that is at least 2 equivalent stack or duct diameters downstream and 2½ diameters upstream from any flow disturbance. Then, locate the velocity measurement site 2 equivalent diameters downstream from the PM sampling site. Follow Section 2.1 of Method 1 for calculating equivalent diameters for a rectangular cross section.

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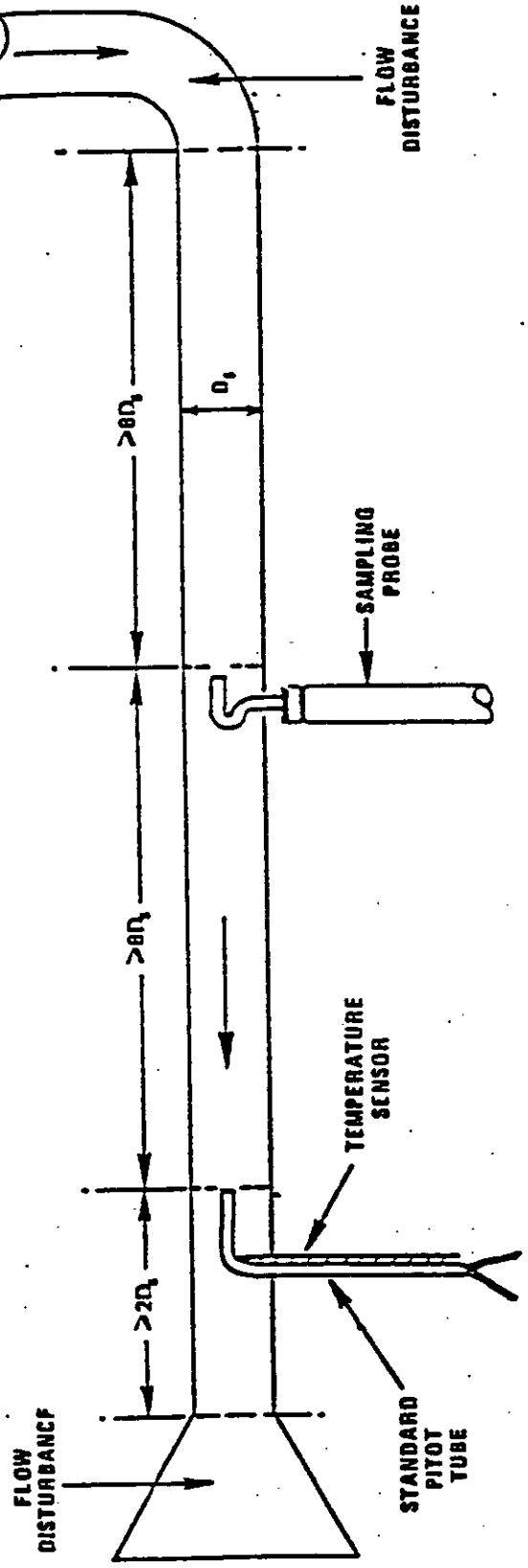

Figure 1A-1. Recommended sampling arrangement for small ducts.

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2.1.2 PM Sampling (Steady Flow) or only Velocity Measurements. For PM sampling when the volumetric flow rate in a duct is constant with respect to time, Section 2.1 of Method 1 may be followed, with the PM sampling and velocity measurement performed at one location. To demonstrate that the flow rate is constant (within 10 percent) when PM measurements are made, perform complete velocity traverses before and after the PM sampling run, and calculate the deviation of the flow rate derived after the PM sampling run from the one derived before the PM sampling run. The PM sampling run is acceptable if the deviation does not exceed 10 percent.

2.2 Determining the Number of Traverse Points.

2.2.1 PM Sampling. Use Figure 1-1 of Method 1 to determine the number of traverse points to use at both the velocity measurement and PM sampling locations. Before referring to the figure, however, determine the distances between both the velocity measurement and PM sampling sites to the nearest upstream and downstream disturbances. Then divide each distance by the stack diameter or equivalent diameter to express the distances in terms of the number of duct diameters. Next, determine the number of traverse points from Figure 1-1 of Method 1 corresponding to each of these four distances. Choose the highest of the four numbers of traverse points (or a greater number) so that, for circular ducts, the number is a multiple of four, and for rectangular ducts, the number is one of those shown in Table 1-1 of Method 1. When the optimum duct diameter location criteria can be satisfied, the minimum number of traverse points required is eight for circular ducts and nine for rectangular ducts.

2.2.2 PM Sampling (Steady Flow) or Velocity Measurements. Use Figure 1-2 of Method 1 to determine the number of traverse points, following the same procedure used for PM sampling traverses as described in Section 2.2.1 of Method 1. When the optimum duct diameter location criteria can be satisfied, the minimum number of traverse points required is eight for circular ducts and nine for rectangular ducts.

3. Bibliography

1. Same as in Method 1, Section 3, Citations 1 through 6.

2. Vollaro, Robert F. Recommended Procedure for Sample Traverses in Ducts Smaller Than 12 Inches in Diameter. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, North Carolina. January 1977.

* * * * *

Method 2C—Determination of Stack Gas Velocity and Volumetric Flow Rate in Small Stacks or Ducts (Standard Pitot Tube)

1. Applicability and Principle

1.1 Applicability.

1.1.1 The applicability of this method is identical to Method 2, except this method is limited to stationary source stacks or ducts less than about 0.30 meter (12 in.) in diameter or 0.071 m^2 (113 $in.^2$) in cross-sectional area, but equal to or greater than about 0.10 meter (4 in.) in diameter or 0.0081 m^2 (12.57 $in.^2$) in cross-sectional area.

1.1.2 The apparatus, procedure, calibration, calculations, and bibliography are the same as in Method 2, Sections 2, 3, 4, 5, and 6, except as noted in the following sections.

1.2 Principle. The average gas velocity in a stack or duct is determined from the gas density and from measurement of velocity heads with a standard pitot tube.

2. Apparatus

2.1 Standard Pitot Tube (Instead of Type S). Use a standard pitot tube that meets the specifications of Section 2.7 of Method 2. Use a coefficient value of 0.99 unless it is calibrated against another standard pitot tube with an NBS-traceable coefficient.

2.2 Alternative Pitot Tube. A modified hemispherical-nosed pitot tube (see Figure 2C-1), which features a shortened stem and enlarged impact and static pressure holes, may be used. This pitot tube is useful in liquid drop-laden gas streams when a pitot "back purge" is ineffective. Use a coefficient value of 0.99 unless the pitot is calibrated as mentioned in Section 2.1 above.

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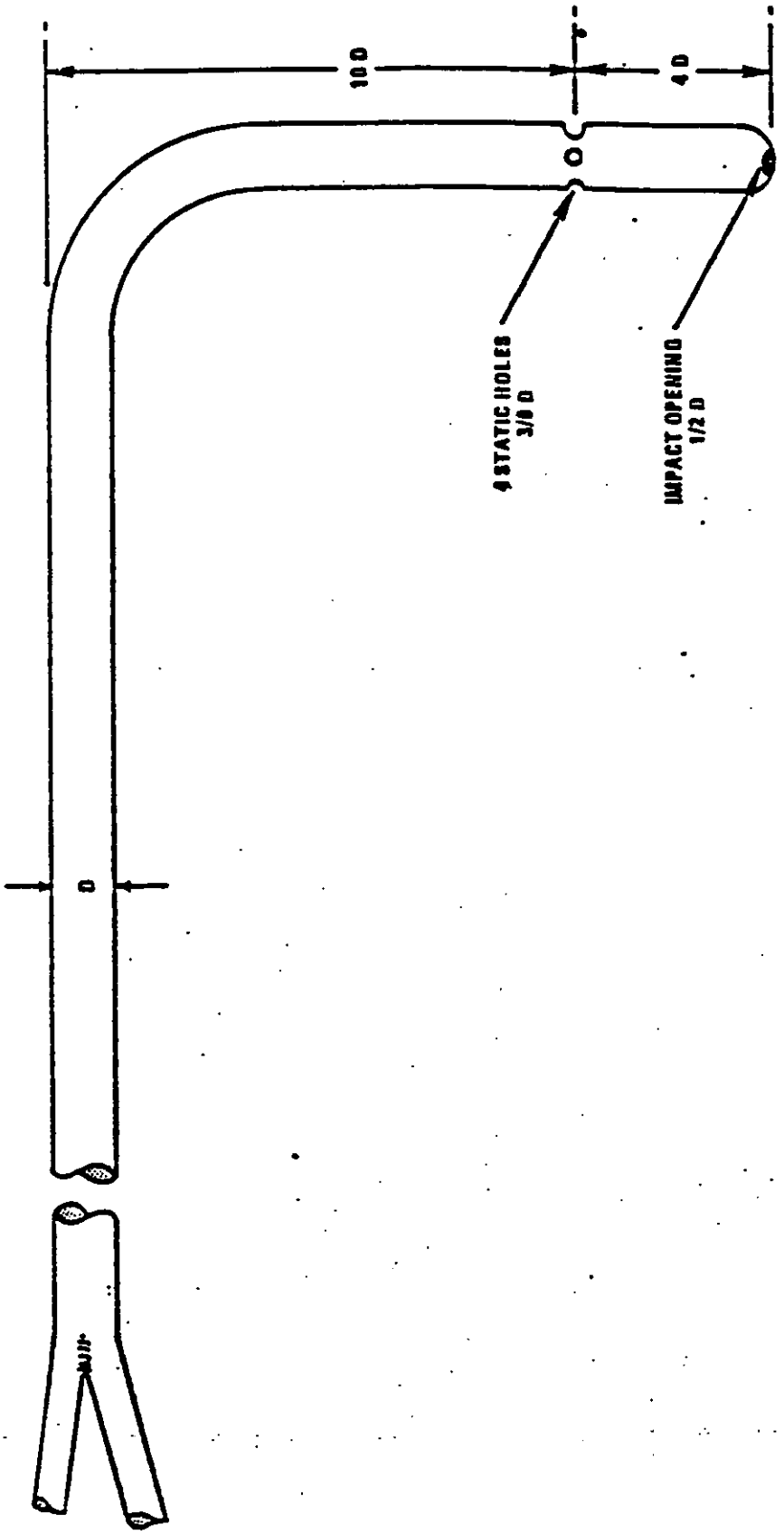

Figure 2C-1. Modified hemispherical-nosed pitot tube.

3. Procedure

Follow the general procedures in Section 3 of Method 2, except conduct the measurements at the traverse points specified in Method 1A. The static and impact pressure holes of standard pitot tubes are susceptible to plugging in PM-laden gas streams. Therefore, the tester must furnish adequate proof that the openings of the pitot tube have not plugged during the traverse period; this proof can be obained by first recording the velocity head (Δp) reading at the final traverse point, then cleaning out the impact and static holes of the standard pitot tube by "back-purging" with pressurized air, and finally by recording another Δp reading at the final traverse point. If the Δp reading made after the air purge is within 5 percent of the reading during the traverse, then the traverse is acceptable. Otherwise, reject the run. Note that if the Δp at the final traverse point is so low as to make this determination too difficult, then another traverse point may be selected. If "back purging" at regular intervals is part of the procedure, then take comparative Δp readings, as above, for the last two back purges at which suitable high Δp readings are observed.

Method 2D—Measurement of Gas Volumetric Flow Rates in Small Pipes and Ducts

1. Applicability and Principle

1.1 Applicability. This method applies to the measurement of gas flow rates in small pipes and ducts, either before or after emission control devices.

1.2 Principle. To measure flow rate or pressure drop, all the stack gas is directed through a rotameter, orifice plate or similar flow rate measuring device. The measuring device has been previously calibrated in a manner that insures its proper calibration for the gas or gas mixture being measured. Absolute temperature and pressure measurements are also made to calculate volumetric flow rates at standard conditions.

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.

2.1 Flow Rate Measuring Device. A rotameter, orifice plate, or other flow rate measuring device capable of measuring all the stack flow rate to within 5 percent of its true value. The measuring device shall be equipped with a temperature gauge accurate to within 2 percent of the minimum absolute stack temperature and a pressure gauge accurate to within 5 mm Hg. The capacity of the measuring device shall be sufficient for the expected maximum and minimum flow rates at the stack gas conditions. The magnitude and variability of stack gas flow rate, molecular weight, temperature, pressure, compressibility, dew point, corrosiveness, and pipe or duct size are all factors to consider in choosing a suitable measuring device.

2.2 Barometer. Same as in Method 2, Section 2.1.

2.3 Stopwatch. Capable of incremental time measurement to within 1 second.

3. Procedure

3.1 Installation. Use the procedure in Method 2A, Section 3.1.

3.2 Leak Check. Use the procedure in Method 2A, Section 3.2.

3.3 Flow Rate Measurement.

3.3.1 Continuous, Steady Flow. At least once an hour, record the measuring device flow rate reading, and the measuring device temperature and pressure. Make a minimum of twelve equally spaced readings of each parameter during the test period. Record the barometric pressure at the beginning and end of the test period. Record the data on a table similar to Figure 2D-1.

Plant_____
Date_____ Run number_____
Sample location_____
Barometric pressure, mm (in.) Hg
Start_____ Finish_____
Operators_____
Measuring device number_____
Calibration coefficient_____
Calibration gas_____
Last date calibrated_____

Time	Flow rate reading	Static pressure mm (in.) Hg	Temperature °C (°F)	Temperature °K (°R)
	Average			

Figure 2D-1. Flow rate measurement data.

3.3.2 Noncontinuous and Nonsteady Flows. Use flow rate measuring devices with particular caution. Calibration will be affected by variation in stack gas temperature, pressure, compressibility, and molecular weight. Use the procedure in Section 3.3.1. Record all the measuring device parameters on a time interval frequency sufficient to adequately profile each process cyclical or noncontinuous event. A multichannel continuous recorder may be used.

4. Calibration

4.1 Flow Rate Measuring Device. Use the procedure in Method 2A, Section 4, and apply the same performance standards. Calibrate the measuring device with the principal stack gas to be measured (e.g., air, nitrogen) against a standard reference meter. A calibrated dry gas meter is an acceptable reference meter. Ideally, calibrate the measuring device in the field with the actual gas to be measured. For measuring devices that have a *volume* rate readout, calculate the measuring device calibration coefficient, Y_m, for each run as follows:

$$Y_m = \frac{(Q_r)(T_r)P_{bar}}{(Q_m)(T_m)\left(P_{bar} + \frac{P_s}{P_s}\right)} \qquad \text{Eq. 2D-1}$$

where:

Q_r = reference meter flow rate reading, m^3/min (ft^3/min).

Q_m = measuring device flow rate reading, m^3/min (ft^3/min).

T_r = reference meter average absolute temperature, °K (°R).

T_m = measuring device average absolute temperature, °K (°R).

P_{bar} = barometric pressure, mm Hg (in. Hg).

P_s = measuring device average static pressure, mm Hg (in. Hg).

For measuring devices that do not have a readout as flow rate, refer to the manufacturer's instructions to calculate the Q_m corresponding to each Q_r.

4.2 Temperature Gauge. Use the procedure and specifications in Method 2A, Section 4.2. Perform the calibration at a temperature that approximates field test conditions.

4.3 Barometer. Calibrate the barometer to be used in the field test with a mercury barometer prior to the field test.

5. Gas Flow Rate Calculation

Calculate the stack gas flow rate, Q_s, as follows:

$$Q_s = K_1 Y_m Q_m \frac{\left(P_{bar} + \frac{P_s}{P_s}\right)}{T_m} \qquad \text{Eq. 2D-2}$$

where:

K_1 = 0.3858 for international system of units (SI); 17.64 for English units.

6. Bibliography

1. Spink, L.K. Principles and Practice of Flowmeter Engineering. The Foxboro Company, Foxboro, MA. 1967.

2. Benedict, Robert P. Fundamentals of Temperature, Pressure, and Flow Measurements. John Wiley and Sons, Inc. New York, NY. 1969.

3. Orifice Metering of Natural Gas. American Gas Association, Arlington, VA. Report No. 3, March 1978. 88 p.

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[FR Doc. 89-7313 Filed 3-27-89; 8:45 am]
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the sample, the remainder of the analysis procedure must be completed according to Sections 7.3.3 through 7.3.3.

11. *Bibliography*

11.1 Determination of Hydrogen Sulfide, Ammoniacal Cadmium Chloride Method. API Method 772-54. In: Manual on Disposal of Refinery Wastes, Vol. V: Sampling and Analysis of Waste Gases and Particulate Matter, American Petroleum Institute, Washington, DC. 1954.

11.2 Tentative Method of Determination of Hydrogen Sulfide and Mercaptan Sulfur in Natural Gas, Natural Gas Processors Association, Tulsa, OK. NGPA Publication No. 2265-65. 1965.

11.3 Knoll, J. E., and M. R. Midgett. Determination of Hydrogen Sulfide in Refinery Fuel Gases, Environmental Monitoring Series, Office of Research and Development, USEPA, Research Triangle Park, NC 27711, EPA 600/4-77-007.

11.4 Schell, G. W., and M. C. Sharp. Standardization of Method 11 at a Petroleum Refinery, Midwest Research Institute Draft Report for USEPA, Office of Research and Development, Research Triangle Park, NC 27711, EPA Contract No. 68-02-1098. August 1976, EPA 600/4-77-088a (Volume 1) and EPA 600/4-77-088b (Volume 2).

Method 12—Determination of Inorganic Lead Emissions From Stationary Sources

1. *Principle and Applicability*

1.1 Applicability. This method applies to the determination of inorganic lead (Pb) emissions from specified stationary sources only.

1.2 Principle. Particulate and gaseous Pb emissions are withdrawn isokinetically from the source and collected on a filter and in dilute nitric acid. The collected samples are digested in acid solution and analyzed by atomic absorption spectrometry using an air acetylene flame.

2. *Range, Sensitivity, Precision, and Interferences*

2.1 Range. For a minimum analytical accuracy of ±10 percent, the lower limit of the range is 100 μg. The upper limit can be considerably extended by dilution.

2.2 Analytical Sensitivity. Typical sensitivities for a 1-percent change in absorption (0.0044 absorbance units) are 0.2 and 0.5 μg Pb/ml for the 217.0 and 283.3 nm lines, respectively.

2.3 Precision. The within-laboratory precision, as measured by the coefficient of variation ranges from 0.2 to 9.5 percent relative to a run-mean concentration. These values were based on tests conducted at a gray iron foundry, a lead storage battery manufactur-

ing plant, a secondary lead smelter, and a lead recovery furnace of an alkyl lead manufacturing plant. The concentrations encountered during these tests ranged from 0.61 to 123.3 mg Pb/m³.

2.4 Interferences. Sample matrix effects may interfere with the analysis for Pb by flame atomic absorption. If this interference is suspected, the analyst may confirm the presence of these matrix effects and frequently eliminate the interference by using the Method of Standard Additions.

High concentrations of copper may interfere with the analysis of Pb at 217.0 nm. This interference can be avoided by analyzing the samples at 283.3 nm.

3. *Apparatus*

3.1 Sampling Train. A schematic of the sampling train is shown in Figure 12-1; it is similar to the Method 5 train. The sampling train consists of the following components:

3.1.1 Probe Nozzle, Probe Liner, Pitot Tube, Differential Pressure Gauge, Filter Holder, Filter Heating System, Metering System, Barometer, and Gas Density Determination Equipment. Same as Method 5, Sections 2.1.1 to 2.1.6 and 2.1.8 to 2.1.10, respectively.

3.1.2 Impingers. Four impingers connected in series with leak-free ground glass fittings or any similar leak-free noncontaminating fittings. For the first, third, and fourth impingers, use the Greenburg-Smith design, modified by replacing the tip with a 1.3 cm (½ in.) ID glass tube extending to about 1.3 cm (½ in.) from the bottom of the flask. For the second impinger, use the Greenburg-Smith design with the standard tip. Place a thermometer, capable of measuring temperature to within 1°C (2°F) at the outlet of the fourth impinger for monitoring purposes.

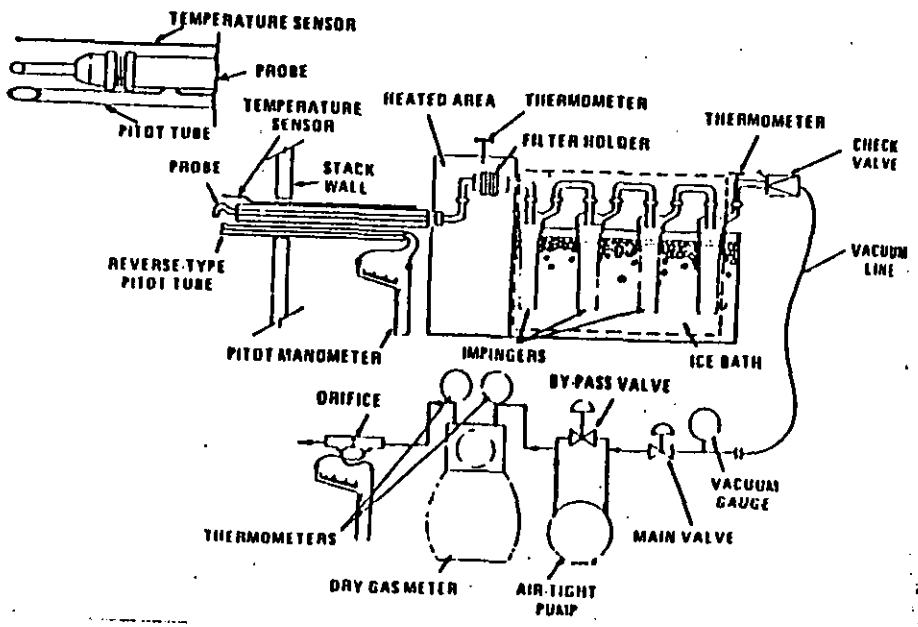

Figure 12-1. Inorganic lead sampling train.

3.2 Sample Recovery. The following items are needed:

3.2.1 Probe-Liner and Probe-Nozzle Brushes, Petri Dishes, Plastic Storage Containers, and Funnel and Rubber Policeman. Same as Method 5, Sections 2.2.1, 2.2.4, 2.2.6, and 2.2.7, respectively.

3.2.2 Wash Bottles. Glass (2).

3.2.3 Sample Storage Containers. Chemically resistant, borosilicate glass bottles, for 0.1 N nitric acid (HNO_3) impinger and probe solutions and washes, 1000-ml. Use screw-cap liners that are either rubber-backed

Teflon* or leak-free and resistant to chemical attack by 0.1 N HNO_3. (Narrow mouth glass bottles have been found to be less prone to leakage.)

3.2.4 Graduated Cylinder and/or Balance. To measure condensed water to within 1 ml or 1 g. Use a graduated cylinder that has a minimum capacity of 500 ml, and subdivisions no greater than 5 ml. (Most laboratory balances are capable of weighing to the nearest 0.5 g or less.)

3.2.5 Funnel. Glass, to aid in sample recovery.

3.3 *Analysis.* The following equipment is needed:

3.3.1 Atomic Absorption Spectrophotometer. With lead hollow cathode lamp and burner for air/acetylene flame.

3.3.2 Hot Plate.

3.3.3 Erlenmeyer Flasks. 125-ml, 24/40 $.

3.3.4 Membrane Filters. Millipore SCWPO 4700 or equivalent.

3.3.5 Filtration Apparatus. Millipore vacuum filtration unit, or equivalent, for use with the above membrane filter.

3.3.6 Volumetric Flasks. 100-ml, 250-ml, and 1000-ml.

4. *Reagents*

4.1 Sampling. The reagents used in sampling are as follows:

4.1.1 Filter. Gelman Spectro Grade, Reeve Angel 934 AH, MSA 1106 BH, all with lot assay for Pb, or other high-purity 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. Conduct the filter efficiency test using ASTM Standard Method D2986-71 (incorporated by reference—see § 60.17) or use test data from the supplier's quality control program.

4.1.2 Silica Gel, Crushed Ice, and Stopcock Grease. Same as Method 5, Sections 3.1.2, 3.1.4, and 3.1.5, respectively.

4.1.3 Water. Deionized distilled, to conform to ASTM Specification D1193-77 (incorporated by reference—see § 60.17), Type 3. If high concentrations of organic matter are not expected to be present, the analyst may delete the potassium permanganate test for oxidizable organic matter.

4.1.4 Nitric Acid, 0.1 N. Dilute 6.5 ml of concentrated HNO_3 to 1 liter with deionized distilled water. (It may be desirable to run blanks before field use to eliminate a high blank on test samples.)

4.2 Pretest Preparation. 6 N HNO_3 is needed. Dilute 300 ml of concentrated HNO_3 to 1 liter with deionized distilled water.

4.3 *Sample Recovery.* 0.1 N HNO_3 (same as 4.1.4 above) is needed for sample recovery.

*Mention of trade names or specific products does not constitute endorsement by the U.S. Environmental Protection Agency.

4.4 Analysis. The following reagents are needed for analysis (use ACS reagent grade chemicals or equivalent, unless otherwise specified):

4.4.1 Water. Same as 4.1.3 above.

4.4.2 Nitric Acid, Concentrated.

4.4.3 Nitric Acid, 50 percent (V/V). Dilute 500 ml of concentrated HNO_3 to 1 liter with deionized distilled water.

4.4.4 Stock Lead Standard Solution, 1000 μg Pb/ml. Dissolve 0.1598 g of lead nitrate ($Pb(NO_3)_2$) in about 60 ml of deionized distilled water, add 2 ml concentrated HNO_3, and dilute to 100 ml with deionized distilled water.

4.4.5 Working Lead Standards. Pipet 0.0, 1.0, 2.0, 3.0, 4.0, and 5.0 ml of the stock lead standard solution (4.4.4) into 250-ml volumetric flasks. Add 5 ml of concentrated HNO_3 to each flask and dilute to volume with deionized distilled water. These working standards contain 0.0, 4.0, 8.0, 12.0, 16.0, and 20.0 μg Pb/ml, respectively. Prepare, as needed, additional standards at other concentrations in a similar manner.

4.4.6 Air. Suitable quality for atomic absorption analysis.

4.4.7 Acetylene. Suitable quality for atomic absorption analysis.

4.4.8 Hydrogen Peroxide, 3 percent (V/V). Dilute 10 ml of 30 percent H_2O_2 to 100 ml with deionized distilled water.

5. *Procedure*

5.1 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.

5.1.1 Pretest Preparation. Follow the same general procedure given in Method 5, Section 4.1.1, except the filter need not be weighed.

5.1.2 Preliminary Determinations. Follow the same general procedure given in Method 5, Section 4.1.2.

5.1.3 Preparation of Collection Train. Follow the same general procedure given in Method 5, Section 4.1.3, except place 100 ml of 0.1 N HNO_3 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. Set up the train as shown in Figure 12-1.

5.1.4 Leak-Check Procedures. Follow the general leak-check procedures given in Method 5, Sections 4.1.4.1. (Pretest Leak-Check), 4.1.4.2 (Leak-Checks During the Sample Run), and 4.1.4.3 (Post-Test Leak-Check).

5.1.5 Sampling Train Operation. Follow the same general procedure given in Method 5, Section 4.1.5. For each run, record the data required on a data sheet such as the one shown in EPA Method 5, Figure 5-2.

5.1.6 Calculation of Percent Isokinetic. Same as *Method 5, Section 4.1.6.*

5.2 Sample Recovery. Begin proper cleanup procedure as soon as the probe is removed from the stack at the end of the sampling period.

Allow the probe to cool. When it can be safely handled, wipe off all external particulate matter near the tip of the probe nozzle and place a cap over it. 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 liquid from the impingers into the filter.

Before moving the sampling train to the cleanup site, remove the probe from the sampling 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 glassware inlet where the probe was fastened and cap the inlet. Remove the umbilical cord from the last impinger and cap the impinger. The tester may use ground-glass stoppers, plastic caps, or serum caps to close these openings.

Transfer the probe and filter-impinger assembly to a cleanup area, which is clean and protected from the wind so that the chances of contaminating or losing the sample are minimized.

Inspect the train prior to and during disassembly and note any abnormal conditions. Treat the samples as follows:

5.2.1 *Container No. 1* (Filter). Carefully remove the filter from the filter holder and place it in its identified petri dish container. If it is necessary to fold the filter, do so such that the sample-exposed side is inside the fold. Carefully transfer to the petri dish any visible sample matter and/or filter fibers that adhere to the filter holder gasket by using a dry Nylon bristle brush and/or a sharp-edged blade. Seal the container.

5.2.2 *Container No. 2* (Probe). Taking care that dust on the outside of the probe or other exterior surfaces does not get into the sample, quantitatively recover sample matter or any condensate from the probe nozzle, probe fitting, probe liner, and front half of the filter holder by washing these components with 0.1 N HNO_3 and placing the wash into a glass sample storage container. Measure and record (to the nearest 2-ml) the total amount of 0.1 N HNO_3 used for each rinse. Perform the 0.1 N HNO_3 rinses as follows:

Carefully remove the probe nozzle and rinse the inside surfaces with 0.1 N HNO_3 from a wash bottle while brushing with a stainless steel, Nylon-bristle brush. Brush until the 0.1 N HNO_3 rinse shows no visible particles, then make a final rinse of the inside surface.

Brush and rinse with 0.1 N HNO_3 the inside parts of the Swagelok fitting in a similar way until no visible particles remain.

Rinse the probe liner with 0.1 N HNO_3. While rotating the probe so that all inside surfaces will be rinsed with 0.1 N HNO_3, tilt the probe and squirt 0.1 N HNO_3 into its upper end. Let the 0.1 N HNO_3 drain from the lower end into the sample container. The tester may use a glass funnel to aid in transferring liquid washes to the container. Follow the rinse with a probe brush. Hold the probe in an inclined position, squirt 0.1 N HNO_3 into the upper end of the probe as the probe brush is being pushed with a twisting action through the probe; hold the sample container underneath the lower end of the probe and catch any 0.1 N HNO_3 and sample matter that is brushed from the probe. Run the brush through the probe three times or more until no visible sample matter is carried out with the 0.1 N HNO_3 and none remains on 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 sample matter can be entrapped. Rinse the brush with 0.1 N HNO_3 and quantitatively collect these washings in the sample container. After the brushing make a final rinse of the probe as described above.

It is recommended that two people clean the probe to minimize loss of sample. Between sampling runs, keep brushes clean and protected from contamination.

After insuring that all joints are wiped clean of silicone grease, brush and rinse with 0.1 N HNO_3 the inside of the front half of the filter holder. Brush and rinse each surface three times or more, if needed, to remove visible sample matter. Make a final rinse of the brush and filter holder. After all 0.1 N HNO_3 washings and sample matter are collected in the sample container, tighten the lid on the sample container so that the fluid will not leak out when it is shipped to the laboratory. Mark the height of the fluid level to determine whether leakage occurs during transport. Label the container to clearly identify its contents.

5.2.3 *Container No. 3* (Silica Gel). Check the color of the indicating 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 the original container and seal. The tester may use a funnel to pour the silica gel and a rubber policeman to remove the silica gel from the impinger. It is not necessary to remove the small amount of particles that may adhere to the walls 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, the tester may follow procedure for Container No. 3 under Section 5.4 (Analysis).

5.2.4 *Container No. 4* (Impingers). Due to the large quantity of liquid involved, the tester may place the impinger solutions in several containers. Clean each of the first three impingers and connecting glassware in the following manner:

1. Wipe the impinger ball joints free of silicone grease and cap the joints.

2. Rotate and agitate each impinger, so that the impinger contents might serve as a rinse solution.

3. Transfer the contents of the impingers to a 500-ml graduated cylinder. Remove the outlet ball joint cap and drain the contents through this opening. Do not separate the impinger parts (inner and outer tubes) while transferring their contents to the cylinder. Measure the liquid volume to within ±2 ml. Alternatively, determine the weight of the liquid to within ±0.5 g. Record in the log the volume or weight of the liquid present, along with a notation of any color or film observed in the impinger catch. The liquid volume or weight is needed, along with the silica gel data, to calculate the stack gas moisture content (see Method 5, Figure 5-3).

4. Transfer the contents to Container No. 4.

5. Note: In steps 5 and 6 below, measure and record the total amount of 0.1 N HNO_3 used for rinsing. Pour approximately 30 ml of 0.1 N HNO_3 into each of the first three impingers and agitate the impingers. Drain the 0.1 N HNO_3 through the outlet arm of each impinger into Container No. 4. Repeat this operation a second time; inspect the impingers for any abnormal conditions.

6. Wipe the ball joints of the glassware connecting the impingers free of silicone grease and rinse each piece of glassware twice with 0.1 N HNO_3; transfer this rinse into Container No. 4. (*Do not rinse or brush the glass-fritted filter support.*) Mark the height of the fluid level to determine whether leakage occurs during transport. Label the container to clearly identify its contents.

5.2.5 Blanks. Save 200 ml of the 0.1 N HNO_3 used for sampling and cleanup as a blank. Take the solution directly from the bottle being used and place into a glass sample container labeled "0.1 N HNO_3 blank."

5.3 Sample Preparation.

5.3.1 *Container No. 1* (Filter). Cut the filter into strips and transfer the strips and all loose particulate matter into a 125-ml Erlenmeyer flask. Rinse the petri dish with 10 ml of 50 percent HNO_3, to insure a quantitative transfer and add to the flask. (Note: If the total volume required in Section 5.3.3 is expected to exceed 80 ml, use a 250-ml Erlenmeyer flask in place of the 125-ml flask.)

5.3.2 *Containers No. 2 and No. 4* (Probe and Impingers). (Check the liquid level in Containers No. 2 and/or No. 4 and confirm as to whether or not leakage occurred during transport; note observation on the analysis sheet. If a noticeable amount of leakage had occurred, either void the sample or take steps, subject to the approval of the Administrator, to adjust the final results.) Combine the contents of Containers No. 2 and No. 4 and take to dryness on a hot plate.

5.3.3 Sample Extraction for Lead. Based on the approximate stack gas particulate concentration and the total volume of stack gas sampled, estimate the total weight of particulate sample collected. Then transfer the residue from Containers No. 2 and No. 4 to the 125-ml Erlenmeyer flask that contains the filter using rubber policeman and 10 ml of 50 percent HNO_3 for every 100 mg of sample collected in the train or a minimum of 30 ml of 50 percent HNO_3, whichever is larger.

Place the Erlenmeyer flask on a hot plate and heat with periodic stirring for 30 min at a temperature just below boiling. If the sample volume falls below 15 ml, add more 50 percent HNO_3. Add 10 ml of 3 percent H_2O_2 and continue heating for 10 min. Add 50 ml of hot (80°C) deionized distilled water and heat for 20 min. Remove the flask from the hot plate and allow to cool. Filter the sample through a Millipore membrane filter or equivalent and transfer the filtrate to a 250-ml volumetric flask. Dilute to volume with deionized distilled water.

5.3.4 Filter Blank. Determine a filter blank using two filters from each lot of filters used in the sampling train. Cut each filter into strips and place each filter in a separate 125-ml Erlenmeyer flask. Add 15 ml of 50 percent HNO_3, and treat as described in Section 5.3.3 using 10 ml of 3 percent H_2O_2 and 50 ml of hot, deionized distilled water. Filter and dilute to a total volume of 100 ml using deionized distilled water.

5.3.5 0.1 N HNO_3 Blank. Take the entire 200 ml of 0.1 N HNO_3 to dryness on a steam bath, add 15 ml of 50 percent HNO_3, and treat as described in Section 5.3.3 using 10 ml of 3 percent H_2O_2 and 50 ml of hot, deionized distilled water. Dilute to a total volume of 100 ml using deionized distilled water.

5.4 Analysis.

5.4.1 Lead Determination. Calibrate the spectrophotometer as described in Section 6.2 and determine the absorbance for each source sample, the filter blank, and 0.1 N HNO_3 blank. Analyze each sample three times in this manner. Make appropriate dilutions, as required, to bring all sample Pb

concentrations into the linear absorbance range of the spectrophotometer.

If the Pb concentration of a sample is at the low end of the calibration curve and high accuracy is required, the sample can be taken to dryness on a hot plate and the residue dissolved in the appropriate volume of water to bring it into the optimum range of the calibration curve.

5.4.2 *Check for Matrix Effects* on the Lead Results. Since the analysis for Pb by atomic absorption is sensitive to the chemical composition and to the physical properties (viscosity, pH) of the sample (matrix effects), the analyst shall check at least one sample from each source using the method of additions as follows:

Add or spike an equal volume of standard solution to an aliquot of the sample solution, then measure the absorbance of the resulting solution and the absorbance of an aliquot of unspiked sample.

Next, calculate the Pb concentration C_s in $\mu g/ml$ of the sample solution by using the following equation:

$$C_s = C_a \frac{A_s}{A_i - A_s} \qquad \text{Eq. 12-1}$$

Where:

C_a = Pb concentration of the standard solution, $\mu g/ml$.

A_s = Absorbance of the sample solution.

A_i = Absorbance of the spiked sample solution.

Volume corrections will not be required if the solutions as analyzed have been made to the same final volume. Therefore, C_a and C_s represent Pb concentration before dilutions.

Method of additions procedures described on pages 9-4 and 9-5 of the section entitled "General Information" of the Perkin Elmer Corporation Atomic Absorption Spectrophotometry Manual, Number 303-0152 (see Section 9.1) may also be used. In any event, if the results of the method of additions procedure used on the single source sample do not agree to within 5 percent of the value obtained by the routine atomic absorption analysis, then reanalyze all samples from the source using a method of additions procedure.

5.4.3 *Container No. 3* (Silica Gel). The tester may conduct this step in the field. Weigh the spent silica gel (or silica gel plus impinger) to the nearest 0.5 g; record this weight.

6. *Calibration*

Maintain a laboratory log of all calibrations.

6.1 *Sampling Train Calibration.* Calibrate the sampling train components according to the indicated sections of Method 5: Probe Nozzle (Section 5.1); Pitot Tube (Section 5.2); Metering System (Section 5.3); Probe Heater (Section 5.4); Temperature Gauges (Section 5.5); Leak-Check of the Metering System (Section 5.6); and Barometer (Section 5.7).

6.2 Spectrophotometer. Measure the absorbance of the standard solutions using the instrument settings recommended by the spectrophotometer manufacturer. Repeat until good agreement (±3 percent) is obtained between two consecutive readings. Plot the absorbance (y-axis) versus concentration in μg Pb/ml (x-axis). Draw or compute a straight line through the linear portion of the curve. Do not force the calibration curve through zero, but if the curve does not pass through the origin or at least lie closer to the origin than ±0.003 absorbance units, check for incorrectly prepared standards and for curvature in the calibration curve.

To determine stability of the calibration curve, run a blank and a standard after every five samples and recalibrate, as necessary.

7. *Calculations*

7.1 *Dry Gas Volume.* Using the data from this test, calculate $V_{m(std)}$, the total volume of dry gas metered corrected to standard conditions (20°C and 760 mm Hg), by using Equation 5-1 of Method 5. If necessary, adjust $V_{m(std)}$ for leakages as outlined in Section 6.3 of Method 5. See the field data sheet for the average dry gas meter temperature and average orifice pressure drop.

7.2 Volume of Water Vapor and Moisture Content. Using data obtained in this test and Equations 5-2 and 5-3 of Method 5, calculate the volume of water vapor $V_{w(std)}$ and the moisture content B_{ws} of the stack gas.

7.3 Total Lead in Source Sample. For each source sample correct the average absorbance for the contribution of the filter blank and the 0.1 N HNO_3 blank. Use the calibration curve and this corrected absorbance to determine the μg Pb concentration in the sample aspirated into the spectrophotometer. Calculate the total Pb content C'_{Pb} (in μg) in the original source sample; correct for all the dilutions that were made to bring the Pb concentration of the sample into the linear range of the spectrophotometer.

7.4 Lead Concentration. Calculate the stack gas Pb concentration C_{Pb} in mg/dscm as follows:

$$C_{Pb} = K \frac{C'_{Pb}}{V_{m(std)}} \qquad \text{Eq. 12-2}$$

Where:

K = 0.001 mg/μg for metric units.

= 3.205 lb/$\mu g \times 10^{-9}$ for English units.

7.5 Isokinetic Variation and Acceptable Results. Same as Method 5, Sections 6.11 and 6.12, respectively. To calculate v_s, the average stack gas velocity, use Equation 2-9 of Method 2 and the data from this field test.

8. *Alternative Test Methods for Inorganic Lead*

8.1 Simultaneous Determination of Particulate and Lead Emissions. The tester may use Method 5 to simultaneously determine Pb provided that (1) he uses acetone to remove particulate from the probe and inside of the filter holder as specified by Method 5, (2) he uses 0.1 N HNO, in the impingers, (3) he uses a glass fiber filter with a low Pb background, and (4) he treats and analyzes the entire train contents, including the impingers, for Pb as described in Section 5 of this method.

8.2 Filter Location. The tester may use a filter between the third and fourth impinger provided that he includes the filter in the analysis for Pb.

8.3 *In-stack Filter.* The tester may use an in-stack filter provided that (1) he uses a glass-lined probe and at least two impingers, each containing 100 ml of 0.1 N HNO_3, after the in-stack filter and (2) he recovers and analyzes the probe and impinger contents for Pb. Recover sample from the nozzle with acetone if a particulate analysis is to be made.

9. *Bibliography*

9.1 Perkin Elmer Corporation. Analytical Methods for Atomic Absorption Spectrophotometry. Norwalk, CT. September 1976.

9.2 American Society for Testing and Materials. Annual Book of ASTM Standards. Part 31; Water, Atmospheric Analysis. Philadelphia, PA. 1974. p. 40-42.

9.3 Klein, R. and C. Hach. Standard Additions—Uses and Limitations in Spectrophotometric Analysis. *Amer. Lab.* 9:21-27. 1977.

9.4 Mitchell, W.J. and M.R. Midgett. Determining Inorganic and Alkyl Lead Emissions from Stationary Sources. U.S. Environmental Protection Agency, Emission Monitoring and Support Laboratory. Research Triangle Park, NC. (Presented at National APCA Meeting. Houston, June 26, 1978).

9.5 Same as Method 5, Citations 2 to 6 and 7 of Section 7.

When using organic solvents, the standard and sample solutions must be prepared with the same solvent. All solutions should be allowed to come to the same temperature before beginning the determination. When there is no other way to compensate for the matrix interference, the method of additions can be used.

Method of Standard Additions

The method of standard additions is a useful technique which often makes it possible to work in the presence of an interference and still make an accurate determination of the analyte concentration. Figure 9.4 illustrates the method of additions.

Take three aliquots of the sample. Dilute the first to a known volume with solvent. Make up the second and third aliquots to the same volume with suitable quantities of known standards added so that the final solutions contain different additions of the metal to be determined.

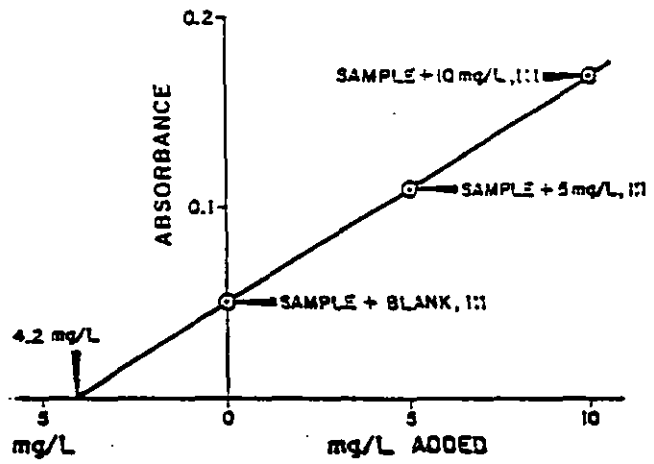

Figure 9.4
Method of Additions

Determine the absorbance for each solution, expanding the scale if necessary to improve readability. Plot the absorbance readings obtained against the added concentration. Extrapolate the resulting straight line through zero absorbance. The intercept on the concentration axis gives the concentration of the metal in the diluted sample solution.

For an accurate determination by the method of additions, the working curve must be linear over the concentration range covered by the sample plus additions. Additions should be of approximately the same concentration as that anticipated for the diluted sample solution.

The method of additions can also be done directly on many atomic absorption spectrophotometers (Figure 9.5). The sample solution containing the unknown is aspirated and the spectrophotometer is set to zero. Then the sample with the standard addition is aspirated and the concentration of the standard is set to 51. The blank solution (which must be representative of the sample matrix) is then read. This negative reading corresponds to the concentration of the element in the sample solution.

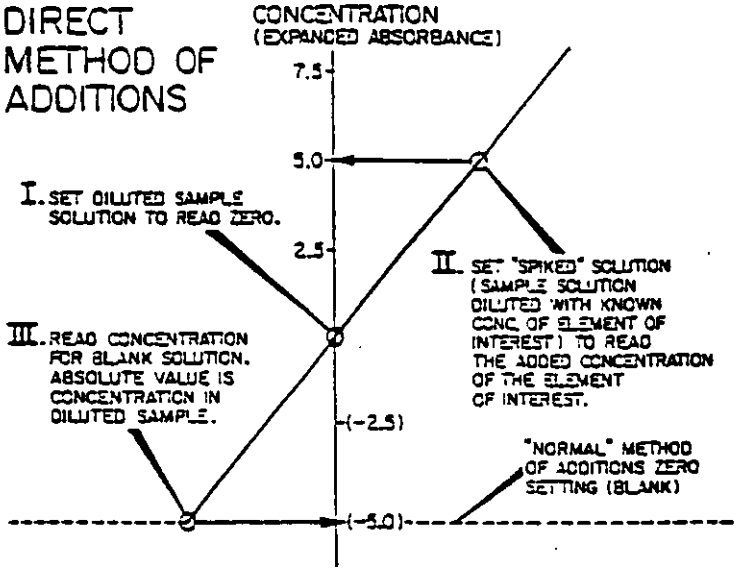

Figure 9.5
Direct Method of Additions

Two factors must be considered when using this method:

1. The sample concentration and the sample-plus-standard-addition concentration used to set the instrument conditions should fall on the linear portion of the calibration graph.

2. There is a maximum negative reading which can be obtained on the instrument. This value must be determined and an appropriate scale expansion used so that this value will not be less than the concentration of the element being determined.

Emission Interferences

At high analyte concentrations, the atomic absorption analysis for highly emissive elements sometimes exhibits poor analytical precision, if the emission signal falls within the spectral bandpass being used. An example of this is Ba in the nitrous oxide-acetylene flame. This degradation occurs because the electronic noise of the photomultiplier is proportional to the total signal incident upon it, even though only the modulated atomic absorption signal is being measured.

There are several ways to compensate for this interference, including decreasing the slit width, increasing the lamp current, diluting the sample, and using a cooler flame.

APPENDIX G

CALIBRATION INFORMATION

NOZZLES

Each new set of nozzles purchased by ETI are first machined and calibrated before being put into field use. Thereafter, whenever it becomes apparent that a nozzle has been damaged, it is again machined and recalibrated. A set of three is matched to within 0.002 inches (Difference between high and low readings). Nozzles are checked prior to each source test.

PITOT TUBES

All pitot tubes used by ETI whether separate or attached to a sampling probe were made by ETI personnel. Prior to being put into field use, they are calibrated. In general, if a type "S" pitot tube is constructed properly, and not positioned too closely to the probe nozzle or any other obstruction, it will have a Cp of 0.83 - 0.87. As long as the pitot tube is not damaged its calibration should not change. All ETI pitot tubes are made to have a Cp of 0.84. If a pitot tube does not initially have a Cp of 0.84, it is altered until a reading of 0.84 is obtained. Pitot tubes are checked before each source test and receive a complete calibration once a year.

DRY GAS METER AND ORIFICE METER

Complete meter box calibrations are performed annually. One point calibrations at the average orifice meter and maximum vacuum readings encountered during the compliance test are performed after each source test. If the dry gas meter calibration factor differs from 1.00 by more than \0.02 then the dry gas meter is repaired and given an annual calibration.

THERMOMETERS, FYRITES, ORSAT AND ORSAT BAGS

Each new thermometer, pyrometer and thermocouple purchased or manufactured by ETI is checked and calibrated before being put into field use. After each source test each temperature sensing device used on the test receives a one point calibration check according to U.S. EPA guidelines.

Fyrites, orsat and orsat bags are checked before and after each source test. If they do not function according to U.S. EPA protocol that piece of equipment is either repaired or replaced.

LABORATORY EQUIPMENT

ETI has a written quality assurance document that covers calibration and maintenance of laboratory equipment. This includes calibration of the analytical balance against Class S weights, and service contracts to maintain traceability to N.B.S. Calibration of thermometers, barometers, stopwatches and wet test meters are traceable to N.B.S. A copy of our quality assurance document may be obtained by written request.

environmental testing inc.

Automatic Post Burner Lines 1 + 2

METHOD 5 PRETEST - POSTEST CALIBRATION CHECKS

Plant Johnson Controls Louisville KY Calibrated by JHB
Meter box number 1401 Date 12/9/89 + 12/19/89

Dry Gas Meter
Pretest meter calibration factor, Y = 1.00 (within ± 2%)
Postest meter calibration factor, Y = 0.984 (within ± 5% of pretest)
Recalibration required? Circle one: yes or (no) If yes new Y = —
Lower cal. factor, Y = — for calculations (pretest or postest)

Dry Gas Meter Thermometers
Was a pretest temperature correction used? Circle one: yes or (no) If yes temperature correction — (within ± 5.4°F over range)
Postest comparison with mercury-in-glass thermometer? (within ±10.8°F at ambient temperature) Recalibration required? Circle one: yes or (no)
Recalibration temperature correction? — (within ±5.4°F over range
If yes, no correction necessary for calculations if meter thermometer temperature is higher; if calibration temperature is higher, add correction to average meter temperature for calculations

Stack Temperature Sensor
Was a pretest temperature correction used? Circle one: yes or (no) If yes temperature correction — °F (within ±1.5% in °R over range)
Average stack temperature of compliance test, 588 °R
Temperature of ref. thermometer for recalibration #1 590 #2 590 °R
(within ± 10% of the average stack temperature)
Temperature of stack thermometer for recalibration #1 584 #2 589 °R
Diff. between ref. and stack thermometer temps. #1 6 #2 1 °R
Do the ref. and stack values agree within ±1.5%? Circle one: (yes) or no
If yes, no correction is necessary for calculations
If no, calculations must be done twice—once with the recorded values and once with the average stack temperature corrected to correspond to the reference temperature differential; both final result values must be reported since there is no way to determine which is correct

Barometer
Was the pretest field barometer reading correct? Circle one: (yes) or no
Postest comparison? 0.005 in. Hg (±0.1 in. Hg) Recalibration required? Circle one: yes or (no) If yes, no correction necessary for calculations when the field barometer has a lower reading; if the mercury-in-glass reading is lower, subtract the difference from the field data readings for the calculations.

	Pretest	Postest
Hg in glass	29.456	28.990
Field	29.455	28.995
Difference	0.001	0.005

Nozzle
Was the nozzle calibrated to the nearest .001 in.? Circle one: (yes) or no

Nozzle #1:	0.504	0.504	0.504	0.505	0.504	: Average 0.504
Nozzle #2:	0.504	0.503	0.503	0.503	0.502	: Average 0.503
Nozzle #3:	0.503	0.502	0.503	0.502	0.502	: Average 0.502

Impinger Thermometer
Was a pretest temperature correction used? Circle one: yes or (no) If yes temperature correction — (within ±5.4°F over range)

POSTEST DRY GAS METER CALIBRATION DATA FORM (English Units)

Test Number 1 Date 12-19-89 Meter Box No. 1401 Plant Johnson Controls Inc Louisville Kentucky

Barometric Pressure, P_b = 29.234 in. Hg Dry Gas Meter No. 1401 Pretest Y 1.00

Orifice manometer setting, inches H_2O ΔH	Gas Volume: Wet test meter, ft³ V_w	Gas Volume: Dry gas meter, ft³ V_d	Temperature: Wet test meter, °F t_w	Temperature: Dry Gas Meter: Inlet °F t_{d_i}	Temperature: Dry Gas Meter: Outlet °F t_{d_o}	Temperature: Dry Gas Meter: Average °F t_d	Time min. θ	Vacuum setting in. Hg	Y_i	$\frac{Y_i V_w P_b (t_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6})(t_w + 460)}$
1.00	10	10.94	62.0	118	89	103.5	14.40	6.0	0.983	$\frac{1(29.234)(103.5+460)}{(29.234+0.1470)(62.0+460)}$
2.00	10	10.95	62.0	119.5	92	105.75	14.43	6.0	0.985	$\frac{1(29.234)(105.75+460)}{(29.234+0.1470)(62.0+460)}$
2.00	10	10.97	62.0	120	93	106.5	14.44	6.0	0.984	$\frac{1(29.234)(106.5+460)}{(29.234+0.1470)(62.0+460)}$
									0.984	

V_w = Gas volume passing through the wet test meter, ft.³

V_d = Gas volume passing throught the dry gas meter, ft.³

t_w = Temperature of the gas in the wet test meter, °F

t_{d_i} = Temperature of the inlet gas of the dry gas meter, °F

t_{d_o} = Temperature of the outlet gas of the dry gas meter, °F

t_d = Average temperature of the gas in the dry gas meter, obtained by the average of t_{d_i} and t_{d_o}, °F

ΔH = Pressure differential across orifice, in. H_2O

Y_i = Ratio of accuracy of wet test meter to dry gas meter for each run

Y = Average ratio of accuracy of wet test meter to dry gas meter for all three runs; tolerance = pretest Y ± 0.05Y

P_b = Barometric pressure, in. Hg

θ = Time of calibration run, min.

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PRETEST – POSTEST THERMOMETER CALIBRATION

Client JOHNSON CONTROLS INC. Louisville Kentucky Date 12-9-89 / 12/15/89

Location ——— Ref. Thermometer #5

Thermometer	Pretest		Postest	
	Temp., °F	Ref. Temp., °F	Temp., °F	Ref. Temp., °F
DGM # 1401	70/71	70	71/71	71
DGM # 1965	70/70	70	71/71	71
DGM # 1348	71/70	70	70/71	71
DGM # —	—	—	—	—
Impinger #1	70	70	71	71
Impinger #2	70	70	71	71
Impinger #3	69	70	71	71
Impinger #4	70	70	71	71
Impinger #5	70	70	70	71
WB # 142	70/70	70	72/71	71
DB # 142	71/71	70	71/71	71
Box #1	70	70	71	71
Box #2	71	70	71	71
Box #3	70	70	71	71
Box #4	70	70	71	71
Box #5	70	70	70	71
Box #6	70	70	71	71
WB Omega 873	70	70	70	71
DB Omega 873	71	70	70	71
WB Omega #142	71/71	70	71/71	71
DB Omega #142	70/71	70	71/71	71
Probe 3' #1	71	70	71	71
Probe 3' #2	71	70	72	71
Probe 4' #1	70	70	71	71
Probe 4' #2	71	70	72	71
—	—	—	—	—

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RAC STAKSAMPLR CALIBRATION SHEET

Meter Box Serial Number: 1401 Barometric Pressure (P_b): 29.240

Leak Check @ 5.8 in. H_2O: OK Date: 12-08-89 Calibrated by: JAB

Pump: OK Pump Oil: OK Clean Quick Connects: OK

Manometers: OK Dry Test Meter: OK Thermometers: OK

Lights: OK Electrical Check: OK Variac: OK

Vacuum Gauge: OK Leak Check @ 27" Hg.: <0.001 CFM

Man. Orifice	CF_w	CF_d	T_w	IT_d	OT_d	T_d ave.	Time t
0.5	5	5.35	62.5	107.5	92.0	99.75	13.10
1.0	5	5.36	62.7	111.0	94.0	102.50	9.46
1.5	10	10.77	62.5	116.0	94.0	105.00	15.66
2.0	10	10.80	62.3	118.0	95.5	106.75	13.49
3.0	10	10.80	62.2	120.5	95.5	108.00	11.10
4.0	10	10.75	62.2	121.0	96.5	108.75	9.65

Calculate Y and $\Delta H_@$ as follows:

$$Y = \frac{CF_w\, P_b\, (T_d \text{ ave.} + 460)}{CF_d\, (P_b + \Delta H/13.6)(T_w + 460)} = 1.00 \qquad \Delta H_@ = \frac{0.0317\ \Delta H}{P_b\, (T_d + 460)} \left(\frac{(T_w + 460)\, t}{CF_w}\right)^2 = 1.86$$

Tolerances: $Y = 0.90 - \underline{1.00} - 1.10\ Y +/- 0.02Y$ $\Delta H_@ = 1.6 - \underline{1.86} - 2.1$ $\Delta H_{@1} +/- 0.15$ in.

CALIBRATION CALCULATIONS PUMP AND ORIFICE METER

Manometer Delta H 0.5 in. H_2O

$$Y = \frac{5 \times 29.240\ (\ 99.75 + 460)}{5.35\ (29.240 + 0.0368)(62.5 + 460)} = 1.002 \qquad \Delta H_@ = \frac{0.01585}{29.240\ (\ 99.75 + 460)} \left(\frac{(62.5 + 460)\ 13.10}{5}\right)^2 = 1.687$$

Manometer Delta H 1.0 in. H_2O

$$Y = \frac{5 \times 29.240\ (102.50 + 460)}{5.36\ (29.240 + 0.0737)(62.7 + 460)} = 1.001 \qquad \Delta H_@ = \frac{0.03170}{29.240\ (102.50 + 460)} \left(\frac{(62.7 + 460)\ 9.46}{5}\right)^2 = 1.858$$

Manometer Delta H 1.5 in. H_2O

$$Y = \frac{10 \times 29.240\ (105.00 + 460)}{10.77\ (29.240 + 0.1103)(62.5 + 460)} = 1.000 \qquad \Delta H_@ = \frac{0.04755}{29.240\ (105.00 + 460)} \left(\frac{(62.5 + 460)\ 15.64}{10}\right)^2 = 1.869$$

Manometer Delta H 2.0 in. H_2O

$$Y = \frac{10 \times 29.240\ (106.75 + 460)}{10.80\ (29.240 + 0.1471)(62.3 + 460)} = 0.999 \qquad \Delta H_@ = \frac{0.06340}{29.240\ (106.75 + 460)} \left(\frac{(62.3 + 460)\ 13.49}{10}\right)^2 = 1.886$$

Manometer Delta H 3.0 in. H_2O

$$Y = \frac{10 \times 29.240\ (108.00 + 460)}{10.80\ (29.240 + 0.2206)(62.2 + 460)} = 0.999 \qquad \Delta H_@ = \frac{0.09510}{29.240\ (108.00 + 460)} \left(\frac{(62.2 + 460)\ 11.10}{10}\right)^2 = 1.915$$

Manometer Delta H 4.0 in. H_2O

$$Y = \frac{10 \times 29.240\ (108.75 + 460)}{10.75\ (29.240 + 0.2941)(62.2 + 460)} = 1.003 \qquad \Delta H_@ = \frac{0.12680}{29.240\ (108.75 + 460)} \left(\frac{(62.2 + 460)\ 9.65}{10}\right)^2 = 1.929$$

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TYPE S PITOT TUBE INSPECTION DATA FORM

Date: 07-24-89
Calibrator: WQB

Specifications:
1.) Pitot tube assembly must be level.
2.) If pitot tube is damaged explain under comments section.
3.) $z = A \sin \tau$ (<0.125) and $w = A \sin \theta$ (<0.03125)
4.) α $<10°$ and β $<5°$

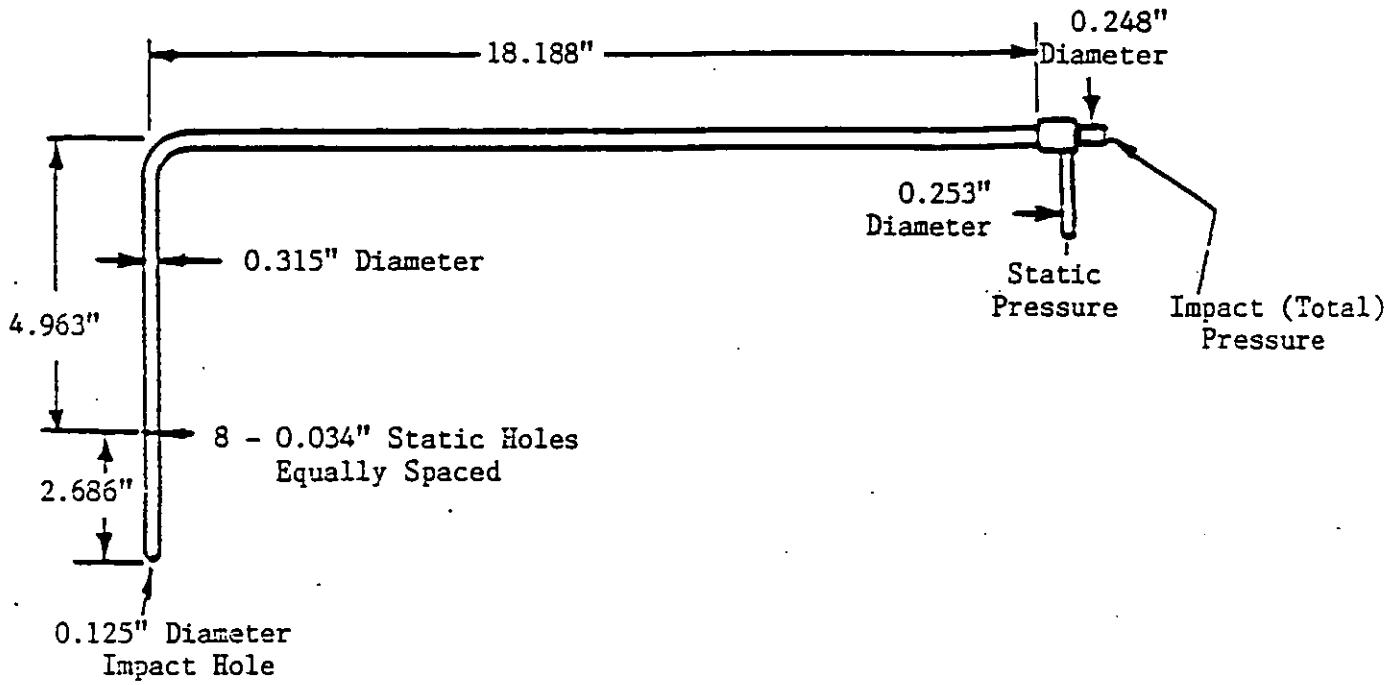
I.D.	α_1°	α_2°	β_1°	β_2°	τ°	θ°	A, in.	z, in.	w, in.	P_A, in.	P_B, in.	D_t, in.
36''- 1	1.0	1.5	1.0	1.5	2.0	0.5	0.730	0.025	0.00640	0.365	0.365	0.376
36''- 2	2.0	2.0	2.0	1.5	0.0	0.5	1.152	0.000	0.01005	0.576	0.576	0.376
40''- 1	1.0	0.0	1.0	0.0	0.5	0.5	1.112	0.010	0.00970	0.556	0.556	0.385
54''- 1	1.0	0.5	0.5	1.0	1.0	1.5	0.960	0.017	0.02513	0.480	0.480	0.385
66''- 1	1.0	0.0	3.0	2.0	0.5	1.5	1.042	0.009	0.02728	0.521	0.521	0.375
96''- 1	0.0	2.0	2.0	1.5	2.0	1.5	0.902	0.032	0.02361	0.451	0.451	0.380
3' - 1	0.0	0.0	0.0	0.0	0.0	1.0	1.057	0.000	0.01845	0.528	0.529	0.376
3' - 2	0.5	0.5	0.0	0.5	0.5	0.0	1.044	0.009	0.00000	0.522	0.522	0.375
3' - 3	0.5	0.5	1.0	0.5	0.5	1.0	1.044	0.009	0.01822	0.522	0.522	0.378
4' - 1	0.5	0.5	0.5	2.0	0.5	1.0	0.950	0.008	0.01658	0.475	0.475	0.378
4' - 2	0.0	0.5	0.0	1.5	1.0	0.5	0.889	0.016	0.00776	0.444	0.445	0.376
4' - 3	3.5	2.5	1.0	1.5	0.5	1.5	0.875	0.008	0.02290	0.437	0.438	0.376
4' - 4	0.5	3.5	2.5	1.5	0.5	1.0	0.837	0.007	0.01461	0.419	0.418	0.375
4' - 5	0.5	1.0	1.5	0.0	0.0	1.5	0.861	0.000	0.02254	0.431	0.430	0.374
4' - 6	0.5	0.0	0.5	0.5	1.0	1.5	0.947	0.017	0.02479	0.474	0.473	0.379
5' - 1	1.0	1.0	1.0	2.0	2.0	0.5	1.044	0.036	0.00911	0.522	0.522	0.373
5' - 2	0.5	1.0	1.0	1.5	0.5	0.5	1.046	0.009	0.00913	0.523	0.523	0.373
5' - 3	0.5	1.0	0.5	0.5	0.5	1.5	1.045	0.009	0.02736	0.523	0.522	0.376
5' - 4	3.0	0.5	0.0	0.5	2.5	1.0	1.027	0.045	0.01792	0.513	0.514	0.376
6' - 1	0.0	1.0	0.0	0.5	1.0	1.0	0.993	0.017	0.01745	0.496	0.497	0.376
6' - 2	0.5	0.0	0.0	0.5	2.0	1.0	1.008	0.035	0.01759	0.504	0.504	0.376
6' - 3	0.5	0.5	1.5	0.5	1.0	1.5	1.004	0.018	0.02628	0.502	0.502	0.377
6' - 4	1.0	0.5	1.0	0.0	2.0	1.0	1.000	0.035	0.01745	0.500	0.500	0.375
8' - 1	1.0	0.0	1.5	2.0	3.0	0.5	0.841	0.044	0.00734	0.420	0.421	0.378
8' - 2	1.0	0.0	2.5	3.0	2.0	2.0	0.871	0.030	0.03039	0.435	0.436	0.373
8' - 3	1.0	0.0	4.0	1.0	0.0	1.5	0.905	0.000	0.02369	0.452	0.453	0.374
8' - 4	2.0	2.0	0.0	0.0	0.0	0.0	1.007	0.000	0.00000	0.504	0.503	0.378
8' - 5	0.0	2.0	0.0	0.0	2.0	1.0	0.965	0.034	0.01684	0.482	0.483	0.380
8' - 6	0.5	2.0	0.5	2.0	1.0	0.0	0.917	0.016	0.00000	0.458	0.459	0.383
8'9''	1.0	2.0	1.5	1.5	1.0	2.0	0.895	0.016	0.03124	0.447	0.448	0.380
9'7''-1	0.0	1.0	0.0	1.0	0.0	0.5	0.905	0.000	0.00790	0.452	0.453	0.377
9'7''-2	0.0	1.0	3.0	2.0	3.0	1.5	0.951	0.050	0.02489	0.475	0.476	0.377
12'6''	1.5	1.5	2.5	2.5	0.0	0.5	0.809	0.000	0.00705	0.404	0.404	0.377

Comments: Only minor filing and cleaning required.

Pitot tubes requiring further calibration: None.

Standard Pitot Tube Calibration

Serial # 160 - 18 - 1



2.7.1	Hemispherical Tip
2.7.2	8.53 Diameters
2.7.3	15.76 Diameters
2.7.4	0.034"
2.7.5	90° curved bend

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WET BULB - DRY BULB - NOx & HOT BOX: BIMETALLIC
TEMPERATURE SENSOR CALIBRATION DATA FORM
TOLERANCE: +/- 5.4 F

DATE: 07/25/89
AMBIENT TEMPERATURE, F : 72
CALIBRATOR: WQB

BAROMETRIC PRESSURE: 29.419
REFERENCE THERMOMETER # 22 & #5

REFERENCE POINT #		SOURCE	REFERENCE THERMOMETER TEMPERATURE, F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, F	TEMPERATURE DIFFERENCE, %
Bimetallic					
Wb1	A.	water bath	72	72	0.00
	B.	oil bath	130	130	0.00
	C.	oil bath	185	184	0.16
	D.	oil bath	242	243	-.14
	E.	oil bath	270	272	-.27
Db1	A.	water bath	72	71	0.19
	B.	oil bath	131	130	0.17
	C.	oil bath	185	185	0.00
	D.	oil bath	243	244	-.14
	E.	oil bath	270	271	-.14
Wb2	A.	water bath	72	72	0.00
	B.	oil bath	131	130	0.17
	C.	oil bath	185	184	0.16
	D.	oil bath	243	243	0.00
	E.	oil bath	270	271	-.14
Db2	A.	water bath	72	70	0.38
	B.	oil bath	131	130	0.17
	C.	oil bath	185	186	-.16
	D.	oil bath	243	243	0.00
	E.	oil bath	270	271	-.14
NOx	A.	water bath	72	71	0.19
	B.	oil bath	131	131	0.00
	C.	oil bath	185	186	-.16
	D.	oil bath	243	244	-.14
	E.	oil bath	270	272	-.27
Hot Box	A.	water bath	72	70	0.38
	B.	oil bath	131	130	0.17
	C.	oil bath	185	184	0.16
	D.	oil bath	244	242	0.28
	E.	oil bath	270	269	0.14

$$\text{TEMPERATURE DIFFERENCE} = \frac{(\text{REF TEMP, F} + 460) - (\text{TEST TEMP, F} + 460)}{\text{REF TEMP, F} + 460} \times 100 <= 1.5\%$$

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WET - BULB & DRY - BULB: OMEGA TEMP
TEMPERATURE SENSOR CALIBRATION DATA FORM
TOLERANCE: +/- 5.4 F

DATE: 07/25/89 BAROMETRIC PRESSURE: 29.419
AMBIENT TEMPERATURE, F : 72 REFERENCE THERMOMETER # 22 & #5
CALIBRATOR: WQB

REFERENCE POINT #		SOURCE	REFERENCE THERMOMETER TEMPERATURE, F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, F	TEMPERATURE DIFFERENCE, %
Omega Temp HH-2 #1					
Db1	A.	water bath	70	71	-.19
	B.	oil bath	120	120	0.00
	C.	oil bath	170	171	-.16
	D.	oil bath	220	221	-.15
	E.	oil bath	260	259	0.14
Wb1	A.	water bath	70	70	0.00
	B.	oil bath	120	121	-.17
	C.	oil bath	170	171	-.16
	D.	oil bath	220	219	0.15
	E.	oil bath	260	261	-.14
Omega Temp HH-2 #2					
Db2	A.	water bath	70	71	-.19
	B.	oil bath	120	121	-.17
	C.	oil bath	171	172	-.16
	D.	oil bath	221	222	-.15
	E.	oil bath	262	262	0.00
Wb2	A.	water bath	70	69	0.19
	B.	oil bath	121	122	-.17
	C.	oil bath	171	170	0.16
	D.	oil bath	222	222	0.00
	E.	oil bath	262	261	0.14
Omega Temp 873-F					
Db1	A.	water bath	71	71	0.00
	B.	oil bath	121	122	-.17
	C.	oil bath	173	173	0.00
	D.	oil bath	222	223	-.15
	E.	oil bath	262	263	-.14
Wb1	A.	water bath	72	71	0.19
	B.	oil bath	122	121	0.17
	C.	oil bath	173	174	-.16
	D.	oil bath	222	222	0.00
	E.	oil bath	262	261	0.14
Omega Temp 873-F High Temp					
	A.	oil bath	384	385	-.12
	B.	n. furnace	450	452	-.22
	C.	n. furnace	575	573	0.19
	D.	n. furnace	800	803	-.24
	E.	n. furnace	1140	1143	-.19

$$\text{TEMPERATURE DIFFERENCE} = \frac{(\text{REF TEMP, F} + 460) - (\text{TEST TEMP, F} + 460)}{\text{REF TEMP, F} + 460} \times 100 <= 1.5\%$$

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METER BOX
TEMPERATURE SENSOR CALIBRATION DATA FORM
TOLERANCE: +/- 5.4 F

DATE: 07/25/89
AMBIENT TEMPERATURE, F : 72
CALIBRATOR: WQB

BAROMETRIC PRESSURE: 29.419
REFERENCE THERMOMETER # 22 & #5

REFERENCE POINT #		SOURCE	REFERENCE THERMOMETER TEMPERATURE, F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, F	TEMPERATURE DIFFERENCE, %
Meter Box					
1264A	A.	ice bath	35	36	-.20
	B.	water bath	70	69	0.19
	C.	oil bath	122	120	0.34
	D.	oil bath	170	169	0.16
1264B	A.	ice bath	35	36	-.20
	B.	water bath	70	70	0.00
	C.	oil bath	123	124	-.17
	D.	oil bath	171	172	-.16
1348A	A.	ice bath	35	33	0.40
	B.	water bath	70	70	0.00
	C.	oil bath	125	127	-.34
	D.	oil bath	171	171	0.00
1348B	A.	ice bath	35	36	-.20
	B.	water bath	70	70	0.00
	C.	oil bath	126	128	-.34
	D.	oil bath	171	170	0.16
1401A	A.	ice bath	35	36	-.20
	B.	water bath	70	70	0.00
	C.	oil bath	128	128	0.00
	D.	oil bath	172	174	-.32
1401B	A.	ice bath	35	34	0.20
	B.	water bath	70	71	-.19
	C.	oil bath	129	131	-.34
	D.	oil bath	172	172	0.00
1965A	A.	ice bath	35	34	0.20
	B.	water bath	70	69	0.19
	C.	oil bath	130	130	0.00
	D.	oil bath	172	174	-.32
1965B	A.	ice bath	35	35	0.00
	B.	water bath	70	70	0.00
	C.	oil bath	134	136	-.34
	D.	oil bath	172	173	-.16

$$\text{TEMPERATURE DIFFERENCE} = \frac{(\text{REF TEMP, F} + 460) - (\text{TEST TEMP, F} + 460)}{\text{REF TEMP, F} + 460} \times 100 <= 1.5\%$$

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PROBE THERMOCOUPLE
TEMPERATURE SENSOR CALIBRATION DATA FORM
TOLERANCE: +/- 5.4 F

DATE: 07/25/89 BAROMETRIC PRESSURE: 29.419
AMBIENT TEMPERATURE, F : 72 REFERENCE THERMOMETER #22 & #5
CALIBRATOR: WQB

REFERENCE POINT #		SOURCE	REFERENCE THERMOMETER TEMPERATURE,F	THERMOCOUPLE POTENTIOMETER TEMPERATURE,F	TEMPERATURE DIFFERENCE, %
Probe - #					
4'-1	A.	oil bath	92	92	0.00
	B.	oil bath	242	242	0.00
	C.	oil bath	383	385	-.24
4'-2	A.	oil bath	92	92	0.00
	B.	oil bath	242	243	-.14
	C.	oil bath	384	385	-.12
5'-1	A.	oil bath	95	93	0.36
	B.	oil bath	242	243	-.14
	C.	oil bath	392	395	-.35
5'-2	A.	oil bath	97	96	0.18
	B.	oil bath	242	242	0.00
	C.	oil bath	384	385	-.12
6'-1	A.	oil bath	98	97	0.18
	B.	oil bath	242	243	-.14
	C.	oil bath	391	392	-.12
6'-2	A.	oil bath	98	96	0.36
	B.	oil bath	244	246	-.28
	C.	oil bath	385	386	-.12
8'-1	A.	oil bath	100	98	0.36
	B.	oil bath	246	248	-.28
	C.	oil bath	385	385	0.00
8'-2	A.	oil bath	100	99	0.18
	B.	oil bath	246	246	0.00
	C.	oil bath	385	385	0.00
8'-3	A.	oil bath	100	98	0.36
	B.	oil bath	246	248	-.28
	C.	oil bath	385	385	0.00
8' 9"	A.	oil bath	102	101	0.18
	B.	oil bath	247	249	-.28
	C.	oil bath	386	386	0.00
9' 7"	A.	oil bath	102	101	0.18
	B.	oil bath	248	249	-.14
	C.	oil bath	391	392	-.12

$$\text{TEMPERATURE DIFFERENCE} = \frac{(\text{REF TEMP, F} + 460) - (\text{TEST TEMP, F} + 460)}{\text{REF TEMP, F} + 460} \times 100 \leq 1.5\%$$

environmental testing inc.

SAMPLE BOX
TEMPERATURE SENSOR CALIBRATION DATA FORM
TOLERANCE: +/- 5.4 F

DATE: 07/25/89 BAROMETRIC PRESSURE: 29.419
AMBIENT TEMPERATURE, F : 72 REFERENCE THERMOMETER # 22 & #5
CALIBRATOR: WQB

REFERENCE POINT #		SOURCE	REFERENCE THERMOMETER TEMPERATURE, F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, F	TEMPERATURE DIFFERENCE, %
Sample Box					
#1	A.	oil bath	122	121	0.17
	B.	oil bath	200	200	0.00
	C.	oil bath	220	220	0.00
	D.	oil bath	260	260	0.00
	E.	oil bath	287	288	-.13
#2	A.	oil bath	122	122	0.00
	B.	oil bath	200	202	-.30
	C.	oil bath	220	219	0.15
	D.	oil bath	260	260	0.00
	E.	oil bath	287	285	0.27
#3	A.	oil bath	122	121	0.17
	B.	oil bath	200	201	-.15
	C.	oil bath	220	220	0.00
	D.	oil bath	264	265	-.14
	E.	oil bath	289	289	0.00
#4	A.	oil bath	122	123	-.17
	B.	oil bath	200	201	-.15
	C.	oil bath	220	219	0.15
	D.	oil bath	264	264	0.00
	E.	oil bath	290	291	-.13
#5	A.	oil bath	123	123	0.00
	B.	oil bath	200	199	0.15
	C.	oil bath	220	221	-.15
	D.	oil bath	268	268	0.00
	E.	oil bath	291	291	0.00
#6	A.	oil bath	123	124	-.17
	B.	oil bath	200	199	0.15
	C.	oil bath	223	221	0.29
	D.	oil bath	268	266	0.27
	E.	oil bath	291	292	-.13
#7	A.	oil bath	123	124	-.17
	B.	oil bath	200	198	0.30
	C.	oil bath	234	232	0.29
	D.	oil bath	273	275	-.27
	E.	oil bath	294	295	-.13
#8	A.	oil bath	124	124	0.00
	B.	oil bath	200	201	-.15
	C.	oil bath	234	233	0.14
	D.	oil bath	274	275	-.14
	E.	oil bath	296	297	-.13

$$\text{TEMPERATURE DIFFERENCE} = \frac{(\text{REF TEMP, F} + 460) - (\text{TEST TEMP, F} + 460)}{\text{REF TEMP, F} + 460} \times 100 <= 1.5\%$$

environmental testing inc.

IMPINGER
TEMPERATURE SENSOR CALIBRATION DATA FORM
TOLERANCE: +/- 2.0 F

DATE: 07/25/89
AMBIENT TEMPERATURE, F : 72
CALIBRATOR: WQB

BAROMETRIC PRESSURE: 29.419
REFERENCE THERMOMETER # 22 & #5

REFERENCE POINT #		SOURCE	REFERENCE THERMOMETER TEMPERATURE, F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, F	TEMPERATURE DIFFERENCE, %
Impinger					
#1	A.	ice bath	32	32	0.00
	B.	water bath	70	70	0.00
	C.	water bath	95	95	0.00
	D.	water bath	130	130	0.00
#2	A.	ice bath	32	32	0.00
	B.	water bath	70	71	-.19
	C.	water bath	95	95	0.00
	D.	water bath	130	130	0.00
#3	A.	ice bath	32	33	-.20
	B.	water bath	70	70	0.00
	C.	water bath	95	95	0.00
	D.	water bath	130	130	0.00
#4	A.	ice bath	32	33	-.20
	B.	water bath	70	71	-.19
	C.	water bath	95	95	0.00
	D.	water bath	130	131	-.17
#5	A.	ice bath	32	33	-.20
	B.	water bath	71	70	0.19
	C.	water bath	95	95	0.00
	D.	water bath	130	130	0.00

$$\text{TEMPERATURE DIFFERENCE} = \frac{(\text{REF TEMP, F} + 460) - (\text{TEST TEMP, F} + 460)}{\text{REF TEMP, F} + 460} \times 100 <= 1.5\%$$

GCA CORPORATION
Precision Scientific Group

3737 West Cortland Street
Chicago, Illinois 60647
Telephone: 312-227-2660
Telex: 254028

February 2, 1984

Environmental Testing
1700 University Commercial Place
Charlotte, N.C. 28213

Attn: Mr. Paul Jenkins

Subj: Certification Wet Test Meter

Dear Mr. Jenskins:

In lieu of any printed certification from our company, we offer as follows our statement on the referenced subject.

> "The Wet Test Meter catalog number 63123, has been tested at our plant facilities using a Meter Prover Bottle NBS registration No. 4897. The Meter was found to perform to our advertised specifications of plus or minus 1/2% error in flow rate and conforms to specifications of ASTM D-1071."

Respectfully,

Bob Husberg
Supervisor, Customer Service

BH/mg

Whatman Inc.

Whatman Inc. • 9 Bridewell Place, Clifton, New Jersey 07014 • Telephone: (201) 777-4825
Telex: 133426 • Cable: REEVEPAP

February 1, 1979

Mr. Paul R. Jenkins, Jr.
Vice-President
Environmental Testing Inc.
1700 University Commercial Place
Charlotte, North Carolina 28213

Dear Mr. Jenkins:

Further to our telephone conversation on January 15, 1979 Reeve Angel Grade 900AF is tested with a Q128 DOP Penetrometer manufactured by the Air Technology Association to measure DOP. This is a more sophisticated unit than that listed in the Federal Register, Part II, Thursday, August 18, 1977, Environmental Protection Agency, Standards of Performance for New Stationary Sources.

Grade 900AF will meet the EPA DOP requirements of 0.05 $\leq$ percent penetration on a 0.3 micron dioctyl phthalate smoke particles as listed on page 41778 of the Federal Register, Vol. 42, No. 160, Thursday, August 18, 1977 under 3. Reagent, 3.1.1 Filters.

I hope this will satisfy your inquiry. If we can be of any further service, please contact us at your convenience.

Very truly yours,

John Zacharias
Vice President
Business Manager, Paper Division, N. A.

JZ/mpm

CORNING

Science Products
Corning Glass Works
Corning, New York 14831 USA
Tel: 607-974-9000

a CORNING Laboratory Sciences Company

November 18, 1986

Mr. Paul Jenkins
Environmental Testing Inc.
1700 University Commercial Place
Charlotte, NC 28213

Dear Mr. Jenkins:

Confirming our telephone conversation, our volumetric apparatus is calibrated in conformance with ASTM Standard E 542.

Very truly yours,

Allen R. Fuller
Product Engineering Supervisor

b10012

METTLER

Weight Traceability Certificate

To: Environmental Testing, Inc
1700 University Commercial Dr.
Charlotte, NC 28213

The balances listed below have been serviced by our representative on
December 27, 1988

This is to certify that the test weights used are traceable to the National Bureau of Standards.

	Analytical	Precision
METTLER identification number of test weights used:	26	
METTLER calibration date of test weights used:	7-1-88	
National Bureau of Standards test number:	737/0670-Met49	

Model and serial number of balances serviced:

AE163-C57742
H54AR-677277

R. T. [illegible]
METTLER Service Representative

12-27-88
Date of Issue

WALTER H. KESSLER COMPANY, INC.

THERMOMETERS KESSLER HYDROMETERS

ONE-SIXTY HICKS STREET • WESTBURY, LONG ISLAND, NEW YORK • 516 EDGEWOOD 4-4064

MANUFACTURERS CERTIFICATE OF CALIBRATION

This is to certify that the instrument listed below has been tested in our temperature calibration laboratory in accordance with the latest procedures in the finest constant temperature equipment available, against National Bureau of Standards certified master standards.

Certified for: Fisher Scientific Company

Description: Thermometer #15-041D -1/201°C in 0.2° Div Total Immersion

Instrument Serial No. 811 007 Date Certified: January 30, 1981

Reading of This Instrument	Reading of N.B.S. Standard (True Temperature)
+0.02C	0.00C
20.00C	20.00C
40.00C	40.00C
59.96C	60.00C
79.98C	80.00C
100.02C	100.00C
119.92C	120.00C
139.98C	140.00C
160.00C	160.00C
180.00C	180.00C
199.86C	200.00C

The tabulated readings apply provided the ice-point reading taken after exposure for not less than 3 days to a temperature of about 25° C (77° F) is +0.02C . If the ice-point reading is found to be higher (or lower) than stated, all other readings will be higher (or lower) by the same amount.

Serial & Test numbers of National Bureau of Standards certified instruments referenced in certification of the thermometer listed above:

NBS Standard M44165,78A-227,M44451,78A-220,78A-601/602

NBS Test No 176240,219883,176240,219883,219606

WALTER H. KESSLER COMPANY, INC.

Irene Ciciulla

KIMBLE
Division of
Owens-Illinois

December 11, 1986

Mr. Paul R. Jenkins
Environmental Testing, Inc.
1700 University Commercial Place
Charlotte, North Carolina 28213

REF: Calibration of volumetric glassware
Mr. P. Jenkins letter 12-5-86

Dear Mr. Jenkins,

Volumetric standards, utilized by Kimble for calibration of class A and B laboratory glassware, are designed to meet applicable calibration requirements of ASTM Standard E 542.

Accuracy of balances, weights and thermometers employed for calibration of volumetric standards is traceable to National Bureau of Standards.

Sincerely,

Lew Horan
Standards Dept.

Mike Mollick
Quality Control

cc: Mr. N. DeBello - M.O.
Mr. E. Trasoras - Q.A.

the OMEGA Group

DATE: 12-10-85

CERTIFICATE OF CALIBRATION

CUSTOMER: ENVIRONMENTAL TESTING INC
1700 UNIV COMMERICAL PL
CHARLOTTE NC 28213

Customer Purchase Order: 2861RO
OMEGA Work Order No: SO 511268760
MODEL: HH-2
SERIAL NO: 14403

OMEGA ENGINEERING certifies that the above instrumentation has been calibrated and tested to meet or exceed the published specifications. This calibration and testing was performed using instrumentation and standards that are traceable to the U.S. National Bureau of Standards.

Reference: NATIONAL BUREAU OF STANDARDS TEST NO(s): 36320

Tony D'Inverno
Supervisor, Instrumentation

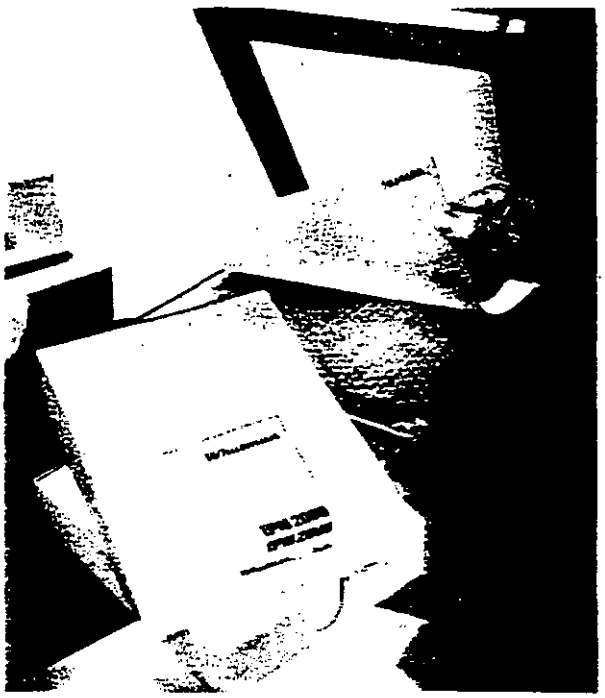
CAL-3

OMEGA ENGINEERING, INC.
OMEGA PRESS
OMEGA INTERNATIONAL CORP.
BIOMEGA
One Omega Drive, Box 4047, Stamford, CT 06907-0047 (203) 359-1660 Telex 996404 Cable OMEGA FAX (203) 359-7700

Whatman
AIR POLLUTION FILTERS

TECHNICAL DATA ON

EPM 2000 AIR SAMPLING FILTERS



SELECTED AS THE EPA STANDARD

EPM 2000 is the new Whatman filter which has been specifically developed for use in high volume air samplers, and has been chosen by the EPA for its technical excellence and overall suitability for use in the nationwide network of Hi-Vol air samplers. The high air flow rate and excellent particle retention characteristics make EPM 2000 the filter of choice for high volume sampling.

- Specifically developed for use with high volume air samplers.
- Chosen by the EPA for their National Air Surveillence Network (Contract No. 68-02-3709).
- Manufactured from 100% borosilicate glass microfibres under strictly controlled conditions.
- Retention efficiency 99.999% for NaCl particles, mass median 0.6 microns.
- Heat-treated after manufacture to remove organic traces.
- No binder used in manufacture for maximum purity.
- Each sheet individually numbered for rapid identification and recording.

EPM 2000 – THE STATE OF THE ART FILTER MEDIUM FOR HI-VOL AIR SAMPLING

Today, more than ever before, concern over the potential effects on human life of toxic particulates in the air, is running high. The sampling and analytical methods employed in the monitoring of air quality are becoming ever more sophisticated.

EPM 2000, as successor to the popular EPM 1000, has been developed to complement these methods as a technically advanced air filtration medium, suitable for both quantitative and qualitative measurements.

HIGH PURITY – HIGH PERFORMANCE

The EPA place specific requirements on the purity and performance of the glass microfibre filters which are used throughout their National Air Surveillence Network of pollution monitoring stations.

EPM 2000 is manufactured from 100% pure borosilicate glass microfibres, with no added binder, under strictly controlled conditions. Maximum purity is ensured by the use of heat treatment after manufacture to remove any traces of organic material which may interfere with subsequent analyses, and closely monitored quality assurance methods are employed. Detailed chemical analyses of trace pollutants can thus be carried out with utmost accuracy and minimum background interference.

EPM 2000 offers high flow rates while simultaneously providing exceptionally high particle retention efficiencies. Complete reliance can be placed on EPM 2000 to provide optimum results in airborne particulate collection.

Each 8" × 10" sheet of EPM 2000 is individually numbered for rapid identification and recording.

AVAILABILITY

Two sizes are available as standard

8" x 10" sheets (packs of 100)	Cat. No. 1882 866
4.7 cm circles (packs of 100)	Cat. No. 1882 047

PUBLICATION NO 888 EPM A