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

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

Background Report Reference

AP-42 Section Number: 12.15

Background Chapter: 4

Reference Number: 15

Title: Source Sampling Report for Johnson Controls, Inc., Middletown, Delaware

Environmental Testing

1988

environmental testing inc.

SOURCE SAMPLING REPORT

FOR

JOHNSON CONTROLS, INC.

South Barton Oxide System

Middletown, Delaware

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

James S. McCormack, PE
November 1988

NORTH CAROLINA PROFESSIONAL SEAL 5178 ENGINEER JAMES S. McCORMACK

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

Paul R. Jenkins, Jr.
November 1988

Memo from Mark Ishihara

1/26/89

Debbie:

As we discussed,

The information contained within is not being declared confidential.

[redacted]

Mark

TABLE OF CONTENTS

INTRODUCTION

Source sampling was performed for the Johnson Controls, Inc., Middletown, Delaware, plant to determine lead emissions from the South Barton Oxide System. Four sampling runs were completed for the South Ventilation Baghouse stack. Three sampling runs were completed for the South Melting Pot stack, and the South Process Baghouse stack on November 1 and 2, 1988. Typical sampling locations are shown in Figures 1 through 3.

The measurements of stack gas flow rate and pollutant concentrations were made according to U.S. Environmental Protection Agency and the Delaware Department of Natural Resources and Environmental Control (DE DNREC) recommendations. Mr. Charles Krick, PE (DE DNREC), and Mr. Ali Mirzakhalili (DE DNREC) were present to observe the test proceedings.

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

South Ventilation Baghouse

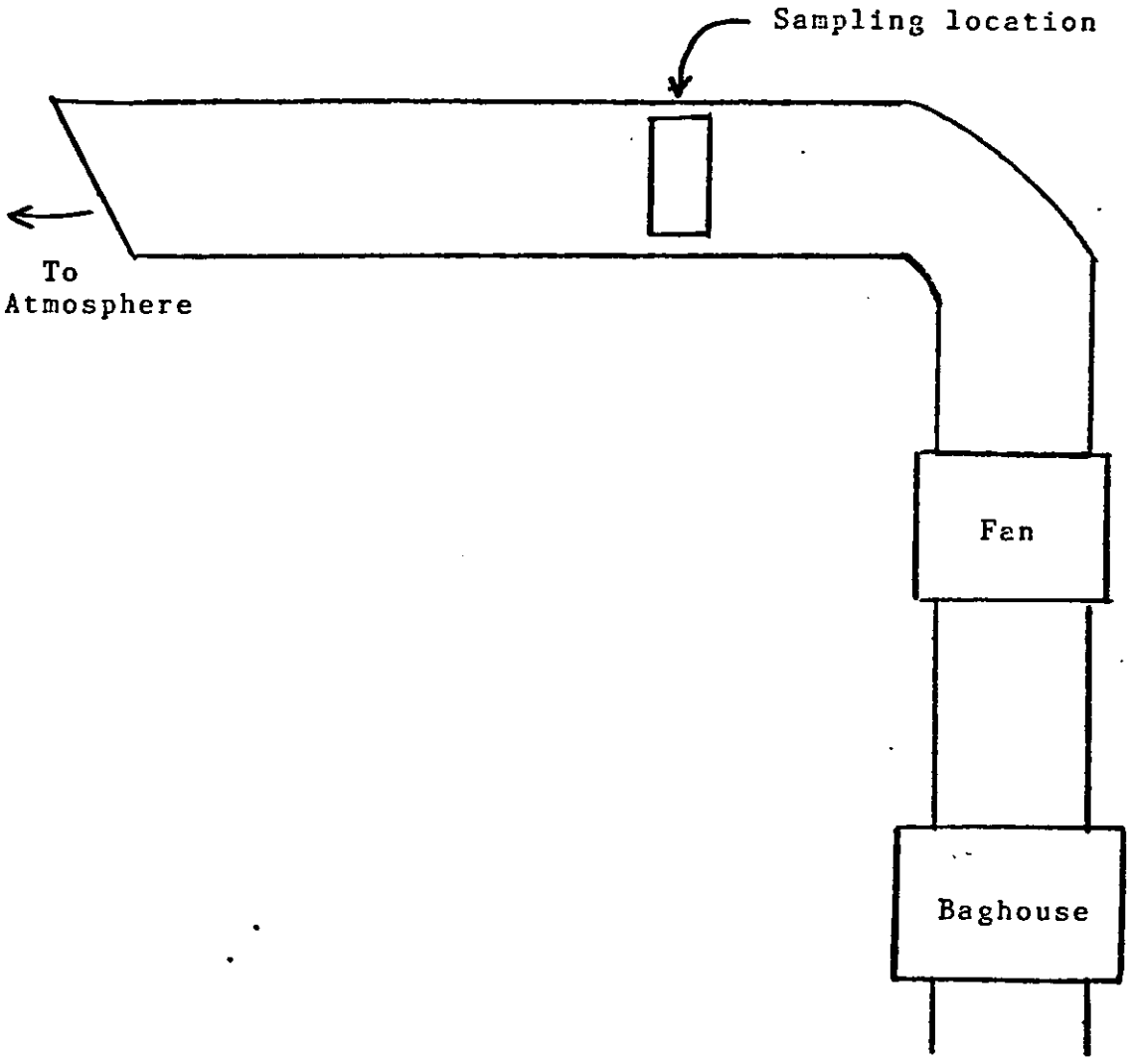
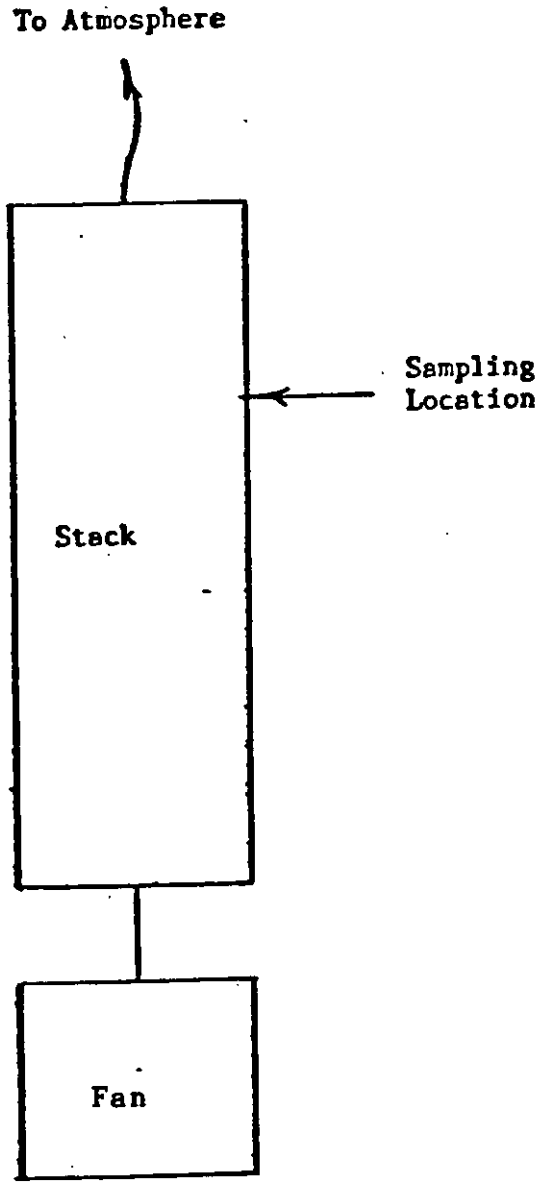


Figure 1

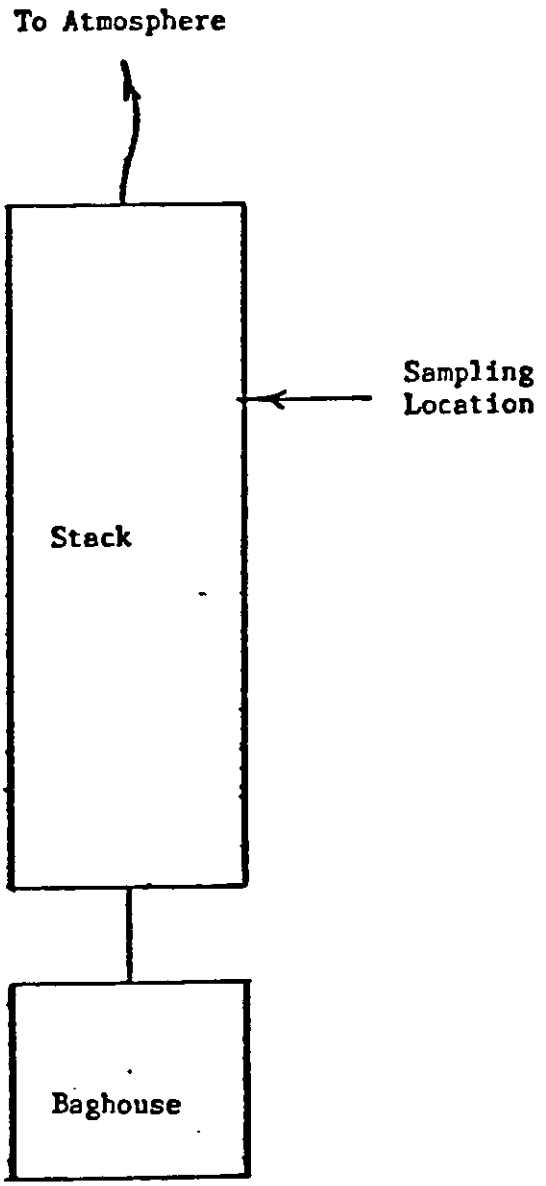
South Melting Pot



FLOW DIAGRAM

Figure 2

South Process Baghouse



FLOW DIAGRAM

Figure 3

SUMMARY OF RESULTS

Tables 1 through 3 present the summary of results from the lead sampling. The mean lead concentration from the South Ventilation Baghouse (runs 2, 3, & 4) was 0.178×10^{-4} grains per dry standard cubic foot. The mean lead emission rate was 0.0000402 pounds per ton. The mean lead concentration from the South Melting Pot was 0.478×10^{-4} grains per dry standard cubic foot. The mean lead emission rate was 0.000530 pounds per ton. The mean lead concentration from the South Process Baghouse was 0.467×10^{-5} grains per dry standard cubic foot. The mean lead emission rate was 0.000162 pounds per ton.

The results of the Delaware field audit samples were 0.9725 mg of lead for sample number 69 and 0.4963 mg of lead for sample number 87.

TABLE 1

SUMMARY OF RESULTS, LEAD SAMPLING

South Ventilation Baghouse

Run Number	1	2	3	4
Date	11/01/88	11/01/88	11/01/88	11/01/88
% Isokinetic	102.82	103.15	102.27	104.42
Volume of Gas Sampled, SCF * Dry	45.036	49.565	40.739	40.130
Stack Gas Flow Rate, SCFM * Dry	331.0	369.7	301.1	295.7
Stack Gas Flow Rate, ACFM	347.8	389.4	315.4	308.9
Lead:				
Catch, mgrams	0.0580	0.0478	0.0780	0.0235
Concentration, grains/ SCF * Dry	0.0000198	0.0000149	0.0000295	0.00000902
Emission Rate, lbs/hr	0.0000563	0.0000471	0.0000761	0.0000229
Process Weight, tons/hr	1.211	1.211	1.211	1.211
Emission Rate, lbs/ton	0.0000465	0.0000389	0.0000628	0.0000189

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

TABLE 2

SUMMARY OF RESULTS, LEAD SAMPLING

South Melting Pot

Run Number	1	2	3
Date	11/02/88	11/02/88	11/02/88
% Isokinetic	100.00	100.99	100.25
Volume of Gas Sampled, SCF * Dry	41.717	41.898	41.773
Stack Gas Flow Rate, SCFM * Dry	1378.5	1371.0	1377.0
Stack Gas Flow Rate, ACFM	1508.9	1496.2	1512.8
Lead:			
Catch, mgrams	0.0398	0.1518	0.1978
Concentration, grains/ SCF * Dry	0.0000147	0.0000558	0.0000729
Emission Rate, lbs/hr	0.000174	0.000656	0.000860
Process Weight, tons/hr	1.063	1.063	1.063
Emission Rate, lbs/ton	0.000163	0.000617	0.000809

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

TABLE 3

SUMMARY OF RESULTS, LEAD SAMPLING

South Process Baghouse

Run Number	1	2	3
Date	11/02/88	11/02/88	11/02/88
% Isokinetic	105.23	102.95	103.55
Volume of Gas Sampled, SCF * Dry	41.458	42.699	40.918
Stack Gas Flow Rate, SCFM * Dry	4240.7	4370.3	4298.9
Stack Gas Flow Rate, ACFM	5614.2	5817.5	5760.1
Lead:			
Catch, mgrams	0.0083	0.0133	0.0163
Concentration, grains/ SCF * Dry	0.00000308	0.00000480	0.00000613
Emission Rate, lbs/hr	0.000112	0.000180	0.000226
Process Weight, tons/hr	1.063	1.063	1.063
Emission Rate, lbs/ton	0.000105	0.000169	0.000213

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

PROCESS DESCRIPTION AND OPERATION

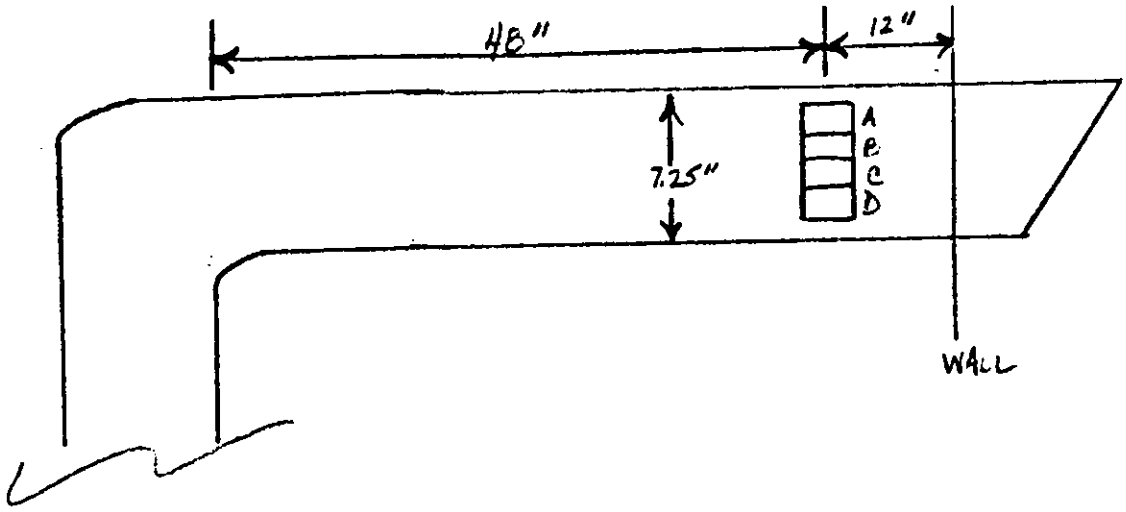
The Johnson Controls, Inc., Middletown, Delaware, plant has a Barton Oxide System (South) that produces lead oxide used for paste. This oxide system has three processes that vent to the atmosphere. The Barton Melting Pot process melts lead ingots. This process is completed when the emissions are discharged to the atmosphere. The resulting molden lead is stirred by paddles while the Process Baghouse filters the remaining lead oxide. Emissions from the baghouse are then discharged to the atmosphere. The Ventilation Baghouse filters the lead oxide while it is being stored for future use at the battery plant. The emissions from the baghouse are discharged to the atmosphere.

No unusual conditions were noted during sampling. The process was continuous and ran in a normal manner.

LOCATION OF SAMPLING POINTS

The dimensions of each stack and the locations of the sampling points are shown in Figures 4 through 6. The stack cross section for the South Ventilation Baghouse was divided into 16 equal areas. The ports were labeled A, B, C and D. Each point was sampled for a period of 4 minutes per point which yielded a total test time of 64 minutes per run. The stack cross section for the South Melting Pot was divided into 24 equal areas. The ports were labeled A and B. Each point was sampled for a period of 2.5 minutes per point which yielded a total test time of 60 minutes per run. The stack cross section for the South Process Baghouse 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.



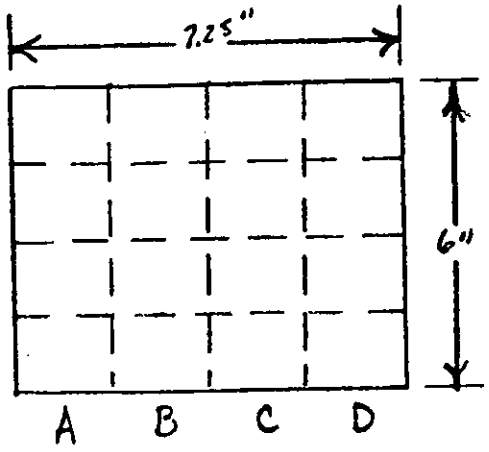
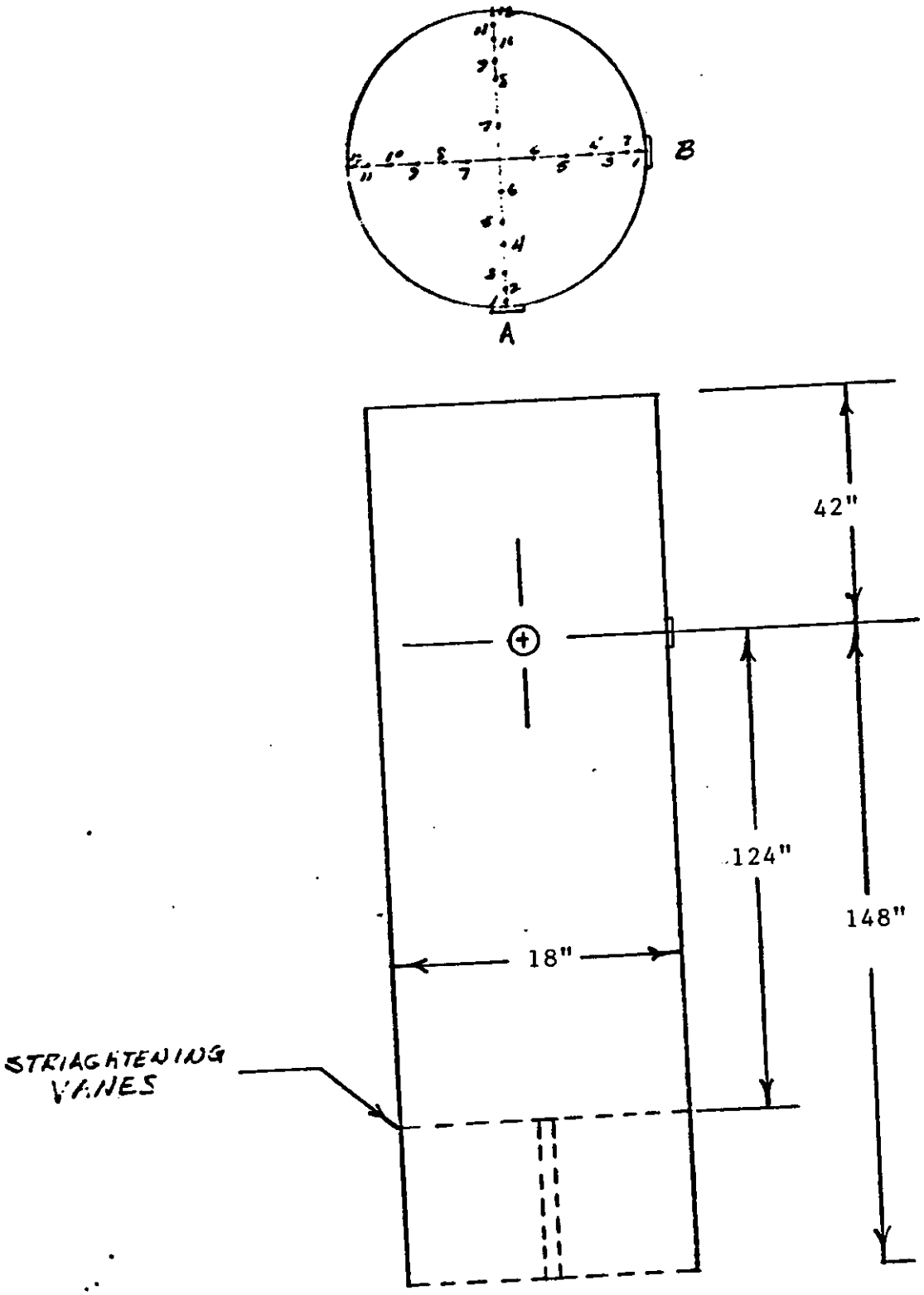
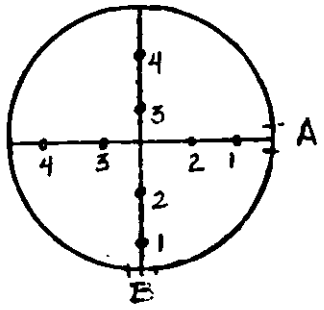


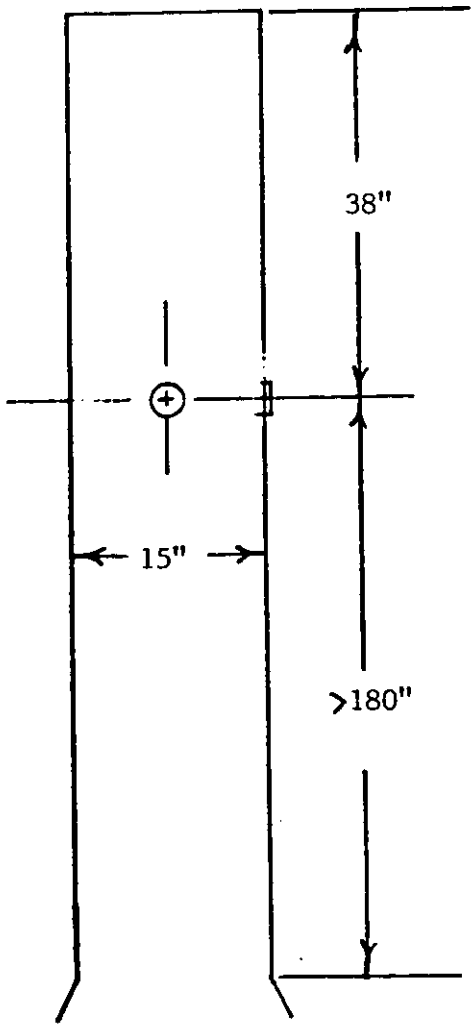
Figure 4



LOCATION OF SAMPLING POINTS

Figure 5





LOCATION OF SAMPLING PORTS AND POINTS

Figure 6

SAMPLING AND ANALYTICAL PROCEDURES

All sampling and analytical procedures used were those recommended by the U.S. Environmental Protection Agency and the DE DNREC. All Audit samples and source test samples were compared to Atomic Absorption Spectroscopy by using the "Method of Standard Additions" as outlined in the Perkin Elmer Corporation Manual (Citation 9.4) as required by the Federal Register Volume 47, No. 74, Friday, April 16, 1982 (Section 5.4.2). The results of the source test samples agreed within ±5% between Atomic Absorption Spectroscopy and the "Method of Standard Additions". Therefore, results used in the calculations were those obtained by Atomic Absorption Spectroscopy.

Complete details are found in Appendix E 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 (Methods 1 through 4), and the Federal Register, Volume 47, Number 74, 16 April 1982 (Method 12), Recommended Procedure for Sample Traverses In Ducts Smaller Than 12 Inches In Diameter, 03 January 1977 and Perkin Elmer Corporation Manual (Citation 9.4).

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 Method 12 Lead Results

Johnson Controls Inc. Middletown DE South Ventilation Baghouse

Run Number		1	2	3	4
Date		11/ 1/88	11/ 1/88	11/ 1/88	11/ 1/88
DN	Sample nozzle dia., in.	0.339	0.336	0.339	0.336
TT	Net time of test	64	64	64	64
PB	Barometric pressure, in. Hg.	29.95	29.95	29.95	29.95
PM	Average orifice pressure drop, in. H2O	1.748	2.139	1.396	1.351
VM	Volume of dry gas sampled, cu. ft. at meter conditions	47.10	52.70	43.39	42.67
TM	Average gas meter temp. in degrees F.	94.91	104.69	104.63	103.63
VMSTD	Volume of dry gas sampled at standard conditions*, SCF	45.036	49.565	40.739	40.130
VW	Total water collected in impingers + silica gel, ML.	14.6	16.4	13.0	13.1
VMV	Volume of water vapor at standard conditions*, SCF	0.688	0.772	0.612	0.617
PMV	Percent moisture by volume	1.504	1.534	1.480	1.514
MD	Mole fraction dry gas	0.9850	0.9847	0.9852	0.9849
PCO2	Percent CO2 by volume, dry	0.00	0.00	0.00	0.00
PO2	Percent O2 by volume, dry	20.90	20.90	20.90	20.90
PCO	Percent CO by volume, dry	0.00	0.00	0.00	0.00
PN2	Percent N2 by volume, dry	79.10	79.10	79.10	79.10
MWD	Molecular weight-dry stack gas	28.836	28.836	28.836	28.836
MW	Molecular weight-stack gas	28.673	28.670	28.676	28.672
CP	Pitot tube coefficient	0.84	0.84	0.84	0.84
DPS	Average velocity head of stack gas, inches water	0.3336	0.3730	0.3029	0.2971
TS	Average stack temperature, F	87.13	88.25	85.69	83.94

PSI	Static pressure of stack gas, inches Hg.	0.019	0.019	0.019	0.019
PS	Stack pressure, absolute	29.969	29.969	29.969	29.969
VS	Average stack velocity, FPM	1146.8	1283.8	1040.0	1018.5
AS	Stack area, inches sqrd.	43.5	43.5	43.5	43.5
QS	Stack flow rate, dry, standard conditions, DSCFM	331.0	369.7	301.1	295.7
QSW	Stack flow rate, wet, standard conditions, WSCFM	336.1	375.5	305.6	300.2
QA	Actual stack flow rate, ACFM	347.8	389.4	315.4	308.9
PERI	Percent isokinetic	102.82	103.15	102.27	104.42
FMF	Lead, Mg.	0.0580	0.0478	0.0780	0.0235
CAN	Lead, GR/DSCF	0.198E-04	0.149E-04	0.295E-04	0.902E-05
CAM	Lead, GR/WSCF	0.201E-04	0.151E-04	0.299E-04	0.916E-05
CAT	Lead, GR/ACF	0.189E-04	0.141E-04	0.281E-04	0.863E-05
CAW	Lead, LB/HR	0.563E-04	0.471E-04	0.761E-04	0.229E-04
CAZ	Lead, LB/TON	0.465E-04	0.389E-04	0.628E-04	0.189E-04
FNP	Net sampling points	16	16	16	16
RW	Process weight, Tons/Hr	1.211	1.211	1.211	1.211

*68 Degrees F. 29.92 Inches Hg.

Method 12 Lead Calculations Test Number 1

Johnson Controls Inc. Middletown DE South Ventilation Baghouse

Volume of Dry Gas Sampled at Standard Conditions

$$VMSTD = \frac{17.64 * VM * (PB + PM / 13.6)}{TM + 460} = 45.036$$

Volume of Water Vapor at Standard Conditions

$$VMV = 0.04709 * VW = 0.688$$

Percent Moisture in Stack Gas

$$PMV = \frac{100 * VMV}{VMSTD + VMV} = 1.504$$

Mole Fraction of Dry Gas

$$MD = \frac{100 - PMV}{100} = 0.9850$$

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

$$MW = MWD * MD + 18 * (1-MD) = 28.673$$

Stack Gas Velocity at Stack Conditions

$$VS = 5129.4 * CP * DPS * SQRT(TS + 460)/(PS * MW) = 1146.8$$

Stack Gas Volumetric Flow at Standard Conditions, Dry

$$QS = \frac{0.123 * VS * AS * PS * MD}{TS + 460} = 331.0$$

Stack Gas Volumetric Flow at Stack Conditions

$$QA = \frac{QS * (TS + 460)}{17.64 * PS * MD} = 347.8$$

Percent Isokinetic

$$PERI = \frac{1039 * (TS + 460) * VMSTD}{VS * TT * PS * MD * DN * DN} = 102.82$$

Lead Loading -- Probe, Cyclone, Filter, Impingers
(At Standard Conditions)
CAN = 0.0154 * FMF / VMSTD = 0.198E-04

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

$$CAT = \frac{17.64 * CAN * PS * MD}{TS + 460} = 0.189E-04$$

Lead Lb/Hr -- Probe, Cyclone, Filter, Impingers
(At Standard Conditions)
CAW = 0.00857 * CAN * QS = 0.563E-04

Lead Lb/Ton -- Probe, Cyclone, Filter, Impingers
(At Standard Conditions)
CAZ = CAW / RW = 0.465E-04

Summary of Method 12 Lead Results

Johnson Controls Inc. Middletown DE South Melting Pot

Run Number		1	2	3
Date		11/ 2/88	11/ 2/88	11/ 1/88
DN	Sample nozzle dia., in.	0.405	0.405	0.405
TT	Net time of test	60	60	60
PB	Barometric pressure, in. Hg.	29.57	29.57	29.57
PM	Average orifice pressure drop, in. H2O	1.641	1.610	1.652
VM	Volume of dry gas sampled, cu. ft. at meter conditions	41.83	41.83	42.13
TM	Average gas meter temp. in degrees F.	65.17	62.85	68.23
VMSTD	Volume of dry gas sampled at standard conditions*, SCF	41.717	41.898	41.773
VW	Total water collected in impingers + silica gel, ML.	14.8	9.8	13.7
VMV	Volume of water vapor at standard conditions*, SCF	0.697	0.461	0.645
PMV	Percent moisture by volume	1.643	1.089	1.521
MD	Mole fraction dry gas	0.9836	0.9891	0.9848
PCO2	Percent CO2 by volume, dry	0.00	0.00	0.00
PO2	Percent O2 by volume, dry	20.90	20.90	20.90
PCO	Percent CO by volume, dry	0.00	0.00	0.00
PN2	Percent N2 by volume, dry	79.10	79.10	79.10
MWD	Molecular weight-dry stack gas	28.836	28.836	28.836
MW	Molecular weight-stack gas	28.658	28.718	28.671
CP	Pitot tube coefficient	0.84	0.84	0.84
DPS	Average velocity head of stack gas, inches water	0.2424	0.2403	0.2425
TS	Average stack temperature, F	101.54	103.00	104.29

PSI	Static pressure of stack gas, inches Hg.	-0.003	-0.003	-0.003
PS	Stack pressure, absolute	29.567	29.567	29.567
VS	Average stack velocity, FPM	850.4	843.2	852.6
AS	Stack area, inches sqrd.	254.5	254.5	254.5
QS	Stack flow rate, dry, standard conditions, DSCFM	1378.5	1371.0	1377.0
QSW	Stack flow rate, wet, standard conditions, WSCFM	1401.5	1386.1	1398.2
QA	Actual stack flow rate, ACFM	1508.9	1496.2	1512.8
PERI	Percent isokinetic	100.00	100.99	100.25
FMF	Lead, Mg.	0.0398	0.1518	0.1978
CAN	Lead, GR/DSCF	0.147E-04	0.558E-04	0.729E-04
CAM	Lead, GR/WSCF	0.149E-04	0.564E-04	0.740E-04
CAT	Lead, GR/ACF	0.134E-04	0.511E-04	0.664E-04
CAW	Lead, LB/HR	0.174E-03	0.656E-03	0.860E-03
CAZ	Lead, LB/TON	0.163E-03	0.617E-03	0.809E-03
FNP	Net sampling points	24	24	24
RW	Process weight, Tons/Hr	1.063	1.063	1.063

*68 Degrees F. 29.92 Inches Hg.

Lead Loading -- Probe, Cyclone, Filter, Impingers
(At Standard Conditions)
CAN = 0.0154 * FMF / VMSTD = 0.147E-04

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

$$CAT = \frac{17.64 * CAN * PS * MD}{TS + 460} = 0.134E-04$$

Lead Lb/Hr -- Probe, Cyclone, Filter, Impingers
(At Standard Conditions)
CAW = 0.00857 * CAN * QS = 0.174E-03

Lead Lb/Ton -- Probe, Cyclone, Filter, Impingers
(At Standard Conditions)
CAZ = CAW / RW = 0.163E-03

Method 12 Lead Calculations Test Number 1

Johnson Controls Inc. Middletown DE South Melting Pot

Volume of Dry Gas Sampled at Standard Conditions

$$VMSTD = \frac{17.64 * VM * (PB + PM / 13.6)}{TM + 460} = 41.717$$

Volume of Water Vapor at Standard Conditions

$$VMV = 0.04709 * VW = 0.697$$

Percent Moisture in Stack Gas

$$PMV = \frac{100 * VMV}{VMSTD + VMV} = 1.643$$

Mole Fraction of Dry Gas

$$MD = \frac{100 - PMV}{100} = 0.9836$$

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

$$MW = MWD * MD + 18 * (1-MD) = 28.658$$

Stack Gas Velocity at Stack Conditions

$$VS = 5129.4 * CP * DPS * SQRT(TS + 460)/(PS * MW) = 850.4$$

Stack Gas Volumetric Flow at Standard Conditions, Dry

$$QS = \frac{0.123 * VS * AS * PS * MD}{TS + 460} = 1378.5$$

Stack Gas Volumetric Flow at Stack Conditions

$$QA = \frac{QS * (TS + 460)}{17.64 * PS * MD} = 1508.9$$

Percent Isokinetic

$$PERI = \frac{1039 * (TS + 460) * VMSTD}{VS * TT * PS * MD * DN * DN} = 100.00$$

Summary of Method 12 Lead Results

Johnson Controls Inc. Middletown DE South Process Baghouse

Run Number		1	2	3
Date		11/ 2/88	11/ 2/88	11/ 2/88
DN	Sample nozzle dia., in.	0.187	0.189	0.186
TT	Net time of test	60	60	60
PB	Barometric pressure, in. Hg.	29.55	29.55	29.55
PM	Average orifice pressure drop, in. H2O	1.609	1.708	1.675
VM	Volume of dry gas sampled, cu. ft. at meter conditions	41.50	42.89	41.06
TM	Average gas meter temp. in degrees F.	63.88	65.81	65.25
VMSTD	Volume of dry gas sampled at standard conditions*, SCF	41.458	42.699	40.918
VW	Total water collected in impingers + silica gel, ML.	11.1	10.4	13.0
VMV	Volume of water vapor at standard conditions*, SCF	0.523	0.490	0.612
PMV	Percent moisture by volume	1.245	1.134	1.474
MD	Mole fraction dry gas	0.9875	0.9887	0.9853
PCO2	Percent CO2 by volume, dry	0.00	0.00	0.00
PO2	Percent O2 by volume, dry	20.90	20.90	20.90
PCO	Percent CO by volume, dry	0.00	0.00	0.00
PN2	Percent N2 by volume, dry	79.10	79.10	79.10
MWD	Molecular weight-dry stack gas	28.836	28.836	28.836
MW	Molecular weight-stack gas	28.701	28.713	28.676
CP	Pitot tube coefficient	0.84	0.84	0.84
DPS	Average velocity head of stack gas, inches water	1.1797	1.2186	1.2040
TS	Average stack temperature, F	220.00	224.50	226.63

PSI	Static pressure of stack gas, inches Hg.	-0.065	-0.065	-0.065
PS	Stack pressure, absolute	29.485	29.485	29.485
VS	Average stack velocity, FPM	4556.4	4721.4	4674.8
AS	Stack area, inches sqrd.	176.7	176.7	176.7
QS	Stack flow rate, dry, standard conditions, DSCFM	4240.7	4370.3	4298.9
QSW	Stack flow rate, wet, standard conditions, WSCFM	4294.1	4420.4	4363.2
QA	Actual stack flow rate, ACFM	5614.2	5817.5	5760.1
PERI	Percent isokinetic	105.23	102.95	103.55
FMF	Lead, Mg.	0.0083	0.0133	0.0163
CAN	Lead, GR/DSCF	0.308E-05	0.480E-05	0.613E-05
CAM	Lead, GR/WSCF	0.312E-05	0.485E-05	0.623E-05
CAT	Lead, GR/ACF	0.233E-05	0.360E-05	0.458E-05
CAW	Lead, LB/HR	0.112E-03	0.180E-03	0.226E-03
CAZ	Lead, LB/TON	0.105E-03	0.169E-03	0.213E-03
FNP	Net sampling points	8	8	8
RW	Process weight, Tons/Hr	1.063	1.063	1.063

*68 Degrees F. 29.92 Inches Hg.

Method 12 Lead Calculations Test Number 1

Johnson Controls Inc. Middletown DE South Process Baghouse

Volume of Dry Gas Sampled at Standard Conditions

$$VMSTD = \frac{17.64 * VM * (PB + PM / 13.6)}{TM + 460} = 41.458$$

Volume of Water Vapor at Standard Conditions

$$VMV = 0.04709 * VW = 0.523$$

Percent Moisture in Stack Gas

$$PMV = \frac{100 * VMV}{VMSTD + VMV} = 1.245$$

Mole Fraction of Dry Gas

$$MD = \frac{100 - PMV}{100} = 0.9875$$

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

$$MW = MWD * MD + 18 * (1-MD) = 28.701$$

Stack Gas Velocity at Stack Conditions

$$VS = 5129.4 * CP * DPS * SQRT(TS + 460)/(PS * MW) = 4556.4$$

Stack Gas Volumetric Flow at Standard Conditions, Dry

$$QS = \frac{0.123 * VS * AS * PS * MD}{TS + 460} = 4240.7$$

Stack Gas Volumetric Flow at Stack Conditions

$$QA = \frac{QS * (TS + 460)}{17.64 * PS * MD} = 5614.2$$

Percent Isokinetic

$$PERI = \frac{1039 * (TS + 460) * VMSTD}{VS * TT * PS * MD * DN * DN} = 105.23$$

Lead Loading -- Probe, Cyclone, Filter, Impingers
(At Standard Conditions)
CAN = 0.0154 * FMF / VMSTD = 0.308E-05

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

$$CAT = \frac{17.64 * CAN * PS * MD}{TS + 460} = 0.233E-05$$

Lead Lb/Hr -- Probe, Cyclone, Filter, Impingers
(At Standard Conditions)
CAW = 0.00857 * CAN * QS = 0.112E-03

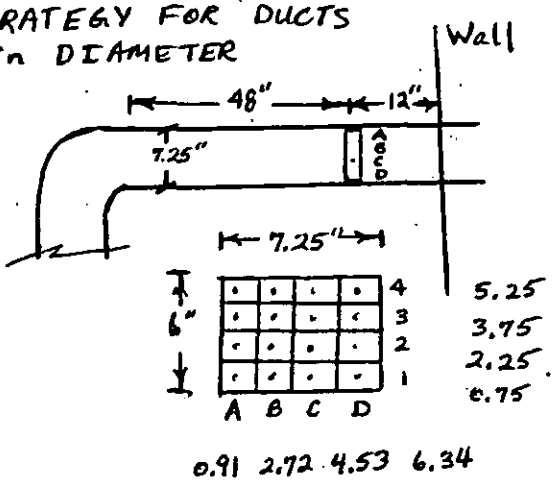
Lead Lb/Ton -- Probe, Cyclone, Filter, Impingers
(At Standard Conditions)
CAZ = CAW / RW = 0.105E-03

APPENDIX B

FIELD DATA

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

STEADY FLOW SAMPLING STRATEGY FOR DUCTS BETWEEN 6" and 12" in DIAMETER



Plant Johnson Controls - Middletown, DE

Date 11-01-88

Sampling location South Ventilation Baghouse

Inside of far wall to outside of nipple (X) 6"

Inside of near wall to outside of nipple (nipple length) (Y) 0.0"

Stack I.D. (X-Y) 6" x 7.25"

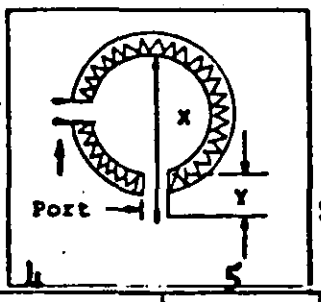
Nearest upstream disturbance 1.83 dd

Nearest downstream disturbance 7.31 dd

Calculated by PRJ

Eq. Diameter = $\frac{2LW}{L+W}$ = 6.57"

4 x 4 matrix



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	0.125	6	0.75	0	0.75
2	0.375	6	2.25	0	2.25
3	0.625	6	3.75	0	3.75
4	0.875	6	5.25	0	5.25

METHOD 2 GAS VELOCITY AND CYCLONIC FLOW DETERMINATION

Plant and City Johnson Controls - Middletown, DE Run Date 11-01-88

Sampling Location South Ventilation Baghouse Clock Time 1315

Run Number 1 Operator PRS - RBM - JAF Amb. Temp., °F 71

Bar. Press., in. Hg 29.95 Static Press., in. H_2O +0.26

Stack Press., in. Hg 29.969 Static Press., in. Hg +0.019

Stack Dimension, in. - Diam. or side 1 7.25" side 2 6.00"

Pitot Tube (C_p) 0.99 Pitot Tube Leak Check <0.1 @ 4.2 in. H_2O

Field data — Not possible in square duct

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 1 0.91X	0.75	0.080	85		
2	2.25	0.085			
3	3.75	0.070			
4	5.25	0.090			
B 1 2.72X	0.75	0.075			
2	2.25	0.080			
3	3.75	0.085			
4	5.25	0.090			
C 1 4.53X	0.75	0.090			
2	2.25	0.085			
3	3.75	0.090			
4	5.25	0.095			
D 1 6.34X	0.75	0.055			
2	2.25	0.090			
3	3.75	0.095			
4	5.25	0.100			
		0.083	0.098	Average angle (α)[a]	

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

NOMAGRAPH DATA

$\Delta H_@$ 1.86 T_m 100 %M 1.3 P_s/P_m 1.00 C 1.15 D_b 86

(Type S) $\overline{\Delta p}$ 0.098 T_s 86 DN_c 0.355 DN_a 0.339 Ref. Δp 0.12 W_b 65/21

METHOD 5 PARTICULATE FIELD DATA

Plant Johnson Controls - Middletown, DE
Run No. 1
Location South Ventilation Baghouse
Date 11-01-88
Operator PRS - RBM - JAF
Sample Box No. 1
Meter Box No. 1348
Filter No. M12-1
Probe No. 1
Pitot Tube Cp 0.99

Very Important — Fill In All Blanks
Leak Checks: Beg. @ 15" 0.001
End @ 5½" 0.001
Pitot Tube: ⊕ <0.1 @ 4.0 "H₂O
⊖ <0.1 @ 4.0 "H₂O
Static Pressure: +0.26 "H₂O
Start: 1340 - 1490
Finish: 1412 1512
Observer C. Krick Agency DE DNREC

Bar. Press. "Hg 29.95
Meter Box ΔH@ 1.86 Y = 1.00
Assumed Tm, °F 100
Dry Bulb, °F 86
Wet Bulb, °F 65
Db - Wb, °F 21
Assumed Moisture % 1.3%
Ps/Pm 1.00
C Factor 1.15

Ambient Temp., °F 71
Heater Box Setting, °F 250
Probe Tip Dia., in. 0.339
Probe Length 3' glass lined
Probe Heater Setting 85%
Average Δp 0.098 Δp 0.12
Average ΔH 1.52 ΔH Ref
Process Weight
Steam Load NA
Steam Pressure NA

Correction Factor 0.99/0.84 = 1.179 (std / Type S)

Pre	Post	Point	Clock Time	Dry Gas Meter, Cu. Ft.	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
0.065	0.070	A1	0	313.70	0.077	1.20	1.20	80	77	2.5	240	55	86		
0.070	0.110	2	4	316.13	0.083	1.28	1.28	83	77	2.8	245	54	86		
0.065	0.110	3	8	318.62	0.077	1.20	1.20	89	78	2.5	250	54	86		
0.060	0.110	4	12	321.04	0.071	1.10	1.10	94	80	2.1	240	56	86		
0.085	0.110	B1	16/0	323.38	0.100	1.53	1.53	99	82	2.9	245	55	86		
0.085	0.105	2	4	326.10	0.100	1.53	1.53	104	84	3.0	250	54	87		
0.080	0.110	3	8	328.84	0.094	1.45	1.45	107	86	2.9	255	55	87		
0.080	0.110	4	12	331.54	0.094	1.45	1.45	110	88	2.9	260	55	87		
0.125	0.125	C1	16/0	334.26	0.124	1.90	1.90	93	89	3.1	260	51	88		
0.120	0.120	2	4	337.28	0.141	2.20	2.20	90	89	3.8	260	52	88		
0.120	0.120	3	8	340.61	0.141	2.20	2.20	106	90	3.8	265	53	88		
0.120	0.125	4	12	344.00	0.141	2.20	2.20	110	91	4.0	265	57	88		
0.120	0.120	D1	16/0	347.38	0.141	2.20	2.20	116	93	4.0	260	55	88		
0.125	0.130	2	4	350.81	0.147	2.25	2.25	118	94	(4.0)	260	54	88		
0.120	0.125	3	8	354.20	0.141	2.20	2.20	119	96	3.5	250	58	87		
0.126	0.125	4	12	357.54	0.136	2.08	2.08	120	97	2.2	245	60	88		
			16	360.80											

0.074 .104
.103

METHOD 5 PARTICULATE FIELD DATA

Plant Johnson Controls - Middletown, DE
Run No. 2
Location South Ventilation Baghouse
Date 1B-01-88
Operator PKJ - RBM - JAF
Sample Box No. 2
Meter Box No. 1348
Filter No. M12-2
Probe No. 2
Pitot Tube Cp 0.99

Very Important — Fill In All Blanks
Leak Checks: Beg. @ 15" 0.007
End @ 5" 0.001
Pitot Tube: ⊕<0.1 @ 4.2 "H2O
⊖<0.1 @ 4.2 "H2O
Static Pressure: +0.26 "H2O
Start: 1540
Finish: 1701
Observer C. Krick Agency DE DNREC

Bar. Press. "Hg 29.95
Meter Box ΔH@ 1.86 Y = 1.00
Assumed Tm, °F 100
Dry Bulb, °F 86
Wet Bulb, °F 65
Db - Wb, °F 21
Assumed Moisture % 1.37
Ps/Pm 1.00
C Factor 1.15

Ambient Temp., °F 72
Heater Box Setting, °F 250
Probe Tip Dia., in. 0.336
Probe Length 3' glass lined
Probe Heater Setting 85%
Average Δp 0.098 Δp 0.12
Average ΔH 1.52 ΔH Ref
Process Weight
Steam Load NA
Steam Pressure NA

C_F = 1.179

Pre	Post	Point	Clock Time	Dry Gas Meter, Cu. Ft.	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
0.115	0.115	A1	0	361.10	0.136	2.08	2.08	98	92	1.0	260	61	89		
0.125	0.115	2	4	364.35	0.147	2.25	2.25	104	94	1.5	260	62	89		
0.125	0.120	3	8	367.69	0.147	2.25	2.25	111	95	1.5	260	63	89		
0.120	0.115	4	12	371.10	0.141	2.20	2.20	115	95	1.5	255	61	89		
0.120	0.120	B1	16/0	374.42	0.141	2.20	2.20	109	96	1.5	255	60	88		
0.115	0.110	2	4	377.67	0.136	2.08	2.08	112	95	1.5	255	60	88		
0.115	0.110	3	8	381.03	0.136	2.08	2.08	114	95	1.5	260	61	88		
0.110	0.110	4	12	384.23	0.130	1.97	1.97	118	96	2.0	260	62	88		
0.115	0.105	C1	16/0	387.43	0.136	2.08	2.08	110	96	2.0	270	58	88		
0.110	0.110	2	4	390.69	0.130	1.97	1.97	114	97	1.7	270	58	88		
0.125	0.115	3	8	393.79	0.147	2.25	2.25	117	98	2.2	260	57	88		
0.120	0.130	4	12	397.16	0.141	2.20	2.20	120	98	2.0	255	57	88		
0.110	0.105	D1	16/0	400.53	0.130	1.97	1.97	114	97	2.0	255	56	88		
0.125	0.115	2	4	403.68	0.147	2.25	2.25	115	99	2.0	255	56	88		
0.120	0.120	3	8	406.99	0.141	2.20	2.20	117	100	2.0	250	56	88		
0.120	0.115	4	12	410.41	0.141	2.20	2.20	119	100	2.0	250	57	88		
			16	413.80											
				3270											

METHOD 5 PARTICULATE FIELD DATA

Plant Johnson Controls - Middletown, DE
Run No. 3
Location South Ventilation Baghouse
Date 11-01-88
Operator PRJ - RBM - JAF
Sample Box No. 3
Meter Box No. 1348
Filter No. M12-3
Probe No. 3
Pitot Tube Cp 0.99

Very Important — Fill In All Blanks
Leak Checks: Beg. @ 15" 0.009
End @ 5" 0.004
Pitot Tube: ⊕ <0.1 @ 4.2 "H2O
⊖ <0.1 @ 4.2 "H2O
Static Pressure: +0.26 "H2O
Start: 1718
Finish: 1834
Observer C. Knick Agency DE DNREC

Bar. Press. "Hg 29.95
Meter Box ΔH@ 1.86 Y = 1.00
Assumed Tm, °F 100
Dry Bulb, °F 86
Wet Bulb, °F 65
Db - Wb, °F 21
Assumed Moisture % 1.3%
Ps/Pm 1.00
C Factor 1.15

Ambient Temp., °F 72
Heater Box Setting, °F 250
Probe Tip Dia., in. 0.339
Probe Length 3' glass lined
Probe Heater Setting 85%
Average Δp 0.098 Δp 0.12
Average ΔH 1.52 ΔH Ref
Process Weight
Steam Load NA
Steam Pressure NA

C_F = 1.179

Pre	Post	Point	Clock Time	Dry Gas Meter, Cu. Ft.	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
0.070	0.070	A1	0	414.10	0.083	1.28	1.28	102	96	1.5	260	51	88		
0.075	0.070	2	4	416.73	0.088	1.32	1.32	106	98	1.5	250	56	88		
0.075	0.075	3	8	419.37	0.088	1.32	1.32	110	98	1.5	260	54	88		
0.075	0.075	4	12	422.01	0.088	1.32	1.32	112	98	1.5	245	55	87		
0.075	0.075	B1	16/0	424.63	0.088	1.32	1.32	108	97	1.5	265	48	86		
0.075	0.075	2	4	427.27	0.088	1.32	1.32	109	98	1.5	270	48	85		
0.075	0.075	3	8	429.92	0.088	1.32	1.32	113	98	1.5	275	49	84		
0.075	0.075	4	12	432.57	0.088	1.32	1.32	114	98	2.0	270	51	85		
0.080	0.075	C1	16/0	435.22	0.094	1.45	1.45	108	97	2.0	260	56	85		
0.080	0.080	2	4	437.98	0.094	1.45	1.45	109	98	2.0	260	54	85		
0.080	0.080	3	8	440.75	0.094	1.45	1.45	112	98	2.0	255	54	85		
0.085	0.080	4	12	443.53	0.100	1.53	1.53	114	98	2.2	255	55	85		
0.070	0.070	D1	16/0	446.48	0.083	1.28	1.28	116	97	2.0	260	56	85		
0.080	0.075	2	4	449.01	0.094	1.45	1.45	118	97	2.5	260	56	85		
0.090	0.085	3	8	452.14	0.106	1.60	1.60	118	97	2.7	265	57	85		
0.090	0.085	4	12	454.61	0.106	1.60	1.60	119	97	2.7	265	57	85		
			16	457.49											

METHOD 5 PARTICULATE FIELD DATA

Plant: Johnson Controls - Middletown, DE
Run No.: 4
Location: South Ventilation Baghouse
Date: 11-01-88
Operator: PRJ - RBM - JAM
Sample Box No.: 1
Meter Box No.: 1348
Filter No.: M12-4
Probe No.: 4
Pitot Tube Cp: 0.99

Very Important — Fill In All Blanks
Leak Checks: Beg. @ 15": 0.002
End @ 5": 0.002
Pitot Tube: ⊕ <0.1 @ 4.2 "H2O
⊖ <0.1 @ 4.2 "H2O
Static Pressure: +0.26 "H2O
Start: 1851
Finish: 2008
Observer: C. KRICH Agency: DE DNREC

Bar. Press. "Hg: 29.95
Meter Box ΔH@: 1.86 Y = 1.00
Assumed Tm, °F: 100
Dry Bulb, °F: 86
Wet Bulb, °F: 65
Db - Wb, °F: 21
Assumed Moisture %: 1.3%
Ps/Pm: 1.00
C Factor: 1.15

Ambient Temp., °F: 72
Heater Box Setting, °F: 250
Probe Tip Dia., in.: 0.336
Probe Length: 3' glass lined
Probe Heater Setting: 85%
Average Δp: 0.098 Δp: 0.12
Average ΔH: 1.52 ΔH: Ref
Process Weight:
Steam Load: NA
Steam Pressure: NA

C_F = 1.179

Pre	Post	Point	Clock Time	Dry Gas Meter, Cu. Ft.	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
0.065	0.055	A1	0	457.90	0.077	1.20	1.20	100	96	1.5	250	58	85		
0.070	0.070	2	4	460.46	0.083	1.28	1.28	107	97	1.5	240	57	85		
0.070	0.070	3	8	463.06	0.083	1.28	1.28	109	97	1.5	265	55	85		
0.070	0.070	4	12	465.66	0.083	1.28	1.28	110	98	1.5	270	55	83		
0.075	0.075	B1	16/0	468.24	0.088	1.32	1.32	113	98	1.5	265	57	84		
0.075	0.075	2	4	470.90	0.088	1.32	1.32	114	98	1.5	255	57	83		
0.075	0.075	3	8	473.55	0.088	1.32	1.32	114	98	1.5	245	58	82		
0.070	0.070	4	12	476.20	0.083	1.28	1.28	114	98	1.5	245	58	83		
0.070	0.070	C1	16/0	478.83	0.083	1.28	1.28	101	96	1.5	270	53	84		
0.075	0.075	2	4	481.40	0.088	1.32	1.32	103	96	1.5	265	51	84		
0.075	0.075	3	8	484.02	0.088	1.32	1.32	107	96	1.5	260	52	85		
0.080	0.080	4	12	486.62	0.094	1.45	1.45	111	97	1.5	260	55	84		
0.080	0.070	D1	16/0	489.38	0.094	1.45	1.45	114	97	1.5	245	56	84		
0.085	0.085	2	4	492.14	0.100	1.53	1.53	114	97	1.5	245	55	84		
0.085	0.085	3	8	494.94	0.100	1.53	1.53	115	98	1.7	255	58	84		
0.080	0.085	4	12	497.75	0.094	1.45	1.45	115	98	1.5	255	57	84		
			16	500.57											

METHOD 3 - ORSAT AND DRY MOLECULAR WEIGHT DETERMINATION

Plant Johnson Controls - Middletown, DE Sample Location South Vertikihon Baghouse
Sample Type - Continuous ✓ Pump Leakfree @ 10" ? ✓
Oxygen Check 20.9% ± 0.1% 20.9 Fuel Type NA
Orsat Leak Check @ 4 min.: Pipet Levels - Leakfree ? ✓
Buret 13.1 - 13.1 = <0.2 ml ? ✓

Run No. 1 Sample Date 11-01-88 Ambient Temp. °F 71
Sampling Time (24 - hr clock) 1340-1512 Analysis By PEJ

Gas \ Run	1		2		3		Avg. %	Mult.	Molecular Wt. Dry lb/lb mole
	Actual	Net	Actual	Net	Actual	Net			
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 11-01-88 Ambient Temp. °F 72
Sampling Time (24 - hr clock) 1540-1701 Analysis By PEJ

Gas \ Run	1		2		3		Avg. %	Mult.	Molecular Wt. Dry lb/lb mole
	Actual	Net	Actual	Net	Actual	Net			
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. 3 Sample Date 11-01-88 Ambient Temp. °F 72
Sampling Time (24 - hr clock) 1718-1834 Analysis By PEJ

Gas \ Run	1		2		3		Avg. %	Mult.	Molecular Wt. Dry lb/lb mole
	Actual	Net	Actual	Net	Actual	Net			
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

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

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METHOD 3 - ORSAT AND DRY MOLECULAR WEIGHT DETERMINATION

Plant Johnson Controls, Middletown DE Sample Location South Ventilation Baghouse

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

Oxygen Check 20.9% ± 0.1% 20.9 Fuel Type NA

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

Buret 13.1 - 13.1 = <0.2 ml ? ✓

Run No. 4 Sample Date 11-01-88 Ambient Temp. °F 72

Sampling Time (24 - hr clock) 1851-2008 Analysis By MLJ

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. _____ Sample Date _____ Ambient Temp. °F _____

Sampling Time (24 - hr clock) _____ Analysis By _____

Gas \ Run	1 Actual	1 Net	2 Actual	2 Net	3 Actual	3 Net	Avg. %	Mult.	Molecular Wt. Dry lb/lb mole
CO_2								.44	
O_2								.32	
CO								.28	
N_2	100		100		100			.28	
								Total	

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

Run No. _____ Sample Date _____ Ambient Temp. °F _____

Sampling Time (24 - hr clock) _____ Analysis By _____

Gas \ Run	1 Actual	1 Net	2 Actual	2 Net	3 Actual	3 Net	Avg. %	Mult.	Molecular Wt. Dry lb/lb mole
CO_2								.44	
O_2								.32	
CO								.28	
N_2	100		100		100			.28	
								Total	

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

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

environmental testing inc. Limit 0.01 lbs/ton

METHOD 12 SAMPLE RECOVERY AND INTEGRITY SHEET

Plant Johnson Controls- Middletown, DE Recovered By PRJ-RBM-JAF
Sample Location South Ventilation Baghouse Recovery Date 11-01-88

Run Number	1	2	3	4
Sample Date	11-01-88	11-01-88	11-01-88	11-01-88
Sample Box Number	1	2	3	1
Probe Number	1	2	3	1

MOISTURE DETERMINATION AND SAMPLE RECOVERY - IMPINGERS

Impingers Cont. Number	1	2	3	7
Description of Water	clear	clear	clear	clear
Liquid Level Marked	✓	✓	✓	✓
Final Volume (wt.), ml	203	202	202	203
Initial Volume (wt.), ml	200	200	200	200
Net Volume (wt.), ml (g)	3	2	2	3
Silica Gel Cont. Number	1	2	3	7
Silica Gel % Spent	10%	10%	15%	10%
Final Weight, g	211.6	214.4	211.0	210.1
Initial Weight, g	200.0	200.0	200.0	200.0
Net Weight, g	11.6	14.4	11.0	10.1
Total Moisture, g	14.6	16.4	13.0	13.1

SAMPLE RECOVERY - FILTER

Filter Cont. Number	M12-1	M12-2	M12-3	M12-7
Particulate Description	None visible	None visible	None visible	None visible
Filter Cont. Sealed	✓	✓	✓	✓
Probe Rinse Cont. Number	1	2	3	7
Liquid Level Marked	✓	✓	✓	✓

SAMPLE WEIGHT CALCULATION

Run #	Conc., mg/l	x	Vol., l	-	Blank, mg	=	Total mg Lead
1	0.232	x	0.250	-	N/A	=	0.0580
2	0.191	x	0.250	-	N/A	=	0.0478
3	0.312	x	0.250	-	N/A	=	0.0780
4	0.094	x	0.250	-	N/A	=	0.0235

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: PRJ-RBM-JAF Date Received: 11-04-88
Stored and Locked: ✓ Remarks: None

METHOD 12 ATOMIC ABSORPTION DATA

SOUTH VENTILATION BAGHOUSE

CALIBRATION DATA

Standard No. 1	=	3.000	mg/l	Absorbance	=	0.183
Standard No. 2	=	1.000	mg/l	Absorbance	=	0.069
Standard No. 3	=	2.000	mg/l	Absorbance	=	0.134
Standard No. 4	=	4.000	mg/l	Absorbance	=	0.251
Standard No. 5	=	5.000	mg/l	Absorbance	=	0.307

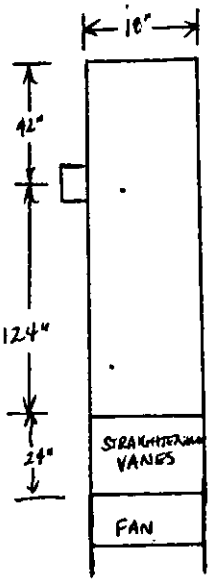
SAMPLE CONCENTRATION DATA

Mean Concentration Run No. 1	=	0.232	mg/l
Mean Concentration Run No. 2	=	0.191	mg/l
Mean Concentration Run No. 3	=	0.312	mg/l
Mean Concentration Run No. 4	=	0.094	mg/l
Mean Concentration Filter Blk. A	=	<0.050	mg/l
Mean Concentration Filter Blk. B	=	<0.050	mg/l
Mean Concentration 0.10N HNO_3	=	<0.050	mg/l

Analyzed by PRJ Date November 17, 1988

Remarks ETI audit filter spiked with 0.7000 mg lead
Spiked recovery: 97.25%
Working range check: true = 0.250
obtained = 0.232
Recovery: 92.8%
Precision checked every 10th sample = 1.2% avg. diff.
Matrix effect checked by Method of Standard Additions
all samples were verified to within + or - 4.0%

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS



Plant Johnson Controls, Middletown DE

Date 11-02-88

Sampling location Melting Pot South

Inside of far wall to outside of nipple (I) 21"

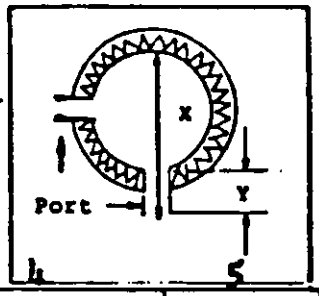
Inside of near wall to outside of nipple (nipple length) (I) 3"

Stack I.D. (I-I) 18"

Nearest upstream disturbance 2.3 dd

Nearest downstream disturbance 6.8 dd

Calculated by PRJ



SCHEMATIC OF SAMPLING LOCATION

1	2	3			
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	0.021	18"	ADJ. 0.500	3"	3.500
2	0.067	"	1.206	"	4.206
3	0.118	"	2.124	"	5.124
4	0.177	"	3.186	"	6.186
5	0.250	"	4.500	"	7.500
6	0.356	"	6.408	"	9.408
7	0.644	"	11.592	"	14.592
8	0.750	"	13.500	"	16.500
9	0.823	"	14.814	"	17.814
10	0.882	"	15.876	"	18.876
11	0.933	"	16.794	"	19.794
12	0.979	↓	ADJ 17.500	↓	20.500

METHOD 2 GAS VELOCITY AND CYCLONIC FLOW DETERMINATION

Plant and City Johnson Controls, Middletown DE Run Date 11-02-88

Sampling Location Melting Pot South Clock Time 1255

Run Number 1 Operator PRT-RBM-JAH Amb. Temp., °F 54

Bar. Press., in. Hg 29.57 Static Press., in. H_2O -0.040

Stack Press., in. Hg 29.567 Static Press., in. Hg -0.003

Stack Dimension, in. - Diam. or side 1 18" side 2 ——

Pitot Tube (C_p) 0.84 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 A	Velocity head (Δp_s), in. H_2O B	Stack temp., °F A	Stack temp., °F B	Cyclonic flow determination: Δp_s at 0° reference A	Δp_s at 0° reference B	Angle (α) which yields a null Δp A	Angle (α) which yields a null Δp B
1	3.500	.055	.045	108	108	-.010	-.005	2	2
2	4.206	.055	.045			-.005	-.005	2	2
3	5.124	.060	.050			-.005	-.005	2	3
4	6.186	.060	.050			-.010	0	5	0
5	7.500	.060	.055			-.010	0	4	0
6	9.408	.060	.055			-.005	0	4	0
7	14.592	.055	.055			0	0	0	0
8	16.500	.055	.055			0	+.005	0	3
9	17.814	.050	.050			0	0	0	0
10	18.826	.045	.050			+.005	+.005	4	4
11	19.794	.040	.050			+.005	+.010	5	6
12	20.500	.040	.045			+.005	+.005	5	5

Average angle (α)[a]

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

NOMAGRAPH DATA

$\Delta H_@$ 1.86 T_m 70 %M 2% P_s/P_m 1.0 C 1.08 D_b 108

$\overline{\Delta p}$ 0.052 T_s 110 DN_c 0.43 DN_a 0.405 Ref. Δp 0.067 W_b 62

D| 46

METHOD 5 PARTICULATE FIELD DATA

Plant Johnson Controls, Middletown DE
Run No. 1
Location Melting Pot South
Date 11-02-89
Operator PRS - RBM - JAF
Sample Box No. 4
Meter Box No. 1348
Filter No. M12-4
Probe No. 4
Pitot Tube Cp 0.84

Very Important — Fill In All Blanks
Leak Checks: Beg. @ 15" 0.006
End @ 4" 0.008
Pitot Tube: ⊕ <0.1 @ 7.8 "H_2O
⊖ <0.1 @ 7.8 "H_2O
Static Pressure: -0.040 "H_2O
Start: 1545
Finish: 1649
Observer C. KIRK Agency DE DNREC

Bar. Press. "Hg 29.57
Meter Box ΔH@ 1.86 Y = 1.00
Assumed Tm, °F 70
Dry Bulb, °F 108
Wet Bulb, °F 62
Db - Wb, °F 46
Assumed Moisture % 29.
Ps/Pm 1.0
C Factor 1.08

Ambient Temp., °F 51
Heater Box Setting, °F 250
Probe Tip Dia., in. 0.405
Probe Length 4' glass lined
Probe Heater Setting 650
Average Δp 0.052 Δp 0.067
Average ΔH 1.43 ΔH Rel
Process Weight
Steam Load NA
Steam Pressure NA

Point	Clock Time	Dry Gas Meter, Cu. Ft.	Pitot Manometer (Δp) in H_2O	Orifice Manometer (ΔH) in H_2O		Dry Gas Temp. °F		Pump Vacuum in Hg Gauge	Box Temp. °F	Impinger Temp. °F	Stack Temp. °F	% CO_2	% O_2
				Desired	Actual	Inlet	Outlet						
A1	0	630.68	0.075	2.08	2.08	60	59	2.0	235	45	100		
2	2½	632.57	0.075	2.08	2.08	62	59	2.1	240	46	100		
3	5	634.52	0.075	2.08	2.08	63	59	2.1	245	46	100		
4	7½	636.46	0.070	1.95	1.95	67	59	2.0	245	45	105		
5	10	638.37	0.070	1.95	1.95	69	59	2.0	250	44	104		
6	12½	640.21	0.070	1.95	1.95	70	59	2.0	245	46	104		
7	15	642.09	0.060	1.65	1.65	71	60	1.8	250	46	101		
8	17½	643.87	0.055	1.51	1.51	71	60	1.8	255	45	102		
9	20	645.63	0.050	1.38	1.38	72	60	1.5	250	44	101		
10	22½	647.28	0.050	1.38	1.38	71	60	1.5	250	45	100		
11	25	648.90	0.050	1.38	1.38	71	60	1.5	255	46	101		
12	27½	650.53	0.050	1.38	1.38	71	60	1.5	260	47	100		
B1	30/0	652.15	0.060	1.65	1.65	67	60	1.5	265	48	102		
2	2½	653.89	0.065	1.79	1.79	70	61	1.5	260	49	101		
3	5	655.71	0.065	1.79	1.79	71	61	1.5	260	48	101		
4	7½	657.54	0.065	1.79	1.79	72	61	1.5	260	48	100		
5	10	659.36	0.065	1.79	1.79	72	61	1.5	255	47	101		
6	12½	661.19	0.065	1.79	1.79	73	62	1.5	260	48	102		
7	15	663.01	0.065	1.79	1.79	73	62	1.5	260	48	101		
8	17½	664.82	0.060	1.65	1.65	73	62	1.5	245	45	105		
9	20	666.57	0.050	1.38	1.38	73	62	1.5	245	41	102		
10	22½	668.20	0.045	1.24	1.24	73	62	1.5	245	41	102		
11	25	669.77	0.035	0.98	0.98	72	61	1.5	250	45	102		
12	27½	671.15	0.035	0.98	0.98	71	61	1.5	245	50	100		
	30	672.51											

METHOD 5 PARTICULATE FIELD DATA

Plant Johnson Controls, Middletown, DE
Run No. 2
Location Melting Pot South
Date 11-02-88
Operator PBI-RBM-JAF
Sample Box No. 5
Meter Box No. 1348
Filter No. MIE-5
Probe No. 5
Pitot Tube Cp 0.84

Very Important — Fill In All Blanks
Leak Checks: Beg. @ 15" 0.009
End @ 5" 0.007
Pitot Tube: (+) <0.1 @ 6.4 "H2O
(-) <0.1 @ 6.4 "H2O
Static Pressure: -0.040 "H2O
Start: 1735
Finish: 1840
Observer C. KIRBY Agency DE DNREC

Bar. Press. "Hg 29.57
Meter Box ΔH@ 1.86 Y= 1.00
Assumed Tm, °F 70
Dry Bulb, °F 108
Wet Bulb, °F 62
Db - Wb, °F 46
Assumed Moisture % 2%
Ps/Pm 1.0
C Factor 1.08

Ambient Temp., °F 46
Heater Box Setting, °F 250
Probe Tip Dia., in. 0.405
Probe Length 4' glass lined
Probe Heater Setting 85%
Average Δp 0.052 Δp 0.067
Average ΔH 1.43 ΔH Ref
Process Weight
Steam Load NA
Steam Pressure NA

Point	Clock Time	Dry Gas Meter, Cu. Ft.	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	673.00	0.075	2.08	2.08	58	57	2.0	245	44	101		
2	2½	674.89	0.075	2.08	2.08	59	57	2.0	245	45	101		
3	5	676.91	0.070	1.95	1.95	63	58	2.0	245	45	100		
4	7½	678.73	0.070	1.95	1.95	64	58	2.0	250	43	118		
5	10	680.60	0.065	1.79	1.79	66	58	1.7	250	44	112		
6	12½	682.43	0.065	1.79	1.79	67	59	1.7	250	44	109		
7	15	684.22	0.060	1.65	1.65	68	59	1.5	250	45	108		
8	17½	685.98	0.060	1.65	1.65	68	59	1.5	245	44	107		
9	20	687.73	0.055	1.51	1.51	69	59	1.4	245	44	103		
10	22½	689.42	0.050	1.38	1.38	69	59	1.2	245	45	102		
11	25	691.08	0.050	1.38	1.38	69	59	1.2	245	45	101		
12	27½	692.66	0.045	1.24	1.24	69	59	1.2	245	43	102		
B 1	30/0	694.20	0.065	1.79	1.79	64	58	2.0	250	45	100		
2	2½	696.03	0.065	1.79	1.79	65	58	2.0	250	45	99		
3	5	697.84	0.065	1.79	1.79	67	58	2.0	250	43	100		
4	7½	699.67	0.065	1.79	1.79	68	58	2.0	250	44	100		
5	10	701.45	0.060	1.65	1.65	69	58	2.0	250	45	100		
6	12½	703.30	0.060	1.65	1.65	70	59	2.0	245	42	99		
7	15	705.04	0.065	1.79	1.79	70	59	2.2	245	42	99		
8	17½	706.94	0.055	1.51	1.51	70	59	2.0	245	41	98		
9	20	708.65	0.045	1.24	1.24	70	59	1.7	245	42	101		
10	22½	710.43	0.045	1.24	1.24	70	59	1.7	245	42	103		
11	25	711.99	0.035	0.98	0.98	70	59	1.5	245	42	105		
12	27½	713.45	0.035	0.98	0.98	71	59	1.5	240	41	104		
	30	714.83											

METHOD 5 PARTICULATE FIELD DATA

Plant Johnson Controls, Middletown De
Run No. 3
Location Melting Pot South
Date 11-2-88
Operator PEJ - RCM - JAF
Sample Box No. 6
Meter Box No. 1348
Filter No. M12-6
Probe No. 3
Pitot Tube Cp 0.84

Very Important — Fill In All Blanks
Leak Checks: Beg. @ 15" 0.005
End @ 7' 0.003
Pitot Tube: ⊕ <0.1 @ 4.3 "H2O
⊖ <0.1 @ 4.3 "H2O
Static Pressure: -0.840 "H2O
Start: 1930
Finish: 2038
Observer C. KRICK Agency DE DNREC

Bar. Press. "Hg 29.57
Meter Box ΔH@ 1.86 Y = 1.00
Assumed Tm, °F 70
Dry Bulb, °F 108
Wet Bulb, °F 62
Db - Wb, °F 46
Assumed Moisture % 2%
Ps/Pm 1.0
C Factor 1.08

Ambient Temp., °F 75
Heater Box Setting, °F 250
Probe Tip Dia., in. 0.405
Probe Length 4' glass lined
Probe Heater Setting 85%
Average Δp 0.052 Δp 0.067
Average ΔH 1.43 ΔH Ref
Process Weight
Steam Load NA
Steam Pressure NA

Point	Clock Time	Dry Gas Meter, Cu. Ft.	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	718.30	0.055	1.57	1.51	58	56	5.0	275	45	108		
2	2½	720.03	0.075	2.08	2.08	62	56	6.0	250	46	110		
3	5	721.92	0.070	2.08	2.08	66	56	6.0	255	47	111		
4	7½	723.86	0.075	2.08	2.08	72	58	6.0	255	47	109		
5	10	725.79	0.075	2.08	2.08	74	58	6.0	260	48	106		
6	12½	727.73	0.070	1.95	1.95	75	58	5.5	255	49	108		
7	15	729.65	0.070	1.95	1.95	76	58	5.5	260	49	108		
8	17½	731.54	0.060	1.65	1.65	78	60	5.0	265	47	105		
9	20	733.35	0.050	1.38	1.38	78	61	4.1	255	48	110		
10	22½	735.00	0.050	1.38	1.38	78	61	4.1	255	49	109		
11	25	736.63	0.050	1.38	1.38	78	61	4.1	245	50	106		
12	27½	738.26	0.050	1.38	1.38	78	61	4.0	240	49	105		
B1	30	739.88	0.050	1.38	1.38	78	61	4.0	245	48	102		
2	2½	741.28	0.075	2.08	2.08	79	62	5.5	255	49	100		
3	5	743.25	0.075	2.08	2.08	79	62	5.5	250	45	98		
4	7½	745.11	0.070	1.95	1.95	79	62	5.0	255	46	100		
5	10	746.97	0.070	1.95	1.95	81	63	5.1	250	47	101		
6	12½	748.85	0.070	1.95	1.95	81	63	5.1	245	45	103		
7	15	750.73	0.060	1.65	1.65	80	62	4.5	250	45	101		
8	17½	752.50	0.045	1.24	1.24	80	62	4.0	245	44	100		
9	20	754.21	0.040	1.12	1.12	79	62	3.5	240	43	102		
10	22½	755.79	0.040	1.12	1.12	79	62	3.5	240	44	100		
11	25	757.33	0.040	1.12	1.12	79	62	3.5	250	44	100		
12	27½	758.89	0.040	1.12	1.12	79	62	3.5	245	45	101		
	30	760.43											

environmental testing inc.

METHOD 3 - ORSAT AND DRY MOLECULAR WEIGHT DETERMINATION

Plant Johnson Controls, Middletown DE Sample Location Melting Pot South

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

Oxygen Check 20.9% ± 0.1% 20.9 Fuel Type NA

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

Buret 14.0 - 14.0 = <0.2 ml ? ✓

Run No. 1 Sample Date 11-02-88 Ambient Temp. °F _____

Sampling Time (24 - hr clock) _____ Analysis By PRJ

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 11-02-88 Ambient Temp. °F _____

Sampling Time (24 - hr clock) _____ Analysis By PRJ

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. 3 Sample Date 11-02-88 Ambient Temp. °F _____

Sampling Time (24 - hr clock) _____ Analysis By PRJ

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	79.10	100	79.10	100	79.10	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, Middletown DE — Recovered By PRJ
Sample Location Melting Pot South — Recovery Date 11-02-88

	1	2	3
Run Number			
Sample Date	11-02-88	11-02-88	11-02-88
Sample Box Number	4	5	6
Probe Number	4	5	3

MOISTURE DETERMINATION AND SAMPLE RECOVERY - IMPINGERS

Impingers Cont. Number	M12-4	M12-5	M12-6
Description of Water	Clear	Clear	Clear
Liquid Level Marked	✓	✓	✓
Final Volume (wt.), ml	203	202	203
Initial Volume (wt.), ml	200	200	200
Net Volume (wt.), ml (g)	3	2	3
Silica Gel Cont. Number	M12-4	M12-5	M12-6
Silica Gel % Spent	10%	10%	10%
Final Weight, g	211.8	207.8	210.7
Initial Weight, g	200.0	200.0	200.0
Net Weight, g	11.8	7.8	10.7
Total Moisture, g	14.8	9.8	13.7

SAMPLE RECOVERY - FILTER

Filter Cont. Number	M12-4	M12-5	M12-6
Particulate Description	None visible	none visible	none visible
Filter Cont. Sealed	✓	✓	✓
Probe Rinse Cont. Number	M12-4	M12-5	M12-6
Liquid Level Marked	✓	✓	✓

SAMPLE WEIGHT CALCULATION

Run #	Conc., mg/l	x	Vol., l	-	Blank, mg	=	Total mg Lead
1	0.159	x	0.250	-	N/A	=	0.0398
2	0.607	x	0.250	-	N/A	=	0.1518
3	0.791	x	0.250	-	N/A	=	0.1978

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: PRJ-ROM-JAF — Date Received: 11-04-88
Stored and Locked: ✓ — Remarks: None

METHOD 12 ATOMIC ABSORPTION DATA

SOUTH MELTING POT

CALIBRATION DATA

Standard No. 1 =	3.000	mg/l	Absorbance =	0.183	
Standard No. 2 =	1.000	mg/l	Absorbance =	0.069	
Standard No. 3 =	2.000	mg/l	Absorbance =	0.134	
Standard No. 4 =	4.000	mg/l	Absorbance =	0.251	
Standard No. 5 =	5.000	mg/l	Absorbance =	0.307	

SAMPLE CONCENTRATION DATA

Mean Concentration Run No. 1 =	0.159	mg/l
Mean Concentration Run No. 2 =	0.607	mg/l
Mean Concentration Run No. 3 =	0.791	mg/l
Mean Concentration Filter Blk. A =	<0.050	mg/l
Mean Concentration Filter Blk. B =	<0.050	mg/l
Mean Concentration 0.10N HNO_3 =	<0.050	mg/l

Analyzed by PRJ Date November 17, 1988

Remarks ETI audit filter spiked with 0.7000 mg lead
Spiked recovery: 97.25%
Working range check: true = 0.250
obtained = 0.232
Recovery: 92.8%
Precision checked every 10th sample = 1.2% avg. diff.
Matrix effect checked by Method of Standard Additions
all samples were verified to within + or - 4.0%

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

Plant Johnson Controls, Middletown, DE

Date 11-02-88

Sampling location Process Bagheuse South

Inside of far wall to outside of nipple (X) 18"

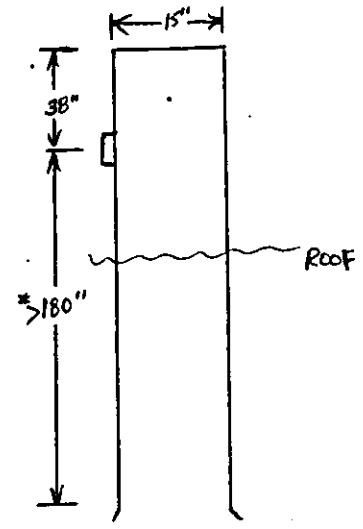
Inside of near wall to outside of nipple (nipple length) (X) 3"

Stack I.D. (X-Y) 15"

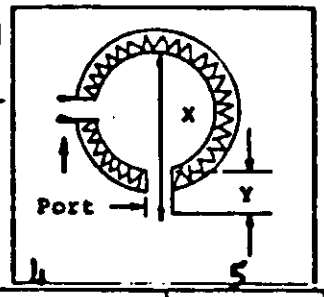
Nearest upstream disturbance 2.53 dd

Nearest downstream disturbance >12 dd

Calculated by PRJ



*ESTIMATED, DEFINITELY GREATER



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	.067	15	1.005	3	4.005
2	.250	15	3.750	↓	7.750
3	.750	15	11.250	↓	14.250
4	.933	15	13.995	↓	16.995

METHOD 2 GAS VELOCITY AND CYCLONIC FLOW DETERMINATION

Plant and City Johnson Controls, Middletown DE Run Date 11-02-88

Sampling Location Process Baghouse South Clock Time 0840

Run Number 1 Operator PRJ-RBM-JAF Amb. Temp., °F 46

Bar. Press., in. Hg 29.55 Static Press., in. H_2O -0.88

Stack Press., in. Hg 29.485 Static Press., in. Hg -0.065

Stack Dimension, in. - Diam. or side 1 15" side 2 ——

Pitot Tube (C_p) 0.84 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 A	Velocity head (Δp_s), in. H_2O B	Stack temp., °F A	Stack temp., °F B	Cyclonic flow determination: Δp_s at 0° reference A	Δp_s at 0° reference B	Angle (α) which yields a null Δp A	Angle (α) which yields a null Δp B
1	4.005	1.55	1.45	202	202	0.04	0.03	3	2
2	7.750	1.80	1.60	202	202	0.02	0.06	2	5
3	14.250	1.60	1.30	202	202	0.04	0.04	3	3
4	16.995	1.00	0.90	202	202	0.03	0.03	3	2
		Std	Types						
		1.35	1.70						
		1.45	1.80						
		1.40	1.60						
		0.92	0.96						
		Corr.	Corr.						
		1.34	1.43						
		1.44	1.51						
		1.39	1.34						
		0.91	0.81						
		Avg.	Avg.						
		1.27	1.27						

Average angle (α)[a] 2.875

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

NOMAGRAPH DATA

$\Delta H_@$ 1.82 T_m 75 %M 2% P_s/P_m 0.998 C 1.08 D_b 203

$\overline{\Delta p}$ 1.40 T_s 205 DN_c 0.195 DN_a ~~0.186~~ 0.187 0.189 0.186 Ref. Δp 1.62 W_b 89 114

METHOD 5 PARTICULATE FIELD DATA

Plant Johnson Controls, Middletown DE
Run No. 1
Location Process Baghouse South
Date 11-02-88
Operator PRJ - RBM - JAF
Sample Box No. 1
Meter Box No. 1348
Filter No. M12 - 8
Probe No. 1
Pitot Tube Cp 0.84

Very Important — Fill In All Blanks
Leak Checks: Beg. @ 15" 0.004
End @ 6" 0.002
Pitot Tube: ⓟ < 0.1 @ 3.6 "H2O
ⓢ < 0.1 @ 3.6 "H2O
Static Pressure: -0.88 "H2O
Start: 1040
Finish: 1146
Observer C. Krick Agency DE DNREC

Bar. Press. "Hg 29.55
Meter Box ΔH@ 1.86 Y = 1.00
Assumed Tm, °F 75
Dry Bulb, °F 203
Wet Bulb, °F 89
Db - Wb, °F 114
Assumed Moisture % 27
Ps/Pm 0.998
C Factor 1.08

Ambient Temp., °F 50
Heater Box Setting, °F 250
Probe Tip Dia., in. 0.187
Probe Length 4' glass lined
Probe Heater Setting 85%
Average Δp 1.40 Δp 1.62
Average ΔH 1.60 ΔH Ref
Process Weight
Steam Load NA
Steam Pressure NA

Point	Clock Time	Dry Gas Meter, Cu. Ft.	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	501.00	1.65	1.88	1.88	61	55	3.7	270	46	215		
2	7½	506.53	1.80	2.05	2.05	66	56	4.7	270	44	220		
3	15	512.38	1.50	1.68	1.68	70	57	3.8	265	45	220		
4	22½	517.73	0.88	1.00	1.00	70	59	2.0	265	46	220		
B 1	30/0	522.99	1.60	1.81	1.81	67	60	4.0	270	45	220		
2	7½	527.50	1.75	1.96	1.96	72	60	4.5	265	47	223		
3	15	533.19	1.40	1.60	1.60	74	61	3.8	245	49	221		
4	22½	538.48	0.77	0.89	0.89	72	62	2.0	245	52	221		
	30	542.50											

METHOD 5 PARTICULATE FIELD DATA

Plant Johnson Controls, Middletown DE
Run No. 2
Location Process Baghouse South
Date 11-2-88
Operator PRJ - RBM - JAF
Sample Box No. 2
Meter Box No. 1348
Filter No. M12-9
Probe No. 2
Pitot Tube Cp 0.84

Very Important — Fill In All Blanks

Leak Checks: Beg. @ 15" 0.004
End @ 5" 0.002
Pitot Tube: Ⓐ <0.1 @ 2.5 "H₂O
Ⓑ <0.1 @ 2.5 "H₂O
Static Pressure: -0.88 "H₂O
Start: 1153
Finish: 1259
Observer C. Kriele Agency DE DNREC

Bar. Press. "Hg 29.55
Meter Box ΔH@ 1.86 Y = 1.00
Assumed Tm, °F 75
Dry Bulb, °F 205
Wet Bulb, °F 89
Db - Wb, °F 114
Assumed Moisture % 3%
Ps/Pm 0.998
C Factor 1.08

Ambient Temp., °F 50
Heater Box Setting, °F 250
Probe Tip Dia., in. 0.189
Probe Length 4' glass lined
Probe Heater Setting 85%
Average Δp 1.70 Δp 1.62
Average ΔH 1.60 ΔH Ref
Process Weight
Steam Load NA
Steam Pressure NA

Point	Clock Time	Dry Gas Meter, Cu. Ft.	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	542.70	1.70	1.93	1.93	65	61	2.2	230	52	222		
2	7½	548.32	2.05	2.30	2.30	72	61	3.0	235	46	225		
3	15	554.54	1.45	1.65	1.65	72	62	2.0	235	47	226		
4	22½	559.92	1.10	1.25	1.25	70	62	1.5	230	47	225		
B1	30/0	564.63	1.70	1.93	1.93	67	62	2.2	225	47	224		
2	7½	570.29	1.70	1.93	1.93	71	62	2.5	225	47	224		
3	15	576.01	1.45	1.65	1.65	72	62	2.0	230	48	225		
4	22½	581.35	0.90	1.02	1.02	70	62	1.5	230	49	225		
	30	585.59											

METHOD 5 PARTICULATE FIELD DATA

Plant Johnson Controls, Middletown DE
Run No. 3
Location Process Backwise South
Date 11-2-88
Operator PRJ-RBM-JAF
Sample Box No. 3
Meter Box No. 1348
Filter No. M12-3
Probe No. 3
Pitot Tube Cp 0.84

Very Important — Fill In All Blanks

Leak Checks: Beg. @ 15" 0.011
End @ 5" 0.032
Pitot Tube: ⊕ ≤0.1 @ 4.8 "H₂O
⊖ ≤0.1 @ 4.8 "H₂O
Static Pressure: -0.88 "H₂O
Start: 1345
Finish:
Observer C. Krick Agency DE DNREC

Bar. Press. "Hg 29.55
Meter Box ΔH@ 1.86 Y= 1.00
Assumed Tm, °F 75
Dry Bulb, °F 203
Wet Bulb, °F 89
Db - Wb, °F 114
Assumed Moisture % 2%
Ps/Pm 0.999
C Factor 1.08

Ambient Temp., °F 50
Heater Box Setting, °F 250
Probe Tip Dia., in. 0.186
Probe Length 4' glass lined
Probe Heater Setting 65%
Average Δp 1.40 Δp Ref 1.62
Average ΔH 1.60 ΔH Ref
Process Weight
Steam Load NA
Steam Pressure NA

Point	Clock Time	Dry Gas Meter, Cu. Ft.	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	588.10	1.85	1.86	1.88	67	59	2.0	230	47	225		
1 2	7½	593.47	1.85	2.10	2.10	72	60	2.5	245	51	225		
3	15	599.28	1.50	1.70	1.70	73	61	2.1	245	50	226		
4	22½	604.68	0.84	0.96	0.96	72	61	1.5	250	49	227		
B 1	30	608.77	1.85	2.10	2.10	68	60	2.5	250	51	227		
2	7½	614.39	1.75	1.96	1.96	69	60	2.0	255	50	227		
3	15	620.30	1.50	1.70	1.70	68	61	2.0	255	50	228		
4	22½	625.67	0.88	1.00	1.00	71	62	1.5	245	54	228		
	30	629.88											
		0.72											
		41.78											
		- 0.72											
		41.06											

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METHOD 3 - ORSAT AND DRY MOLECULAR WEIGHT DETERMINATION

Plant Johnson Controls, Middletown, DE Sample Location Process Baghouse South

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

Oxygen Check 20.9% ± 0.1% 20.9 Fuel Type NA

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

Buret 13.9 - 13.9 = <0.2 ml ? ✓

Run No. 1 Sample Date 11-02-88 Ambient Temp. °F 50

Sampling Time (24 - hr clock) _____ Analysis By PRJ

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 11-02-88 Ambient Temp. °F 57

Sampling Time (24 - hr clock) _____ Analysis By PRJ

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. 3 Sample Date 11-02-88 Ambient Temp. °F 50

Sampling Time (24 - hr clock) _____ Analysis By PRJ

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

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

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METHOD 12 SAMPLE RECOVERY AND INTEGRITY SHEET

Plant Johnson Controls Middletown DE Recovered By PRJ
Sample Location Process Baghouse South Recovery Date 11-02-88

Run Number	1	2	3
Sample Date	11-02-88	11-02-88	11-02-88
Sample Box Number	1	2	3
Probe Number	1	2	6

MOISTURE DETERMINATION AND SAMPLE RECOVERY - IMPINGERS

Impingers Cont. Number	M12-8	M12-9	M12-10
Description of Water	clear	clear	clear
Liquid Level Marked	✓	✓	✓
Final Volume (wt.), ml	203	202	203
Initial Volume (wt.), ml	200	200	200
Net Volume (wt.), ml (g)	3	2	3
Silica Gel Cont. Number	M12-8	M12-9	M12-10
Silica Gel % Spent	10%	10%	10%
Final Weight, g	208.1	208.4	210.0
Initial Weight, g	200.0	200.0	200.0
Net Weight, g	8.1	8.4	10.0
Total Moisture, g	11.1	10.4	13.0

SAMPLE RECOVERY - FILTER

Filter Cont. Number	M-12-8	M-12-9	M12-10
Particulate Description	None visible	none visible	none visible
Filter Cont. Sealed	✓	✓	✓
Probe Rinse Cont. Number	8	9	10
Liquid Level Marked	✓	✓	✓

SAMPLE WEIGHT CALCULATION

Run #	Conc., mg/l	x	Vol., l	-	Blank, mg	=	Total mg Lead
1	0.033	x	0.250	-	N/A	=	0.0083
2	0.053	x	0.250	-	N/A	=	0.0133
3	0.065	x	0.250	-	N/A	=	0.0163

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: PRJ-RBM-JHF Date Received: 11-04-88
Stored and Locked: ✓ Remarks: NAN

METHOD 12 ATOMIC ABSORPTION DATA

SOUTH PROCESS BAGHOUSE

CALIBRATION DATA

Standard No. 1	=	3.000	mg/l	Absorbance	=	0.183
Standard No. 2	=	1.000	mg/l	Absorbance	=	0.069
Standard No. 3	=	2.000	mg/l	Absorbance	=	0.134
Standard No. 4	=	4.000	mg/l	Absorbance	=	0.251
Standard No. 5	=	5.000	mg/l	Absorbance	=	0.307

SAMPLE CONCENTRATION DATA

Mean Concentration Run No. 1	=	0.033	mg/l
Mean Concentration Run No. 2	=	0.053	mg/l
Mean Concentration Run No. 3	=	0.064	mg/l
Mean Concentration Run No. 3 Dup.	=	0.066	mg/l
Mean Concentration Filter Blk. A	=	<0.050	mg/l
Mean Concentration Filter Blk. B	=	<0.050	mg/l
Mean Concentration 0.10N HNO_3	=	<0.050	mg/l

Analyzed by PRJ Date November 17, 1988

Remarks ETI audit filter spiked with 0.7000 mg lead
Spiked recovery: 97.25%
Working range check: true = 0.250
obtained = 0.232
Recovery: 92.8%
Precision checked every 10th sample = 1.2% avg. diff.
Matrix effect checked by Method of Standard Additions
all samples were verified to within + or - 4.0%

APPENDIX C

LABORATORY DATA

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AUDIT SAMPLES

Regular AA

CALIBRATION M12 QC
Pb

AUTO ZERO A

0.001

STD 1

CON 3.000

SIG 0.182
0.183
0.184
0.184
0.183

MEAN 0.183

STD 2

CON 1.000

SIG 0.070
0.070
0.069
0.067
0.068

MEAN 0.069

STD 3

CON 2.000

SIG 0.134
0.133
0.134
0.134
0.137

MEAN 0.134

STD 4

CON 4.000

SIG 0.249
0.249
0.252
0.251
0.255

MEAN 0.251

STD 5

CON 5.000

SIG 0.304
0.308
0.307
0.308
0.306

MEAN 0.307

APP CON

STD 1
2.897

STD 2
0.995

STD 3
2.055

STD 4
4.072

STD 5
4.982

STATISTICS

AUTO ZERO A

0.000

AUTO CAL

STD 1

RCT CON 3.000

DRG CON 3.088

NEW CON 3.000
AUTO CAL

STD 1

RCT CON 3.000

DRG CON 3.022

NEW CON 3.000
AUTO ZERO A

0.001

Delaware Audit
0069.

CON 01 3.928
02 3.899
03 3.852
04 3.838
05 3.828
06 3.874
07 3.909
08 3.921
09 3.921
10 3.928

MEAN 3.890 0.9725mg

SD 0.039

RSD 00.99

RCALC

Delaware Audit
0087.

CON 01 1.982
02 1.936
03 1.948
04 2.009
05 2.014
06 2.004
07 1.972
08 2.015
09 1.982
10 1.983

MEAN 1.985 0.4963mg

SD 0.027

RSD 01.36

RCALC ETI Spike

Spike true = 2.800mg/l
3782. = 0.7000mg

Recovery

CON 01 2.739 97.25%
02 2.717
03 2.708
04 2.725
05 2.725

MEAN 2.723 0.6808mg

SD 0.012

RSD 00.42

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AUDIT SAMPLES

Method of Standard Additions

Std Additions

ANALYSIS

AUTO ZERO A

-0.001

ACALC

69.00 Past linear range dilute and reanalyze

EXP F 1.000

SIG 01 0.237
02 0.239
03 0.242
04 0.240
05 0.242
ACALC 0.240

69.10
06 0.297
07 0.295
08 0.296
09 0.299
10 0.297
ACALC 0.297

69.20
11 0.344
12 0.343
13 0.346
14 0.346
15 0.344
ACALC 0.345

69.30
16 0.392
17 0.389
18 0.395
19 0.389
20 0.389
0.391

AUTO ZERO A

-0.001

AUTO ZERO A

-0.000

ACALC

87.00 ~ 0.5925mg
21 0.130
22 0.131
23 0.131
24 0.131
25 0.132
ACALC 0.131

87.10
26 0.190
27 0.192
28 0.193
29 0.189
30 0.192
ACALC 0.191

87.20
31 0.250
32 0.249
33 0.249
34 0.248
35 0.249
ACALC 0.249

87.30
36 0.302
37 0.298
38 0.298
39 0.298
40 0.300
0.299

Diluted 1:2

AUTO ZERO A

-0.001

ACALC

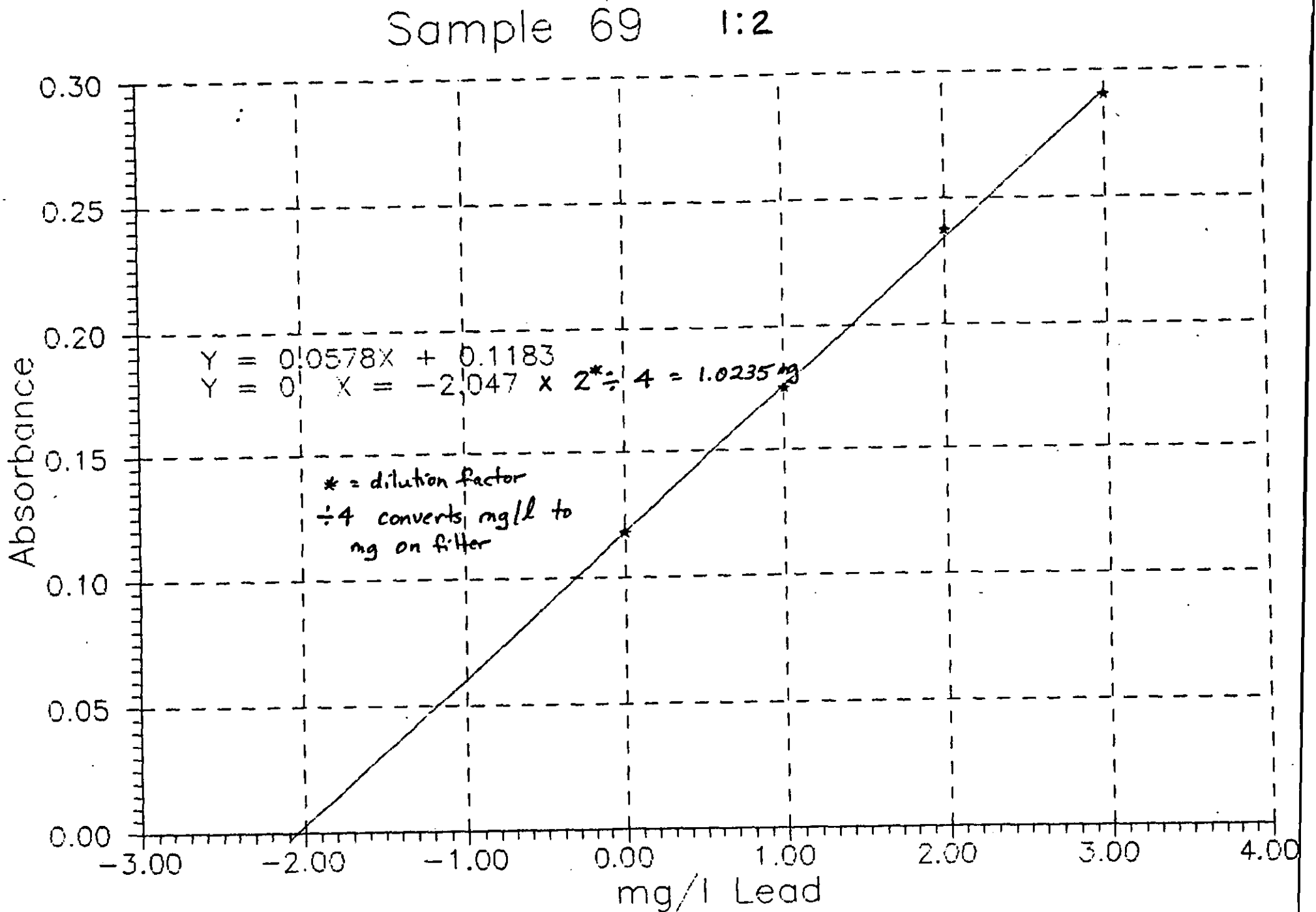
69.00 ~ 1.0234mg
17 0.118
18 0.119
19 0.116
20 0.117
21 0.119
ACALC 0.118

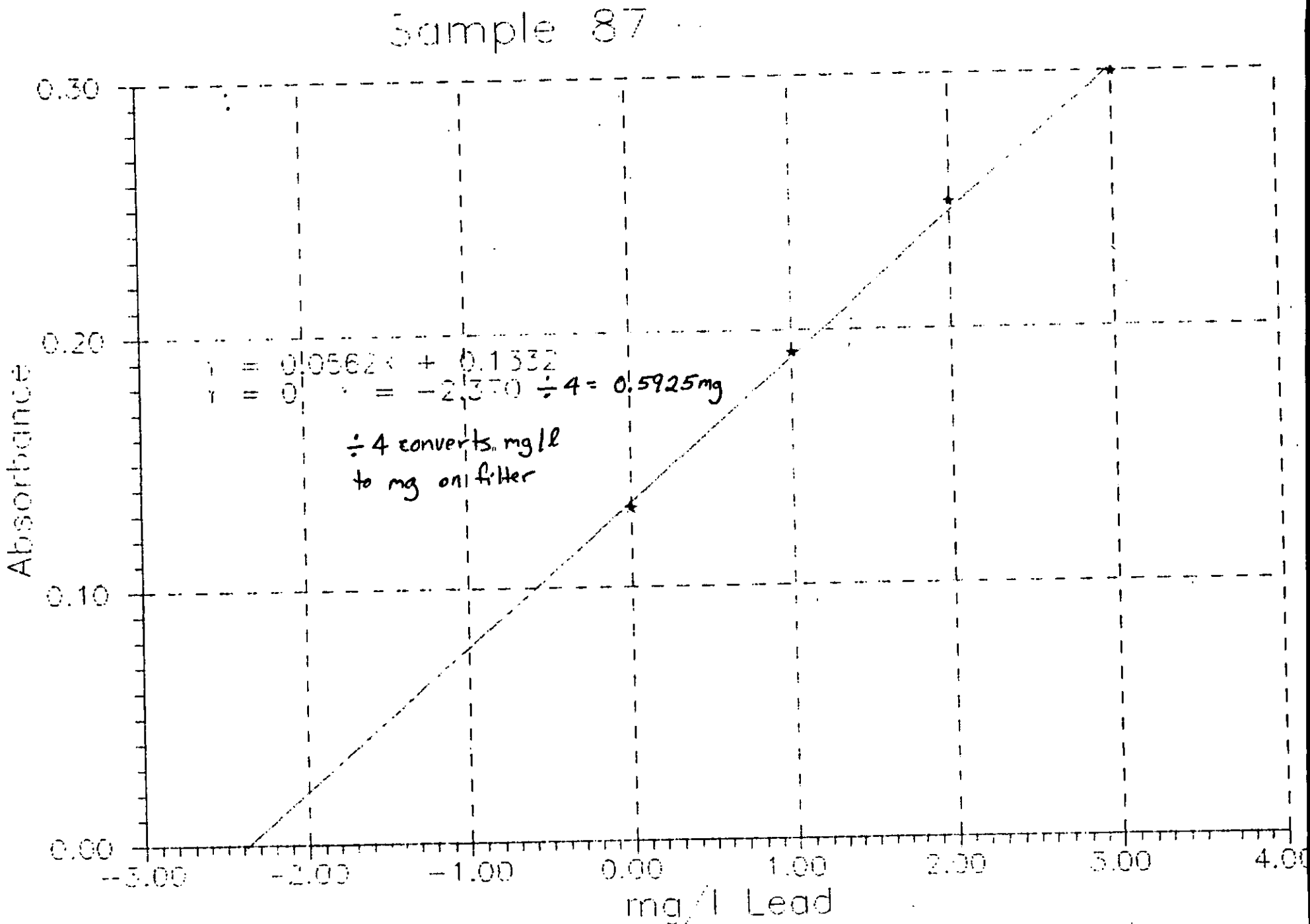
69.10
22 0.176
23 0.173
24 0.175
25 0.176
26 0.175
ACALC 0.175

69.20
27 0.235
28 0.231
29 0.234
30 0.241
31 0.242
ACALC 0.237

69.30
32 0.291
33 0.291
34 0.288
35 0.289
36 0.289
ACALC 0.290

69.00 w/o dilutions
37 0.234
38 0.233
39 0.235
40 0.236
41 0.240
0.236


Sample 69 1:2
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Absorbance
Y = 0.0578X + 0.1183
Y = 0 X = −2.047 x 2*÷ 4 = 1.0235 mg
* = dilution factor
÷4 converts mg/l to mg on filter
−3.00
−2.00
−1.00
0.00
1.00
2.00
3.00
4.00
mg/l Lead


Sample 87
0.30
0.20
0.10
0.00
Absorbance
y = 0.0562x + 0.1332
r = 0.[illegible] = −2.[illegible]70 ÷ 4 = 0.5925mg
÷ 4 converts mg/l to mg on filter
−3.00
−2.00
−1.00
0.00
1.00
2.00
3.00
4.00
mg/l Lead

Method of Standard Additions

#69 0.236 Abs

#69 diluted 1:2 + 3.000 mg/l
0.290 Abs

#69 diluted 1:2 + 2.000 mg/l
0.237 Abs

#69 diluted 1:2 + 1.000 mg/l
0.175 Abs

#69 diluted 1:2
0.118 Abs AZ

#87 + 3.000 mg/l
0.299 Abs

#87 + 2.000 mg/l
0.249 Abs

#87 + 1.000 mg/l
0.191 Abs

#87
0.131 Abs AZ

#69 + 3.000 mg/l
0.391 Abs Past linear range
dilute and reanalyze

#69 + 2.000 mg/l
0.345 Abs

Std Additions #69 + 1.000 mg/l
0.297 Abs

#69
0.240 Abs AZ

Regular AA

true = 2.800 mg/l QC 2.723 mg/l

Recovery for ETI Addit Sample 97.25% #87
1.985 mg/l

#69
3.890 mg/l

AZ

AC

AZ

5.0 mg/l

4.0 mg/l

2.0 mg/l

1.0 mg/l

3.0 mg/l

M12 QC

PRJ

environmental testing inc.

SOUTH BARTON OXIDE SYSTEM SAMPLES - REGULAR AA

AUTO ZERO A

-0.001

AUTO CAL

STD 1

ACT CON 1.000

ORG CON 0.977

NEW CON 1.000

AUTO CAL

STD 1

ACT CON 1.000

ORG CON 0.997

NEW CON 1.000

AUTO ZERO A

-0.000

ACALC

0004.

ACALC

OFLO

0001.

CON 01	0.236
02	0.216
03	0.235
04	0.230
05	0.228
06	0.234
07	0.233
08	0.227
09	0.230
10	0.250
MEAN	0.232
SD	0.009
RSD	03.67

S. Vent. Baghouse Run 1

AUTO ZERO A

0.001

AUTO CAL

STD 1

ACT CON 1.000

ORG CON 1.052

NEW CON 1.000

AUTO CAL

STD 1

ACT CON 1.000

ORG CON 0.998

NEW CON 1.000

AUTO ZERO A

-0.001

ACALC

0002.

CON 01	0.198
02	0.200
03	0.187
04	0.188
05	0.187
06	0.180
07	0.191
08	0.194
09	0.202
10	0.185
MEAN	0.191
SD	0.007
RSD	03.63

S. Vent. Baghouse Run 2

AUTO ZERO A

0.002

AUTO CAL

STD 1

ACT CON 1.000

ORG CON 1.013

NEW CON 1.000

AUTO ZERO A

0.001

ACALC

0003.

CON 01	0.326
02	0.322
03	0.313
04	0.302
05	0.304
06	0.325
07	0.303
08	0.303
09	0.313
10	0.314
MEAN	0.312
SD	0.009
RSD	03.01

S. Vent. Baghouse Run 2

AUTO ZERO A

-0.000

AUTO CAL

STD 1

ACT CON 1.000

ORG CON 0.986

NEW CON 1.000

AUTO ZERO A

-0.000

ACALC

0004.

CON 01	0.161
02	0.159
03	0.159
04	0.156
05	0.163
06	0.154
07	0.157
08	0.167
09	0.161
10	0.153
MEAN	0.159
SD	0.004
RSD	02.80

S. Melting Pot Run 1

SOUTH BARTON OXIDE SYSTEM SAMPLES - REGULAR AA

environmental testing inc.

AUTO ZERO A

0.001

AUTO CAL

STD 1

ACT CON 1.000

ORG CON 1.029

NEW CON 1.000
AUTO CAL

STD 1

ACT CON 1.000

ORG CON 1.005

NEW CON 1.000
AUTO ZERO A

0.001

ACALC

0005.

CON 01	0.605
02	0.600
03	0.603
04	0.621
05	0.613
06	0.612
07	0.606
08	0.620
09	0.592
10	0.600
MEAN	0.607
SD	0.009
RSD	01.54

S. Melting Pot Run 2

AUTO ZERO A

0.001

AUTO CAL

STD 1

ACT CON 1.000

ORG CON 1.016

NEW CON 1.000
AUTO ZERO A

0.002

0006.

CON 01	0.793
02	0.798
03	0.796
04	0.796
05	0.788
06	0.780
07	0.788
08	0.786
09	0.789
10	0.797
MEAN	0.791
SD	0.006
RSD	00.76

S. Melting Pot Run 3

AUTO ZERO A

0.001

AUTO CAL

STD 1

ACT CON 1.000

ORG CON 0.978

NEW CON 1.000
AUTO CAL

STD 1

ACT CON 1.000

ORG CON 1.014

NEW CON 1.000
AUTO ZERO A

-0.000

ACALC

0007.

CON 01	0.097
02	0.100
03	0.099
04	0.092
05	0.086
06	0.089
07	0.091
08	0.100
09	0.096
10	0.090
MEAN	0.094
SD	0.005

S. Vent Baghouse Run 4

AUTO ZERO A

0.002

AUTO CAL

STD 1

ACT CON 1.000

ORG CON 0.963

NEW CON 1.000
AUTO CAL

STD 1

ACT CON 1.000

ORG CON 0.995

NEW CON 1.000
AUTO ZERO A

0.001

RCALC

0008.

CON 01	0.041
02	0.022
03	0.034
04	0.028
05	0.049
06	0.024
07	0.036
08	0.031
09	0.036
10	0.029
MEAN	0.033
SD	0.008
RSD	25.01

S. Process Baghouse Run 1

AUTO ZERO A

0.001

AUTO CAL

STD 1

ACT CON 1.000

ORG CON 0.990

NEW CON 1.000
AUTO ZERO A

-0.000

ACALC

0009.

CON 01	0.044
02	0.051
03	0.048
04	0.042
05	0.065
06	0.068
07	0.059
08	0.045
09	0.052
10	0.053
MEAN	0.053
SD	0.009
RSD	16.47

S. Process Baghouse Run 2

AUTO ZERO A

-0.001

AUTO CAL

STD 1

ACT CON 1.000

ORG CON 0.972

NEW CON 1.000

AUTO CAL

STD 1

ACT CON 1.000

ORG CON 1.035

NEW CON 1.000

AUTO CAL

STD 1

ACT CON 1.000

ORG CON 0.987

NEW CON 1.000

AUTO ZERO A

0.000

0010.

CON 01	0.056
02	0.050
03	0.070
04	0.068
05	0.062
06	0.077
07	0.070
08	0.061
09	0.073
10	0.054
MEAN	0.064
SD	0.009
RSD	14.07

S. Process Baghouse Run 3

ACALC

0010.

CON 01	0.064
02	0.062
03	0.063
04	0.067
05	0.066
06	0.070
07	0.075
08	0.067
09	0.061
10	0.067
MEAN	0.066
SD	0.004
RSD	06.32

Duplicate

S. Process Baghouse Run 3

ACALC

0[redacted]

AUTO ZERO A

-0.001

AUTO CAL

STD 1

ACT CON 1.000

ORG CON 1.005

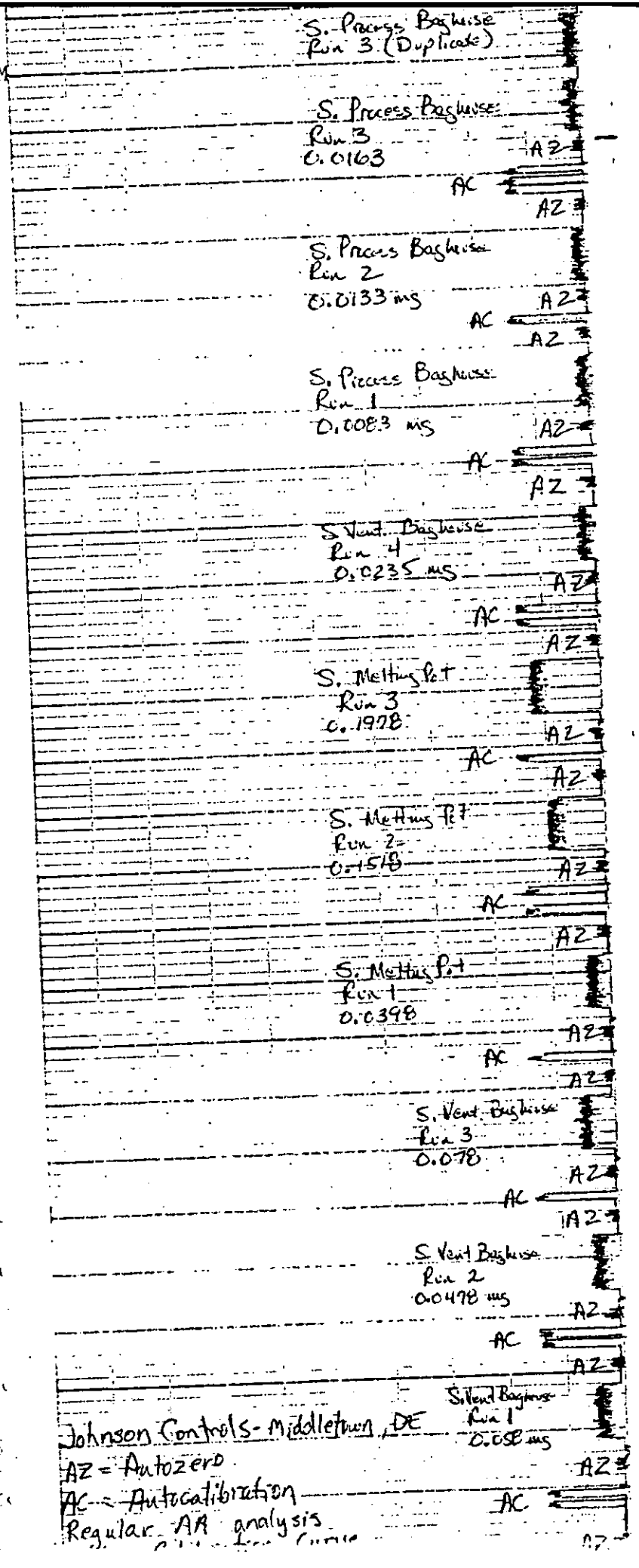
NEW CON 1.000

AUTO ZERO A

0.000

SOUTH BARTON OXIDE SYSTEM

REGULAR AA



Johnson Controls - Middletown, DE

AZ = Autozero

AC = Autocalibration

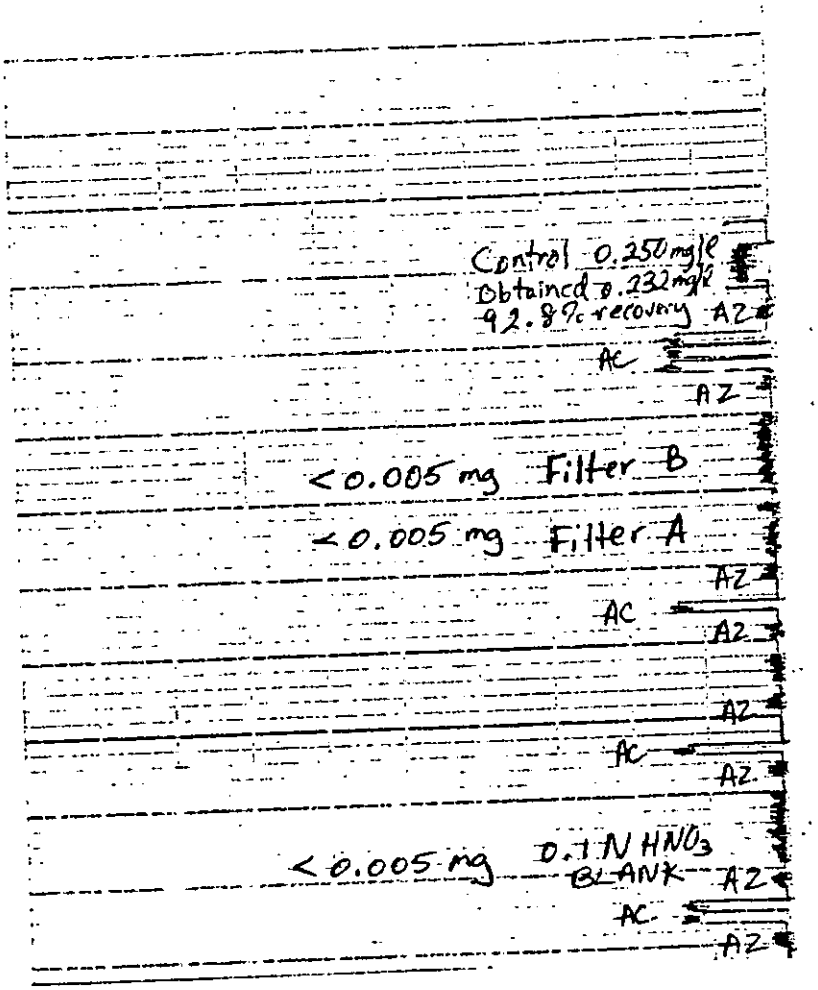
Regular AA analysis

```
ACALC

        0.100 N HNO3

CON 01  -0.001
    02  -0.018
    03  -0.008
    04   0.009
    05   0.003
    06  -0.007
    07   0.002
    08   0.007
    09   0.003
    10   0.005

MEAN    -0.001

SD       0.008

RSD      OFLO
ACALC

         OFLO
        00.00
AUTO ZERO  A

        0.001
AUTO CAL

STD 1

ACT CON 1.000

ORG CON 1.022

NEW CON 1.000
AUTO CAL

STD 1

ACT CON 1.000

ORG CON 0.995

NEW CON 1.000
AUTO ZERO  A

        0.001
```

```
ACALC
                Filter
        0000.A

CON 01  -0.004
    02  -0.001
    03  -0.018
    04  -0.013
    05  -0.002
    06  -0.022
    07  -0.006
    08   0.010
    09  -0.004
    10  -0.011

MEAN    -0.007

SD       0.009

RSD      OFLO
AUTO ZERO  A

        -0.001
AUTO CAL

STD 1

ACT CON 1.000

ORG CON 1.013

NEW CON 1.000
AUTO ZERO  A

        -0.000
```

```
        0000.B Filter

CON 01   0.019
    02   0.005
    03   0.021
    04   0.014
    05   0.013
    06   0.024
    07   0.022
    08   0.013
    09   0.024
    10   0.012

MEAN     0.017

SD       0.006

RSD     37.45
AUTO ZERO  A

        -0.001
AUTO CAL

STD 1

ACT CON 1.000

ORG CON 1.027

NEW CON 1.000
AUTO CAL

STD 1

ACT CON 1.000

ORG CON 0.978

NEW CON 1.000
AUTO CAL

STD 1

ACT CON 1.000

ORG CON 0.994

NEW CON 1.000
AUTO ZERO  A

        -0.001
```

MATRIX BLANKS - REGULAR AA



environmental testing inc.

WORKING RANGE QC CHECK AND ABSORBANCE VALUES FOR BLANKS

0.250

CON	01	0.225
	02	0.233
	03	0.235
	04	0.237
	05	0.222
	06	0.248
	07	0.236
	08	0.224
	09	0.228
	10	0.238
MEAN		0.232
SD		0.006
RSD		02.80

Working Range Check Sample

True = 0.250

92.8% Recovery

0.100 N HNO_3

Absorbance

EXP F 1.000

SIG	01	-0.000
	02	-0.001
	03	-0.002
	04	-0.001
	05	0.002
	06	0.000
	07	0.000
	08	0.001
	09	0.001
	10	-0.000

Absorbance

ACALC Filter Blank A

		0.000
	11	0.001
	12	-0.001
	13	-0.002
	14	-0.001
	15	0.001
	16	-0.001
	17	-0.001
	18	-0.001
	19	-0.001
	20	-0.001

Absorbance

ACALC Filter Blank B

		0.000
	21	-0.000
	22	0.001
	23	0.001
	24	0.000
	25	0.000
	26	0.001
	27	0.002
	28	0.001
	29	0.001
	30	0.001

environmental testing inc.

METHOD OF STANDARD ADDITIONS

SOUTH VENTILATION BAGHOUSE RUN 1

CALIBRATION

AUTO ZERO A

-0.001

STD 1

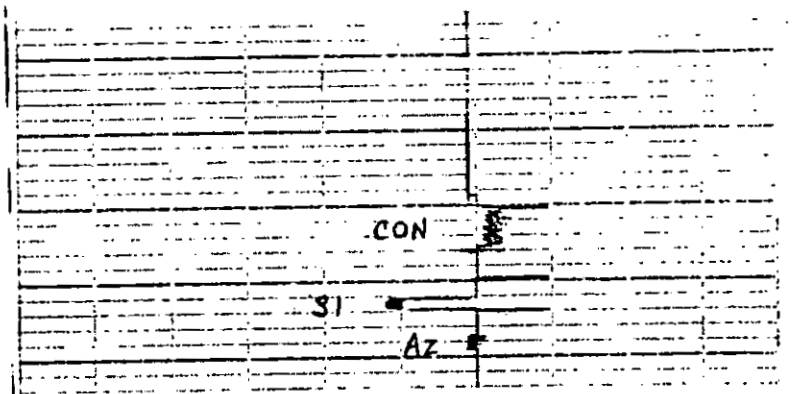
CON 1.000

SIG 0.053
0.051
0.053
0.053
0.052
0.052

MEAN 0.053

APP CON

STD 1
1.000



STATISTICS

CON 01 -0.235
02 -0.234
03 -0.229
04 -0.250
05 -0.255

MEAN -0.241

SD 0.011

RSD -04.65

environmental testing inc.

METHOD OF STANDARD ADDITIONS

SOUTH MELTING POT RUN 1

CALIBRATION

AUTO ZERO A

-0.001

STD 1

CON 1.000

SIG 0.052
0.053
0.055
0.054
0.054

MEAN 0.054

RPP CON

STD 1
1.000

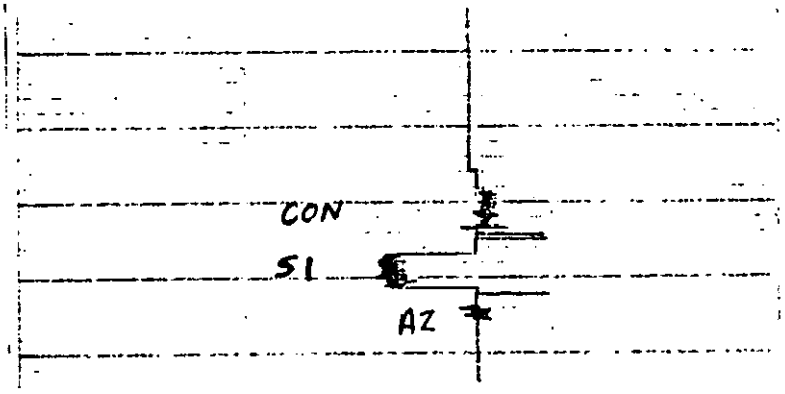
STATISTICS

CON 01 -0.166
02 -0.159
03 -0.159
04 -0.160
05 -0.147

MEAN -0.158

SD 0.007

RSD -04.39



environmental testing inc.

METHOD OF STANDARD ADDITIONS

SOUTH PROCESS BAGHOUSE RUN 1

CALIBRATION

AUTO ZERO A

0.001

STD 1

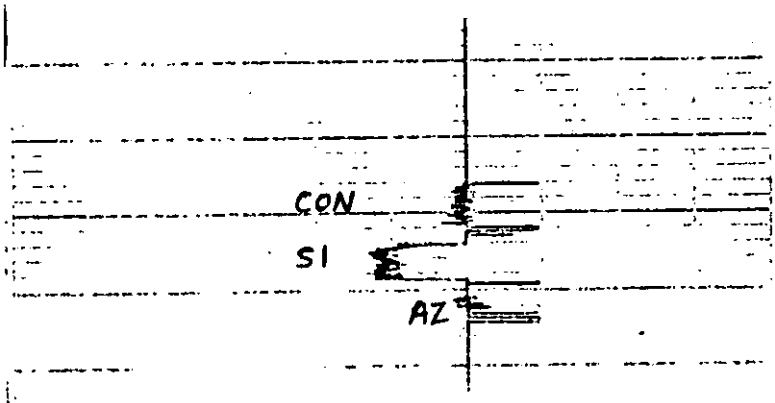
CON 1.000

SIG 0.052
0.051
0.051
0.055
0.047

MEAN 0.051

APP CON

STD 1
1.000



STATISTICS

CON 01 -0.027
02 -0.030
03 -0.036
04 -0.034
05 -0.033

MEAN -0.032

SD 0.004

RSD -11.07

APPENDIX D

PROCESS DATA

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

JOHNSON CONTROLS

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

November 14, 1988

Dear Paul:

RE: Johnson Controls, Inc. - Middletown, DE
Barton System Stack Tests

Listed below are the hourly average production rates for the Barton Systems.

North System

11/3/88	2111 lb./hour

South System

11/1/88	2421 lb./hour (avg. for Runs 2, 3 and 4)
11/2/88	2125 lbs./hour

If you have any questions, please call me at 314/228-2650.

Sincerely,

JOHNSON CONTROLS, INC.

Mark R. Ishihara
Environmental Engineer

MRI/jap

cc: T. K. Brossmann

APPENDIX E

TEST PARTICIPANTS

Paul R. Jenkins, Jr.	Vice-President Environmental Testing, Inc.
Jeff A. Francis	Biologist Environmental Testing, Inc.
Richard B. McCain, III	Environmental Scientist Environmental Testing, Inc.

APPENDIX F

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 procedures.

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-9, 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 rates, 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 subject to standards of performance. The methods are potentially applicable to other sources; however, applicability should be confirmed by careful and appropriate evaluation of the conditions prevalent at such sources.

The approach followed in the formulation of the reference methods involves specifications for equipment, procedures, and performance. In concept, 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 60.8 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 recognized 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 22, 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:

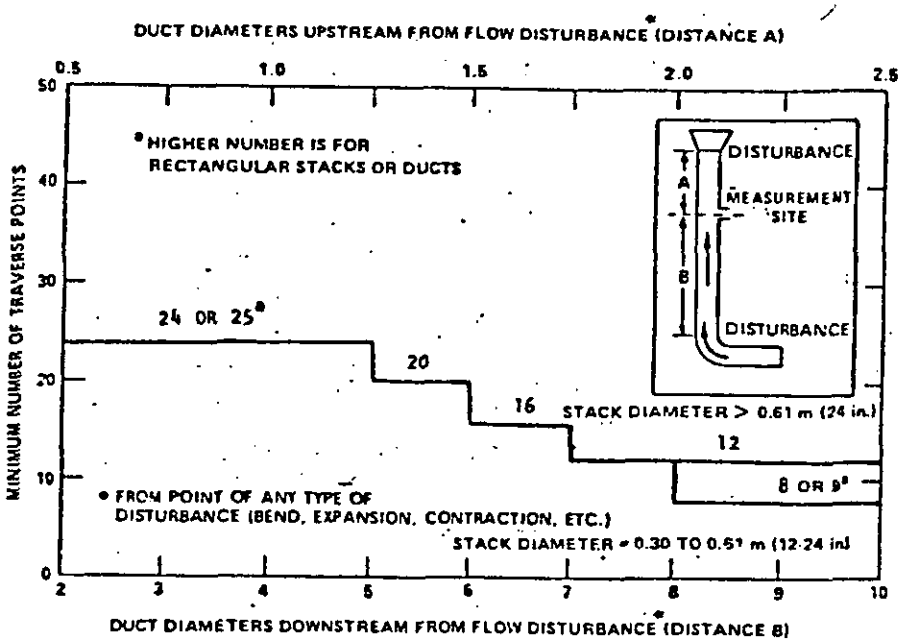


Figure 1-1. Minimum number of traverse points for particulate traverses.

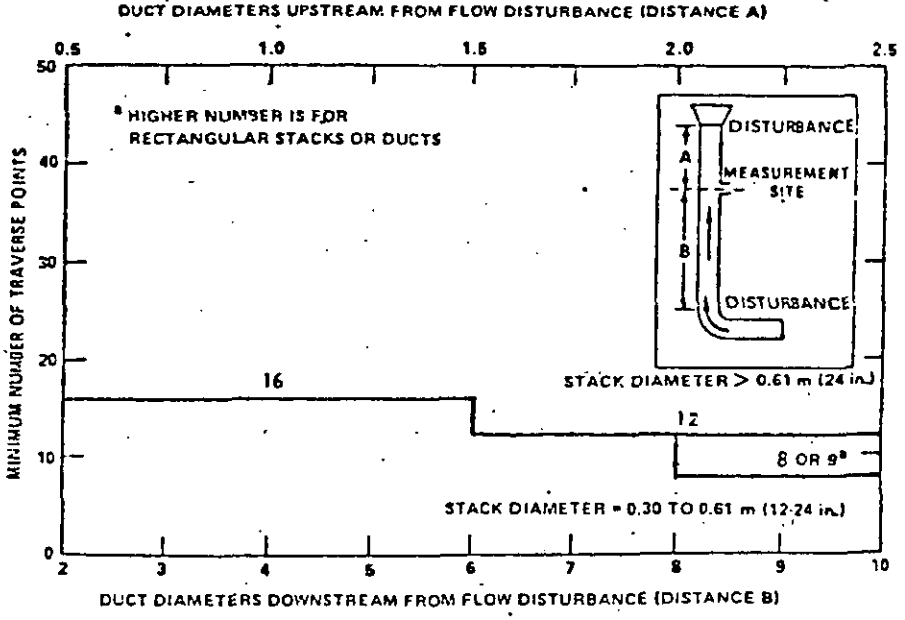


Figure 1-2. Minimum number of traverse points for velocity (nonparticulate) traverses.

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. 350 p.

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

[FR Doc. 83–26377 Filed 9–29–83; 8:45 am]
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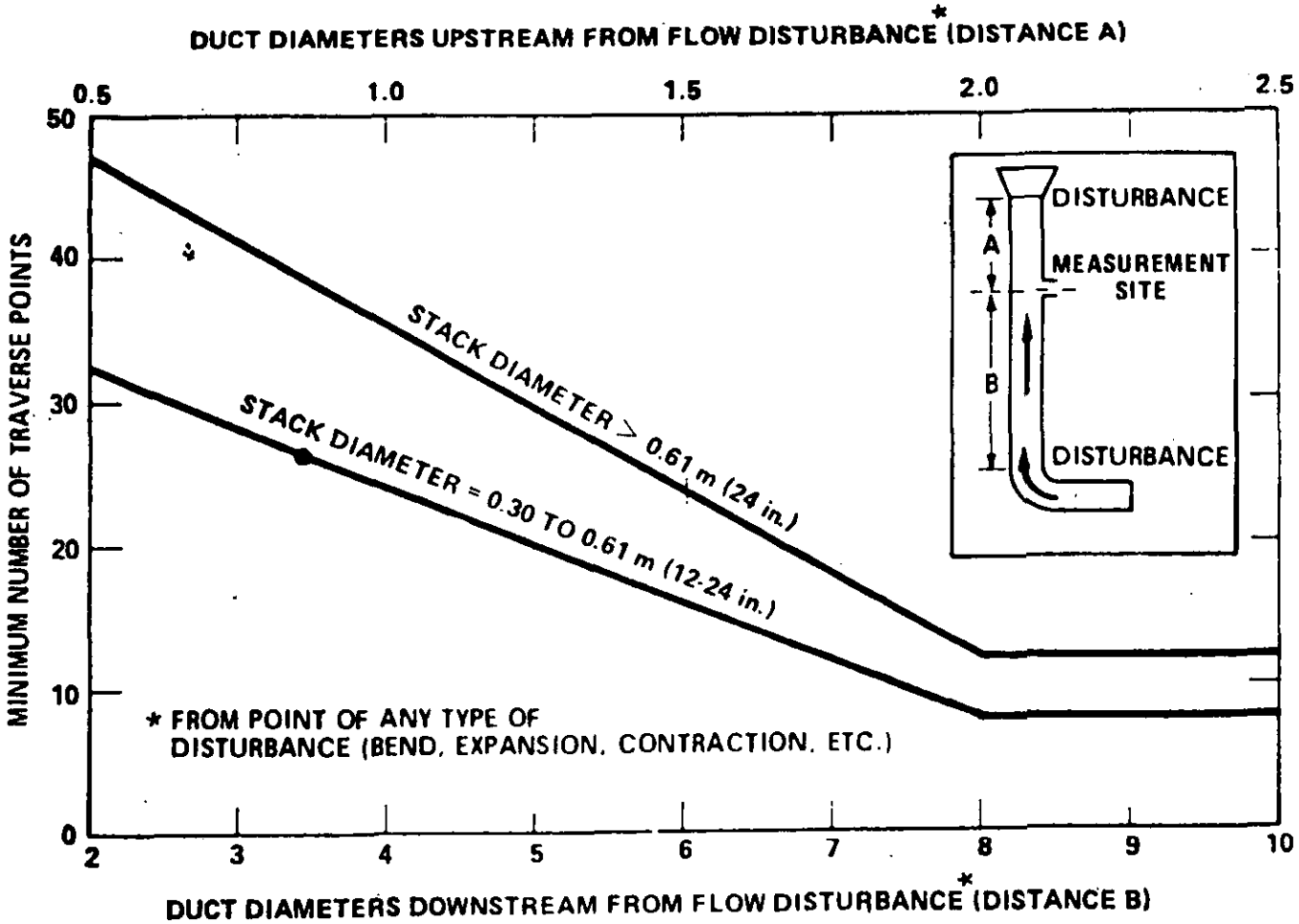

Figure 1-1. Minimum number of traverse points for particulate traverses.

where L = length and W = width.

2.2 Determining the Number of Traverse Points.

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

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

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

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

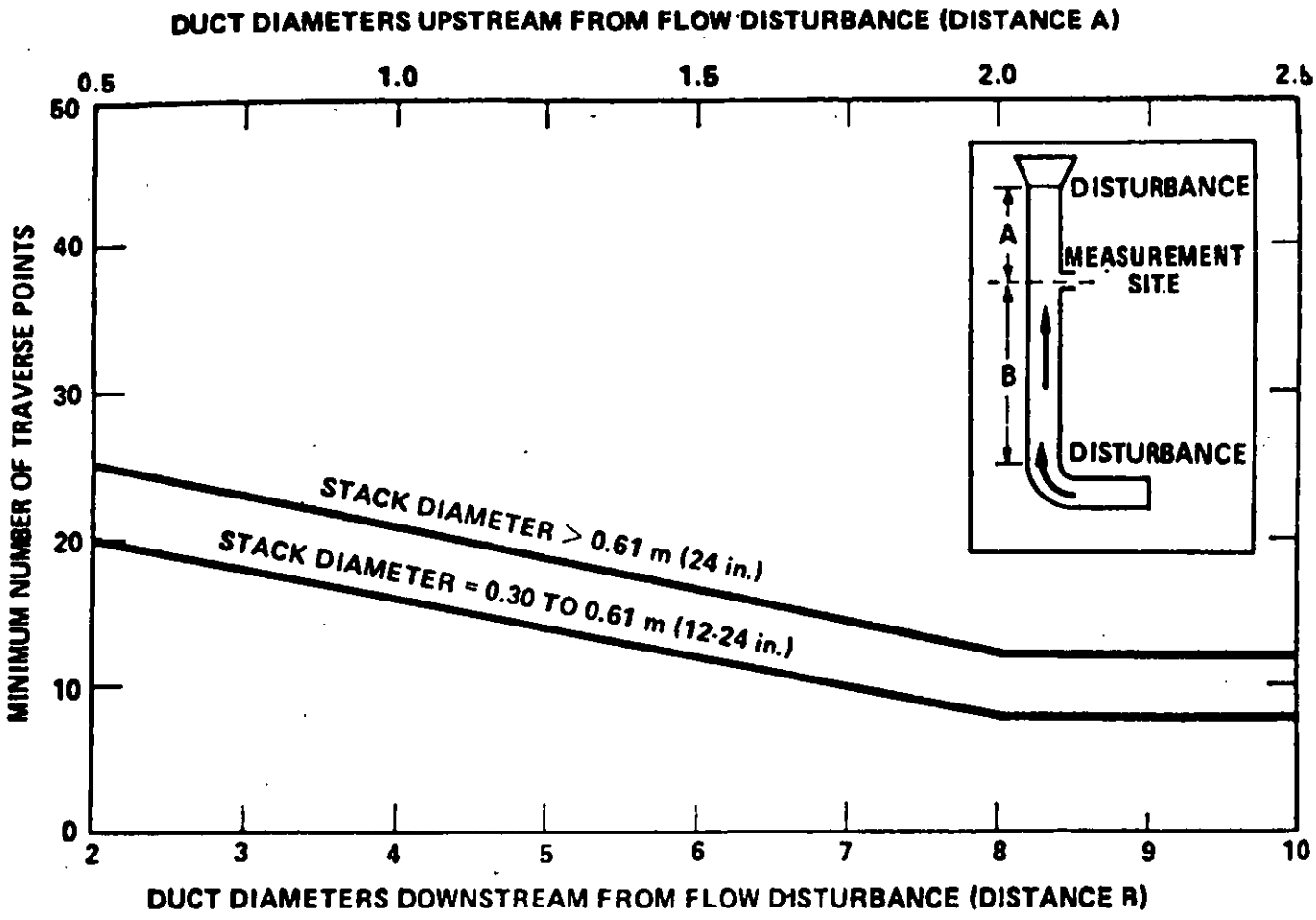

Figure 1-2. Minimum number of traverse points for velocity (nonparticulate) traverses.

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

2.3 Cross-Sectional Layout and Location of Traverse Points.

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

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

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

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

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

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

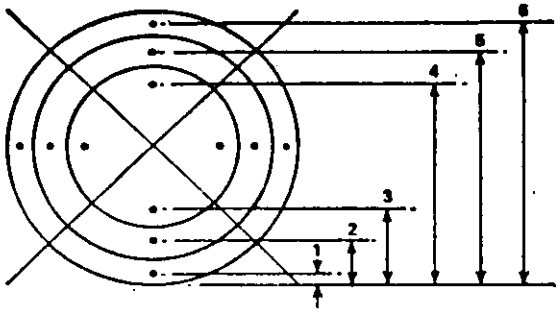

Figure 1-3. Example showing circular stack cross section divided into 12 equal areas, with location of traverse points indicated.

Table 1-2. LOCATION OF TRAVERSE POINTS IN CIRCULAR STACKS

(Percent of stack diameter from inside wall to traverse point)

Traverse point number on a diameter	Number of traverse points on a diameter											
	2	4	6	8	10	12	14	16	18	20	22	24
1	14.6	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	85.4	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3		75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4		93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5			85.4	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6			95.6	80.6	65.8	35.6	26.9	22.0	18.8	16.5	14.6	13.2
7				89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1
8				96.8	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9					91.8	82.3	73.1	62.5	38.2	30.6	26.2	23.0
10					97.4	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11						93.3	85.4	78.0	70.4	61.2	39.3	32.3
12						97.9	90.1	83.1	76.4	69.4	60.7	39.8
13							94.3	87.5	81.2	75.0	68.5	60.2
14							98.2	91.5	85.4	79.6	73.8	67.7
15								95.1	89.1	83.5	78.2	72.8
16								98.4	92.5	87.1	82.0	77.0
17									95.6	90.3	85.4	80.6
18									98.6	93.3	88.4	83.9
19										96.1	91.3	86.8
20										98.7	94.0	89.5
21											96.5	92.1
22											98.9	94.5
23												96.8
24												98.9

2.3.1.2 Stacks With Diameters Equal to or Less Than 0.61 m (24 in.). Follow the procedure in Section 2.3.1.1, noting only that any "adjusted" points should be relocated away from the stack walls to (1) a distance of 1.3 cm (0.50 in.), or (2) a distance equal to the nozzle inside diameter, whichever is larger.

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

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

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

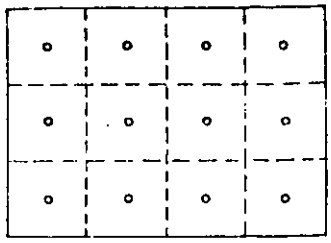

Figure 1-4. Example showing rectangular stack cross section divided into 12 equal areas, with a traverse point at centroid of each area.

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

3. *Bibliography*

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Method 2—Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)

1. *Principle and Applicability*

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

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

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

2. *Apparatus*

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

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, must 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.

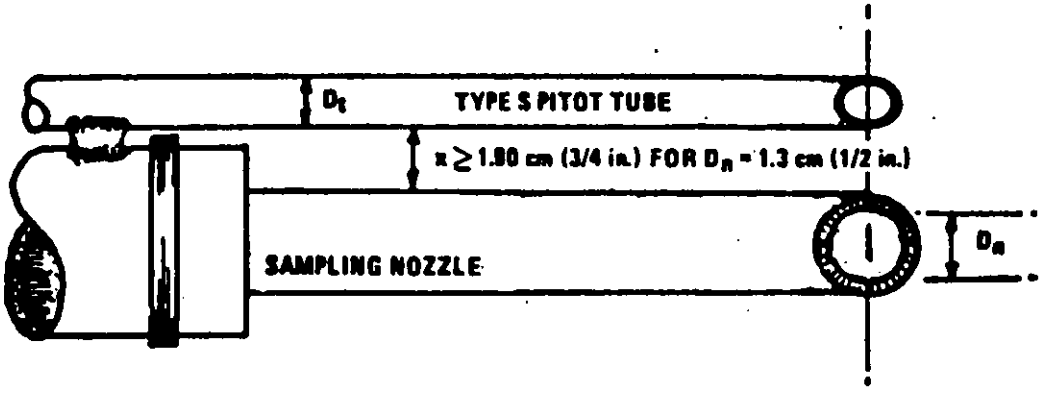
After verifying the face opening alignment, measure and record the following dimensions of the pitot tube: (a) the external tubing diameter (dimension D_t, Figure 2-6b); and (b) the base-to-opening plane distances (dimensions P_A and P_B, Figure 2-2b). If D_t is between 0.48 and 0.95 cm (3/16 and 3/8 in.) and if P_A and P_B are equal and between 1.05 and 1.50 D_t, there are two possible options: (1) the pitot tube may be calibrated according to the procedure outlined in Sections 4.1.2 through 4.1.5 below, or (2) a baseline (isolated tube) coefficient value of 0.84 may be assigned to the pitot tube. Note, however, that if the pitot tube is part of an assembly, calibration may still be required, despite knowledge of the baseline coefficient value (see Section 4.1.1).

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

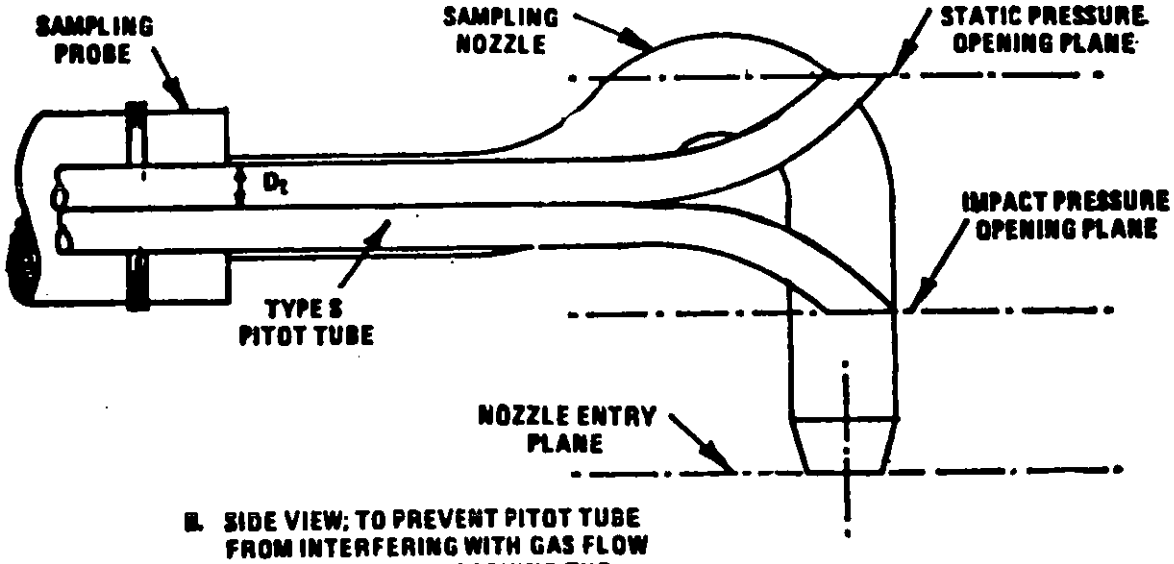
4.1.1 Type S Pitot Tube Assemblies. During sample and velocity traverses, the isolated Type S pitot tube is not always used; in many instances, the pitot tube is used in combination with other source-sampling components (thermocouple, sampling probe, nozzle) as part of an "assembly." The presence of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

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

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



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



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

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

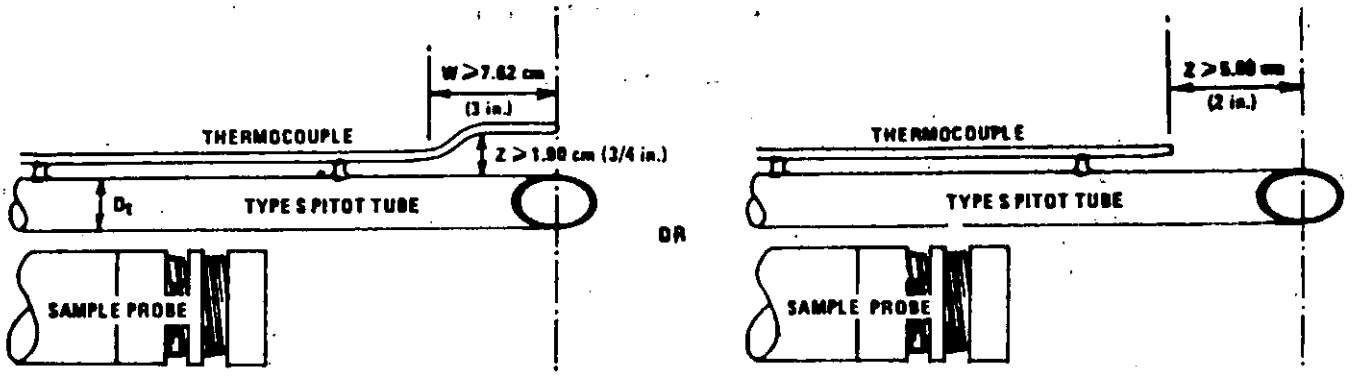


Figure 2-7. Proper thermocouple placement to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

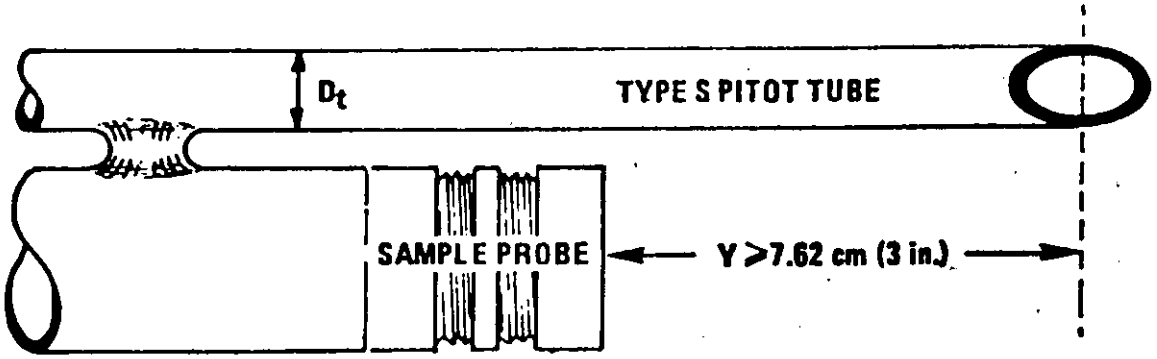


Figure 2-8. Minimum pitot-sample probe separation needed to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

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

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

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

Equation 2-1

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

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

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

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

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

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

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

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

4.1.3.3 Ensure that the manometer is level and zeroed. Position the standard pitot tube at the calibration point (determined as outlined in Section 4.1.5(3)), and align the tube so that its tip is pointed directly into the flow. Particular care should be taken in aligning the tube to avoid yaw and pitch angles. Make sure that the entry port surrounding the tube is properly sealed.

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

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

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

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

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

4.1.3.9 Perform calculations, as described in Section 4.1.4 below.

4.1.4 Calculations.

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

PITOT TUBE IDENTIFICATION NUMBER: _____ DATE: _____

CALIBRATED BY: _____

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

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

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

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

Figure 2-9. Pitot tube calibration data.

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

Equation 2-2

where:

$C_{p(s)}$ = Type S pitot 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 B-side value of $C_{p(s)}$ from $\bar{C}_p$ (side B). Use the following equation:

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

Equation 2-3

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

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

Equation 2-4

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

4.1.5 Special considerations.

4.1.5.1 Selection of calibration point.

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

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

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

4.1.5.2 For those probe assemblies in which pitot tube-nozzle interference is a factor (i.e., those in which the pitot-nozzle separation distance 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 larger nozzle sizes (>0.635 cm or ¼ in.) are not ordinarily used for isokinetic sampling at velocities around 915 m/min (3,000 ft/min), which is the calibration velocity; note also that it is not necessary to draw an isokinetic sample during calibration (see Citation 19 in Section 6).

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

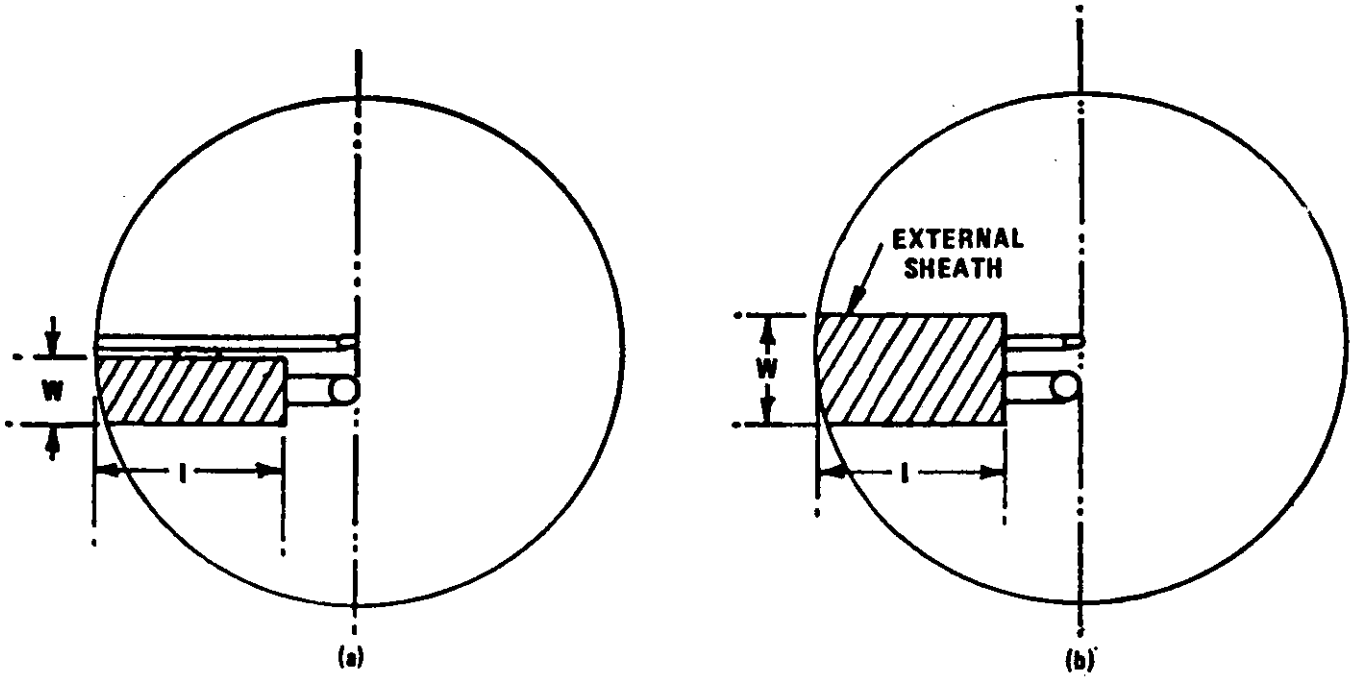


Figure 2-10. Projected-area models for typical pitot tube assemblies.

4.1.6 Field Use and Recalibration.

4.1.6.1 Field Use.

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

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

4.1.6.2 Recalibration.

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

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

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

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

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

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

5. *Calculations*

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

5.1 Nomenclature.

A = Cross-sectional area of stack, 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, m/sec (ft/sec).

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

3,600 = Conversion factor, sec/hr.

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

5.2 Average stack gas velocity.

$$v_s = K_p C_p \left(\sqrt{\Delta p}\right)_{avg} \sqrt{\frac{T_{s(avg)}}{P_s M_s}} \qquad \text{Equation 2-9}$$

5.3 Average stack gas dry volumetric flow rate.

$$Q_{sd} = 3{,}600(1-B_{ws})\,v_s A \left(\frac{T_{std}}{T_{s(avg)}}\right)\left(\frac{P_s}{P_{std}}\right) \qquad \text{Equation 2-10}$$

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

1. *Principle and Applicability*

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

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

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

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 Orab Sampling (Figure 3-1).

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

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

2.2 Integrated Sampling (Figure 3-2).

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

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

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

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

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

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

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

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

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

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

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

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

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

3. Dry Molecular Weight Determination

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

3.1 Single-Point, Grab Sampling and Analytical Procedure.

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

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

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

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

3.2 Single-Point, Integrated Sampling and Analytical Procedure.

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

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

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

3.2.4 Obtain one integrated flue gas sample during each pollutant emission rate determination. Within 8 hours after the sample is taken, analyze it for percent CO_2 and percent O_2 using either an Orsat analyzer or a Fyrite-type combustion gas analyzer. If an Orsat analyzer is used, it is recommended that the Orsat leak-check described in Section 5 be performed before this determination; however, the check is optional. Determine the percentage of the gas that is N_2 and CO 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 3-3.

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. 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.

4.1.3 Place the probe in the stack, with the tip of the probe positioned at the sampling point; purge the sampling line. Draw a sample into the analyzer. For emission rate correction factor determination, immediately analyze the sample, as outlined in Sections 4.1.4 and 4.1.5, for percent CO_2 or percent O_2. If excess air is desired, proceed as follows: (1) immediately analyze the sample, as in Sections 4.1.4 and 4.1.5, for percent CO_2, O_2, and CO; (2) determine the percentage of the gas that is N_2 by subtracting the sum of the percent CO_2, percent O_2, and percent CO from 100 percent; and (3) calculate percent excess air as outlined in Section 6.2.

4.1.4 To ensure complete absorption of the CO_2, O_2, or if applicable, CO, make repeated passes through each absorbing solution until two consecutive readings are the same. Several passes (three or four) should be made between readings. (If constant readings cannot be obtained after three consecutive readings, replace the absorbing solution.)

4.1.5 After the analysis is completed, leak-check (mandatory) the Orsat analyzer once again, as described in Section 5. For the results of the analysis to be valid, the Orsat analyzer must pass this leak test before and after the analysis. NOTE.—Since this single-point, grab sampling and analytical procedure is normally conducted in conjunction with a single-point, grab sampling and analytical procedure for a pollutant, only one analysis is ordinarily conducted. Therefore, great care must be taken to obtain a valid sample and analysis. Although in most cases only CO_2 or O_2 is required, it is recommended that both CO_2 and O_2 be measured, and that Citation 5 in the Bibliography be used to validate the analytical data.

4.2 Single-Point, Integrated Sampling and Analytical Procedure.

4.2.1 The sampling point in the duct shall be located as specified in Section 4.1.1.

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

4.2.3 Sample at a constant rate, or as specified by the Administrator. The sampling run must be simultaneous with, and for the same total length of time as, the pollutant emission rate determination. Collect at least 30 liters (1.00 ft³) of sample gas. Smaller volumes may be collected, subject to approval of the Administrator.

4.2.4 Obtain one integrated flue gas sample during each pollutant emission rate determination. For emission rate correction factor determination, analyze the sample within 4 hours after it is taken for percent CO_2 or percent O_2 (as outlined in Sections 4.2.5 through 4.2.7). The Orsat analyzer must be leak-checked (see Section 5) before the analysis. If excess air is desired, proceed as follows: (1) within 4 hours after the sample is taken, analyze it (as in Sections 4.2.5 through 4.2.7) for percent CO_2, O_2, and CO; (2) determine the percentage of the gas that is N_2 by subtracting the sum of the percent CO_2, percent O_2, and percent CO from 100 percent; 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) 0.5 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 0.3 percent. Average the three acceptable values of percent CO and report the results to the nearest 0.1 percent.

4.2.7 After the analysis is completed, leak-check (mandatory) the Orsat analyzer once again, as described in Section 5. For the results of the analysis to be valid, the Orsat analyzer must pass this leak test before and after the analysis. Note: Although in most instances only CO_2 or O_2 is required, it is recommended that both CO_2 and O_2 be measured, and that Citation 5 in the Bibliography be used to validate the analytical data.

4.3 Multi-Point, Integrated Sampling and Analytical Procedure.

4.3.1 Both the minimum number of sampling points and the sampling point location shall be as specified in Section 3.3.1 of this method. The use of fewer points than specified is subject to the approval of the Administrator.

4.3.2 Follow the procedures outlined in Sections 4.2.2 through 4.2.7, except for the following: Traverse all sampling points and sample at each point for an equal length of time. Record sampling data as shown in Figure 3-3.

5. *Leak-Check Procedure for Orsat Analyzers*

Moving an Orsat analyzer frequently causes it to leak. Therefore, an Orsat analyzer should be thoroughly leak-checked on site before the flue gas sample is introduced into it. The procedure for leak-checking an Orsat analyzer is:

5.1.1 Bring the liquid level in each pipette up to the reference mark on the capillary tubing, and then close the pipette stopcock.

5.1.2 Raise the leveling bulb sufficiently to bring the confining liquid meniscus 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 stopcocks should be checked until the cause of the leak is identified. Leaking stopcocks must be disassembled, cleaned, and regreased. Leaking rubber connections must be replaced. After the analyzer is reassembled, the leak-check procedure must be repeated.

6. *Calculations*

6.1 Nomenclature.

M_d = Dry molecular weight, g/g-mole (lb/lb-mole).
%EA = Percent excess air.
$\%CO_2$ = Percent CO_2 by volume (dry basis).
$\%O_2$ = Percent O_2 by volume (dry basis).
%CO = Percent CO by volume (dry basis).
$\%N_2$ = Percent N_2 by volume (dry basis).
0.264 = Ratio of O_2 to N_2 in air, v/v.
0.280 = Molecular weight of N_2 or CO, divided by 100.
0.320 = Molecular weight of O_2 divided by 100.
0.440 = Molecular weight of CO_2 divided by 100.

6.2 Percent Excess Air. Calculate the percent excess air (if applicable), by substituting the appropriate values of percent O_2, CO, and N_2 (obtained from Section 4.1.3 or 4.2.4) into Equation 3-1.

$$\%EA = \left[\frac{\%O_2 - 0.5\%CO}{0.264\,\%N_2 - (\%O_2 - 0.5\%CO)}\right]100$$

Equation 3-1

Note.—The equation above assumes that ambient air is used as the source of O_2 and that the fuel does not contain appreciable amounts of N_2 (as do coke oven or blast furnace gases). For those cases when appreciable amounts of N_2 are present (coal, oil, and natural gas do not contain appreciable amounts of N_2) or when oxygen enrichment is used, alternate methods, subject to approval of the Administrator, are required.

6.3 Dry Molecular Weight. Use Equation 3-2 to calculate the dry molecular weight of the stack gas.

$$M_d = 0.440(\%CO_2) + 0.320(\%O_2) + 0.280(\%N_2 + \%CO)$$

Equation 3-2

Note.—The above equation does not consider argon in air (about 0.9 percent, molecular weight of 37.7). A negative error of about 0.4 percent is introduced. The tester may opt to include argon in the analysis using procedures subject to approval of the Administrator.

7. *Bibliography*

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METHOD 4—DETERMINATION OF MOISTURE CONTENT IN STACK GASES

1. *Principle and Applicability*

1.1 Principle. A gas sample is extracted at a constant rate from the source; moisture is removed from the sample stream and determined either volumetrically or gravimetrically.

1.2 Applicability. This method is applicable for determining the moisture content of stack gas.

Two procedures are given. The first is a reference method, for accurate determinations of moisture content (such as are needed to calculate emission data). The second is an approximation method, which provides estimates of percent moisture to aid in setting isokinetic sampling rates prior to a pollutant emission measurement run. The approximation method described herein is only a suggested approach; alternative means for approximating the moisture content, e.g., drying tubes, wet bulb-dry bulb techniques, condensation techniques, stoichiometric calculations, previous experience, etc., are also acceptable.

The reference method is often conducted simultaneously with a pollutant emission measurement run; when it is, calculation of percent isokinetic, pollutant emission rate, etc., for the run shall be based upon the results of the reference method or its equivalent; these calculations shall not be based upon the results of the approximation method, unless the approximation method is shown, to the satisfaction of the Administrator, U.S. Environmental Protection Agency, to be capable of yielding results within 1 percent H_2O of the reference method.

Note.—The reference method may yield questionable results when applied to saturated gas streams or to streams that contain water droplets. Therefore, when these conditions exist or are suspected, a second determination of the moisture content shall be made simultaneously with the reference method, as follows: Assume that the gas stream is saturated. Attach a temperature sensor (capable of measuring to ±1° C (2° F)) to the reference method probe. Measure the stack gas temperature at each traverse point (see Section 2.2.1) during the reference method traverse; calculate the average stack gas temperature. Next, determine the moisture percentage, either by: (1) using a psychrometric chart and making appropriate corrections if stack pressure is different from that of the chart, or (2) using saturation vapor pressure tables. In cases where the psychrometric chart or the saturation vapor pressure tables are not applicable (based on evaluation of the process), alternate methods, subject to the approval of the Administrator, shall be used.

2. *Reference Method*

The procedure described in Method 5 for determining moisture content is acceptable as a reference method.

2.1 Apparatus. A schematic of the sampling train used in this reference method is shown in Figure 4-1. All components shall be maintained and calibrated according to the procedure outlined in Method 5.

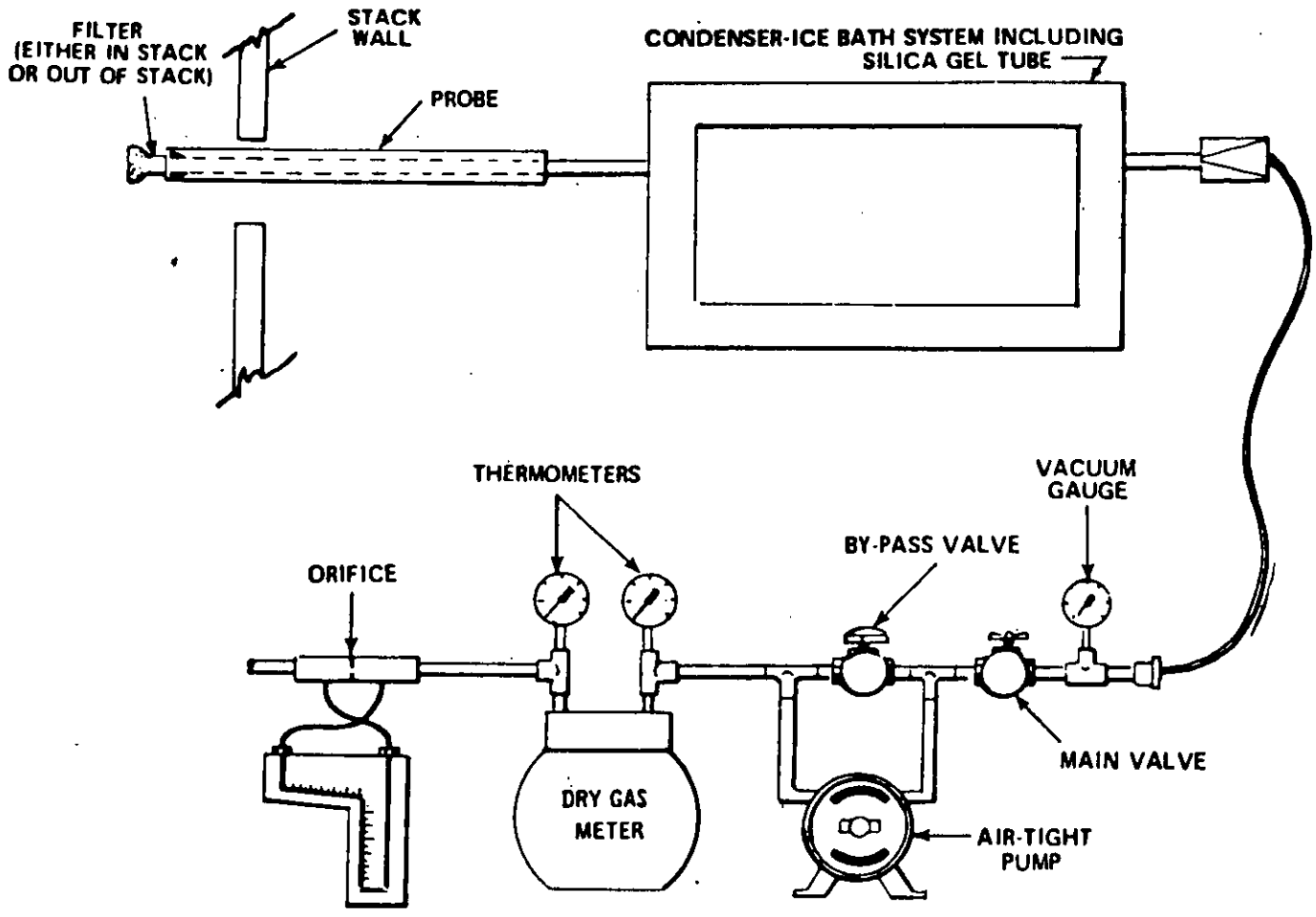

Figure 4-1. Moisture sampling train-reference method.

2.1.1 Probe. The probe is constructed of stainless steel or glass tubing, sufficiently heated to prevent water condensation, and is equipped with a filter, either in-stack (e.g., a plug of glass wool inserted into the end of the probe) or heated out-stack (e.g., as described in Method 5), to remove particulate matter.

When stack conditions permit, other metals or plastic tubing may be used for the probe, subject to the approval of the Administrator.

2.1.2 Condenser. The condenser consists of four impingers connected in series with ground glass, leak-free fittings or any similarly leak-free non-contaminating fittings. The first, third, and fourth impingers shall be of the Greenburg-Smith design, modified by replacing the tip with a 1.3 centimeter (½ inch) ID glass tube extending to about 1.3 cm (½ in.) from the bottom of the flask. The second impinger shall be of the Greenburg-Smith design with the standard tip. Modifications (e.g., using flexible connections between the impingers, using materials other than glass, or using flexible vacuum lines to connect the filter holder to the condenser) may be used, subject to the approval of the Administrator.

The first two impingers shall contain known volumes of water, the third shall be empty, and the fourth shall contain a known weight of 6- to 16-mesh indicating type silica gel, or equivalent desiccant. If the silica gel has been previously used, dry at 175° C (350° F) for 2 hours. New silica gel may be used as received. A thermometer, capable of measuring temperature to within 1° C (2° F), shall be placed at the outlet of the fourth impinger, for monitoring purposes.

Alternatively, any system may be used (subject to the approval of the Administrator) that cools the sample gas stream and allows measurement of both the water that has been condensed and the moisture leaving the condenser, each to within 1 ml or 1 g. Acceptable means are to measure the condensed water, either gravimetrically or volumetrically, and to measure the moisture leaving the condenser by: (1) monitoring the temperature and pressure at the exit of the condenser and using Dalton's law of partial pressures, or (2) passing the sample gas stream through a tared silica gel (or equivalent desiccant) trap, with exit gases kept below 20° C (68° F), and determining the weight gain.

If means other than silica gel are used to determine the amount of moisture leaving the condenser, it is recommended that silica gel (or equivalent) still be used between the condenser system and pump, to prevent moisture condensation in the pump and metering devices and to avoid the need to make corrections for moisture in the metered volume.

2.1.3 Cooling System. An ice bath container and crushed ice (or equivalent) are used to aid in condensing moisture.

2.1.4 Metering System. This system includes a vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 3° C (5.4° F), dry gas meter capable of measuring volume to within 2 percent, and related equipment as shown in Figure 4-1. Other metering systems, capable of maintaining a constant sampling rate and determining sample gas volume, may be used, subject to the approval of the Administrator.

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

2.1.6 Graduated Cylinder and/or Balance. These items are used to measure condensed water and moisture caught in the silica gel to within 1 ml or 0.5 g. Graduated cylinders shall have subdivisions no greater than 2 ml. Most laboratory balances are capable of weighing to the nearest 0.5 g or less. These balances are suitable for use here.

2.2 Procedure. The following procedure is written for a condenser system (such as the impinger system described in Section 2.1.2) incorporating volumetric analysis to measure the condensed moisture, and silica gel and gravimetric analysis to measure the moisture leaving the condenser.

2.2.1 Unless otherwise specified by the Administrator, a minimum of eight traverse points shall be used for circular stacks having diameters less than 0.61 m (24 in.), a minimum of nine points shall be used for rectangular stacks having equivalent diameters less than 0.61 m (24 in.), and a minimum of twelve travers points shall be used in all other cases. The traverse points shall be located according to Method 1. The use of fewer points is subject to the approval of the Administrator. Select a suitable probe and probe length such that all traverse points can be sampled. Consider sampling from opposite sides of the stack (four total sampling ports) for large stacks, to permit use of shorter probe lengths. Mark the probe with heat resistant tape or by some other method to denote the proper distance into the stack or duct for each sampling point. Place known volumes of water in the first two impingers. Weigh and record the weight of the silica gel to the nearest 0.5 g, and transfer the silica gel to the fourth impinger; alternatively, the silica gel may first be transferred to the impinger, and the weight of the silica gel plus impinger recorded.

2.2.2 Select a total sampling time such that a minimum total gas volume of 0.60 scm (21 scf) will be collected, at a rate no greater than 0.021 m³/min (0.75 cfm). When both moisture content and pollutant emission rate are to be determined, the moisture determination shall be simultaneous with, and for the same total length of time as, the pollutant emission rate run, unless otherwise specified in an applicable subpart of the standards.

2.2.3 Set up the sampling train as shown in Figure 4-1. Turn on the probe heater and (if applicable) the filter heating system to temperatures of about 120° C (248° F), to prevent water condensation ahead of the condenser; allow time for the temperatures to stabilize. Place crushed ice in the ice bath container. It is recommended, but not required, that a leak check be done, as follows: Disconnect the probe from the first impinger or

(if applicable) from the filter holder. Plug the inlet to the first impinger (or filter holder) and pull a 380 mm (15 in.) Hg vacuum; a lower vacuum may be used, provided that it is not exceeded during the test. A leakage rate in excess of 4 percent of the average sampling rate or 0.00057 m³/min (0.02 cfm), whichever is less, is unacceptable. Following the leak check, reconnect the probe to the sampling train.

2.2.4 During the sampling run, maintain a sampling rate within 10 percent of constant rate, or as specified by the Administrator. For each run, record the data required on the example data sheet shown in Figure 4-2. Be sure to record the dry gas meter reading at the beginning and end of each sampling time increment and whenever sampling is halted. Take other appropriate readings at each sample point, at least once during each time increment.

2.2.5 To begin sampling, position the probe tip at the first traverse point. Immediately start the pump and adjust the flow to the desired rate. Traverse the cross section, sampling at each traverse point for an equal length of time. Add more ice and, if necessary, salt to maintain a temperature of less than 20° C (68° F) at the silica gel outlet.

2.2.6 After collecting the sample, disconnect the probe from the filter holder (or from the first impinger) and conduct a leak check (mandatory) as described in Section 2.2.3. Record the leak rate. If the leakage rate exceeds the allowable rate, the tester shall either reject the test results or shall correct the sample volume as in Section 6.3 of Method 5. Next, measure the volume of the moisture condensed to the nearest ml. Determine the increase in weight of the silica gel (or silica gel plus impinger) to the nearest 0.5 g. Record this information (see example data sheet, Figure 4-3) and calculate the moisture percentage, as described in 2.3 below.

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

PLANT_____

LOCATION_____

OPERATOR_____

DATE_____

RUN NO._____

AMBIENT TEMPERATURE_____

BAROMETRIC PRESSURE_____

PROBE LENGTH m(ft)_____

SCHEMATIC OF STACK CROSS SECTION

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STACK TEMPERATURE °C (°F)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH), mm(in.) H_2O	METER READING GAS SAMPLE VOLUME m^3 (ft^3)	ΔV_m m^3 (ft^3)	GAS SAMPLE TEMPERATURE AT DRY GAS METER		TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER, °C (°F)
						INLET ($T_{m_{in}}$), °C (°F)	OUTLET ($T_{m_{out}}$), °C (°F)	
TOTAL						Avg.	Avg.	
AVERAGE						Avg.		

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

	IMPINGER VOLUME, ml	SILICA GEL WEIGHT, g
FINAL		
INITIAL		
DIFFERENCE		

Figure 4-3. Analytical data - reference method.

2.3.1 Nomenclature.

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

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

P_m = Absolute pressure (for this method, same as barometric pressure) at the dry gas meter, mm Hg (in. Hg).

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

R = Ideal gas constant, 0.06236 (mm Hg) (m^3)/(g-mole) (°K) for metric units and 21.85 (in. Hg) (ft^3)/(lb-mole) (°R) for English units.

T_m = Absolute temperature at meter, °K (°R).

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

V_m = Dry gas volume measured by dry gas meter, dcm (dcf).

ΔV_m = Incremental dry gas volume measured by dry gas meter at each traverse point, dcm (dcf).

$V_{m(std)}$ = Dry gas volume measured by the dry gas meter, corrected to standard conditions, dscm (dscf).

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

2.3.2 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 m^3/ml for metric units
= 0.04707 ft^3/ml for English units

2.3.3 Volume of water vapor collected in silica gel.

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

Equation 4-2

where:

K_2 = 0.001335 m^3/g for metric units
= 0.04718 ft^3/g for English units

2.3.4 Sample gas volume.

$$V_{m(std)} = V_m Y \frac{(P_m)(T_{std})}{(P_{std})(T_m)} = K_3 Y \frac{V_m P_m}{T_m}$$

Equation 4-3

where:

K_3 = 0.3858 °K/mm Hg for metric units
= 17.64 °R/in. Hg for English units

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

2.3.5 Moisture Content.

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

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.

2.3.6 Verification of constant sampling rate. For each time increment, determine the ΔV_m. Calculate the average. If the value for any time increment differs from the average by more than 10 percent, reject the results and repeat the run.

3. *Approximation Method*

The approximation method described below is presented only as a suggested method (see Section 1.2).

3.1 Apparatus.

3.1.1 Probe. Stainless steel or glass tubing, sufficiently heated to prevent water condensation and equipped with a filter (either in-stack or heated out-stack) to remove particulate matter. A plug of glass wool, inserted into the end of the probe, is a satisfactory filter.

3.1.2 Impingers. Two midget impingers, each with 30 ml capacity, or equivalent.

3.1.3 Ice Bath. Container and ice, to aid in condensing moisture in impingers.

3.1.4 Drying Tube. Tube packed with new or regenerated 6- to 16-mesh indicating-type silica gel (or equivalent desiccant), to dry the sample gas and to protect the meter and pump.

3.1.5 Valve. Needle valve, to regulate the sample gas flow rate.

3.1.6 Pump. Leak-free, diaphragm type, or equivalent, to pull the gas sample through the train.

3.1.7 Volume meter. Dry gas meter, sufficiently accurate to measure the sample volume within 2%, and calibrated over the range of flow rates and conditions actually encountered during sampling.

3.1.8 Rate Meter. Rotameter, to measure the flow range from 0 to 3 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 2.1.5 above.

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

3.2 Procedure.

3.2.1 Place exactly 5 ml distilled water in each impinger. 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.

3.2.2 Connect the probe, insert it into the stack, and sample at a constant rate of 2 lpm (0.071 cfm). Continue sampling until the dry gas meter registers about 30 liters (1.1 ft³) or until visible liquid droplets are carried over from the first impinger to the second. Record temperature, pressure, and dry gas meter readings as required by Figure 4-5.

3.2.3 After collecting the sample, combine the contents of the two impingers and measure the volume to the nearest 0.5 ml.

3.3 Calculations. The calculation method presented is designed to estimate the moisture in the stack gas; therefore, other data, which are only necessary for accurate moisture determinations, are not collected. The following equations adequately estimate the moisture content, for the purpose of determining isokinetic sampling rate settings.

3.3.1 Nomenclature.

B_{ws} = Approximate proportion, by volume, of water vapor in the gas stream leaving the second impinger, 0.025.

B_{wo} = 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.

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

Equation 4-5

where:

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

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.

$$B_{ws} = \frac{V_{wc}}{V_{wc} + V_{m(std)}} + B_{wo} = \frac{V_{wc}}{V_{wc} + V_{m(std)}} + (0.025)$$

Equation 4-7

4. *Calibration*

4.1 For the reference method, calibrate equipment as specified in the following sections of Method 5: Section 5.3 (metering system); Section 5.5 (temperature gauges); and Section 5.7 (barometer). The recommended leak check of the metering system (Section 5.6 of Method 5) also applies to the reference method. For the approximation method, use the procedures outlined in Section 5.1.1 of Method 6 to calibrate the metering system, and the procedure of Method 5, Section 5.7 to calibrate the barometer.

5. *Bibliography*

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METHOD 5—DETERMINATION OF PARTICULATE EMISSIONS FROM STATIONARY SOURCES

1. *Principle and Applicability*

1.1 Principle. Particulate matter is withdrawn isokinetically from the source and collected on a glass fiber filter maintained at a temperature in the range of 120±14° C (248±25° F) or such other temperature as specified by an applicable subpart of the standards or approved by the Administrator, U.S. Environmental Protection Agency, for a particular application. The particulate mass, which includes any material that condenses at or above the filtration temperature, is determined gravimetrically after removal of uncombined water.

1.2 Applicability. This method is applicable for the determination of particulate emissions from stationary sources.

2. *Apparatus*

2.1 Sampling Train. A schematic of the sampling train used in this method is shown in Figure 5-1. Complete construction details are given in APTD-0581 (Citation 2 in Section 7); commercial models of this train are also available. For changes from APTD-0581 and for allowable modifications of the train shown in Figure 5-1, see the following subsections.

The operating and maintenance procedures for the sampling train are described in APTD-0576 (Citation 3 in Section 7). Since correct usage is important in obtaining valid results, all users should read APTD-0576 and adopt the operating and maintenance procedures outlined in it, unless otherwise specified herein. The sampling train consists of the following components.

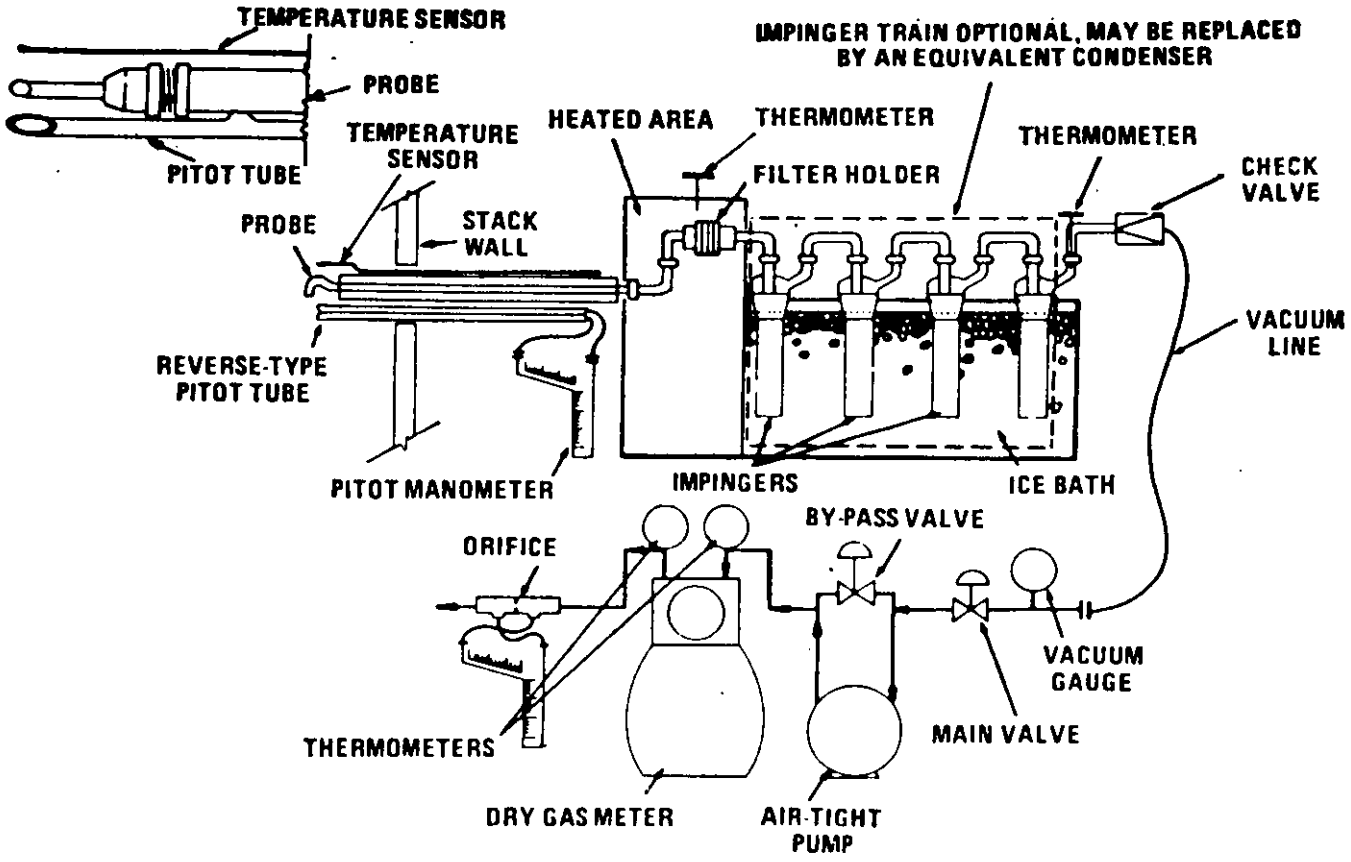

Figure 5 1. Particulate-sampling train.

2.1.1 Probe Nozzle. Stainless steel (316) or glass with sharp, tapered leading edge. The angle of taper shall be ≤30° and the taper shall be on the outside to preserve a constant internal diameter. The probe nozzle shall be of the button-hook or elbow design, unless otherwise specified by the Administrator. If made of stainless steel, the nozzle shall be constructed from seamless tubing; other materials of construction may be used, subject to the approval of the Administrator.

A range of nozzle sizes suitable for isokinetic sampling should be available, e.g., 0.32 to 1.27 cm (⅛ to ½ in.)—or larger if higher volume sampling trains are used—inside diameter (ID) nozzles in increments of 0.16 cm (1/16 in.). Each nozzle shall be calibrated according to the procedures outlined in Section 5.

2.1.2 Probe Liner. Borosilicate or quartz glass tubing with a heating system capable of maintaining a gas temperature at the exit end during sampling of 120±14° C (248±25° F), or such other temperature as specified by an applicable subpart of the standards or approved by the Administrator for a particular application. (The tester may opt to operate the equipment at a temperature lower than that specified.) Since the actual temperature at the outlet of the probe is not usually monitored during sampling, probes constructed according to APTD-0581 and utilizing the calibration curves of APTD-0576 (or calibrated according to the procedure outlined in APTD-0576) will be considered acceptable.

Either borosilicate or quartz glass probe liners may be used for stack temperatures up to about 480° C (900° F); quartz liners shall be used for temperatures between 480 and 900° C (900 and 1,650° F). Both types of liners may be used at higher temperatures than specified for short periods of time, subject to the approval of the Administrator. The softening temperature for borosilicate is 820° C (1,508° F), and for quartz it is 1,500° C (2,732° F).

Whenever practical, every effort should be made to use borosilicate or quartz glass probe liners. Alternatively, metal liners (e.g., 316 stainless steel, Incoloy 825,[2] or other corrosion resistant metals) made of seamless tubing may be used, subject to the approval of the Administrator.

2.1.3 Pitot Tube. Type S, as described in Section 2.1 of Method 2, or other device approved by the Administrator. The pitot tube shall be attached to the probe (as shown in Figure 5–1) to allow constant monitoring of the stack gas velocity. The impact (high pressure) opening plane of the pitot tube shall be even with or above the nozzle entry plane (see Method 2, Figure 2–6b) during sampling. The Type S pitot tube assembly shall have a known coefficient, determined as outlined in Section 4 of Method 2.

2.1.4 Differential Pressure Gauge. Inclined manometer or equivalent device (two), as described in Section 2.2 of Method 2. One manometer shall be used for velocity head (Δp) readings, and the other, for orifice differential pressure readings.

2.1.5 Filter Holder. Borosilicate glass, with a glass frit filter support and a silicone rubber gasket. Other materials of construction (e.g., stainless steel, Teflon, Viton) may be used, subject to approval of the Administrator. The holder design shall provide a positive seal against leakage from the outside or around the filter. The holder shall be attached immediately at the outlet of the probe (or cyclone, if used).

2.1.6 Filter Heating System. Any heating system capable of maintaining a temperature around the filter holder during sampling of 120±14° C (248±25° F), or such other temperature as specified by an applicable subpart of the standards or approved by the Administrator for a particular application. Alternatively, the tester may opt to operate the equipment at a temperature lower than that specified. A temperature gauge capable of measuring temperature to within 3° C (5.4° F) shall be installed so that the temperature around the filter holder can be regulated and monitored during sampling. Heating systems other than the one shown in APTD-0581 may be used.

2.1.7 Condenser. The following system shall be used to determine the stack gas moisture content: Four impingers connected in series with leak-free ground glass fittings or any similar leak-free non-contaminating fittings. The first, third, and fourth impingers shall be of the Greenburg-Smith design, modified by replacing the tip with 1.3 cm (½ in.) ID glass tube extending to about 1.3 cm (½ in.) from the bottom of the flask. The second impinger shall be of the Greenburg-Smith design with the standard tip. Modifications (e.g., using flexible connections between the impingers, using materials other than glass, or using flexible vacuum lines to connect the filter holder to the condenser) may be used, subject to the approval of the Administrator. The first and second impingers shall contain known quantities of water (Section 4.1.3), the third shall be empty, and the fourth shall contain a known weight of silica gel, or equivalent desiccant. A thermometer, capable of measuring temperature to within 1° C (2° F) shall be placed at the outlet of the fourth impinger for monitoring purposes.

Alternatively, any system that cools the sample gas stream and allows measurement of the water condensed and moisture leaving the condenser, each to within 1 ml or 1 g may be used, subject to the approval of the Administrator. Acceptable means are to measure the condensed water either gravimetrically or volumetrically and to measure the moisture leaving the condenser by: (1) monitoring the temperature and pressure at the exit of the condenser and using Dalton's law of partial pressures; or (2) passing the sample gas stream through a tared silica gel (or equivalent desiccant) trap with exit gases kept below 20° C (68° F) and determining the weight gain.

If means other than silica gel are used to determine the amount of moisture leaving the condenser, it is recommended that silica gel (or equivalent) still be used between the condenser system and pump to prevent moisture condensation in the pump and metering devices and to avoid the need to make corrections for moisture in the metered volume.

NOTE.—If a determination of the particulate matter collected in the impingers is desired in addition to moisture content, the impinger system described above shall be used, without modification. Individual States or control agencies requiring this information shall be contacted as to the sample recovery and analysis of the impinger contents.

2.1.8 Metering System. Vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 3° C (5.4° F), dry gas meter capable of measuring volume to within 2 percent, and related equipment, as shown in Figure 5–1. Other metering systems capable of maintaining sampling rates within 10 percent of isokinetic and of determining sample volumes to within 2 percent may be used, subject to the approval of the Administrator. When the metering system is used in conjunction with a pitot tube, the system shall enable checks of isokinetic rates.

Sampling trains utilizing metering systems designed for higher flow rates than that described in APTD-0581 or APTD-0576 may be used provided that the specifications of this method are met.

2.1.9 Barometer. Mercury, aneroid, or other barometer capable of measuring atmospheric pressure to within 2.5 mm Hg (0.1 in. Hg). In many cases, the barometric reading may be obtained from a nearby national weather service station, in which case the station value (which is

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

the absolute barometric pressure) shall be requested and an adjustment for elevation differences between the weather station and sampling point shall be applied at a rate of minus 2.5 mm Hg (0.1 in. Hg) per 30 m (100 ft) elevation increase or vice versa for elevation decrease.

2.1.10 Gas Density Determination Equipment. Temperature sensor and pressure gauge, as described in Sections 2.3 and 2.4 of Method 2, and gas analyzer, if necessary, as described in Method 3. The temperature sensor shall, preferably, be permanently attached to the pitot tube or sampling probe in a fixed configuration, such that the tip of the sensor extends beyond the leading edge of the probe sheath and does not touch any metal. Alternatively, the sensor may be attached just prior to use in the field. Note, however, that if the temperature sensor is attached in the field, the sensor must be placed in an interference-free arrangement with respect to the Type S pitot tube openings (see Method 2, Figure 2-7). As a second alternative, if a difference of not more than 1 percent in the average velocity measurement is to be introduced, the temperature gauge need not be attached to the probe or pitot tube. (This alternative is subject to the approval of the Administrator.)

2.2 Sample Recovery. The following items are needed.

2.2.1 Probe-Liner and Probe-Nozzle Brushes. Nylon bristle brushes with stainless steel wire handles. The probe brush shall have extensions (at least as long as the probe) of stainless steel, Nylon, Teflon, or similarly inert material. The brushes shall be properly sized and shaped to brush out the probe liner and nozzle.

2.2.2 Wash Bottles—Two. Glass wash bottles are recommended, polyethylene wash bottles may be used at the option of the tester. It is recommended that acetone not be stored in polyethylene bottles for longer than a month.

2.2.3 Glass Sample Storage Containers. Chemically resistant, borosilicate glass bottles, for acetone washes, 500 ml or 1000 ml. Screw cap liners shall either be rubber-backed Teflon or shall be constructed so as to be leak-free and resistant to chemical attack by acetone. (Narrow mouth glass bottles have been found to be less prone to leakage.) Alternatively, polyethylene bottles may be used.

2.2.4 Petri Dishes. For filter samples, glass or polyethylene, unless otherwise specified by the Administrator.

2.2.5 Graduated Cylinder and/or Balance. To measure condensed water to within 1 ml or 1 g. Graduated cylinders shall have subdivisions no greater than 2 ml. Most laboratory balances are capable of weighing to the nearest 0.5 g or less. Any of these balances is suitable for use here and in Section 2.3.4.

2.2.6 Plastic Storage Containers. Air-tight containers to store silica gel.

2.2.7 Funnel and Rubber Policeman. To aid in transfer of silica gel to container; not necessary if silica gel is weighed in the field.

2.2.8 Funnel. Glass or polyethlene, to aid in sample recovery.

2.3 Analysis. For analysis, the following equipment is needed.

2.3.1 Glass Weighing Dishes.

2.3.2 Desiccator.

2.3.3 Analytical Balance. To measure to within 0.1 mg.

2.3.4 Balance. To measure to within 0.5 g.

2.3.5 Beakers. 250 ml.

2.3.6 Hygrometer. To measure the relative humidity of the laboratory environment.

2.3.7 Temperature Gauge. To measure the temperature of the laboratory environment.

3. *Reagents*

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

3.1.1 Filters. Glass fiber filters, without organic binder, exhibiting at least 99.95 percent efficiency (≤0.05 percent penetration) on 0.3-micron dioctyl phthalate smoke particles. The filter efficiency test shall be conducted in accordance with ASTM standard method D 2986-71. Test data from the supplier's quality control program are sufficient for this purpose.

3.1.2. Silica Gel. Indicating type, 6 to 16 mesh. If previously used, dry at 175° C (350° F) for 2 hours. New silica gel may be used as received. Alternatively, other types of desiccants (equivalent or better) may be used, subject to the approval of the Administrator.

3.1.3 Water. When analysis of the material caught in the impingers is required, distilled water shall be used. Run blanks prior to field use to eliminate a high blank on test samples.

3.1.4 Crushed Ice.

3.1.5 Stopcock Grease. Acetone-insoluble, heat-stable silicone grease. This is not necessary if screw-on connectors with Teflon sleeves, or similar, are used. Alternatively, other types of stopcock grease may be used, subject to the approval of the Administrator.

3.2 Sample Recovery. Acetone—reagent grade, ≤0.001 percent residue, in glass bottles—is required. Acetone from metal containers generally has a high residue blank and should not be used. Sometimes, suppliers transfer acetone to glass bottles from metal containers; thus, acetone blanks shall be run prior to field use and only acetone with low blank values (≤0.001 percent) shall be used. In no case shall a blank value of greater than 0.001 percent of the weight of acetone used be subtracted from the sample weight.

3.3 Analysis. Two reagents are required for the analysis:

3.3.1 Acetone. Same as 3.2.

3.3.2 Desiccant. Anhydrous calcium sulfate, indicating type. Alternatively, other types of desiccants may be used, subject to the approval of the Administrator.

4. *Procedure*

4.1 Sampling. The complexity of this method is such that, in order to obtain reliable results, testers should be trained and experienced with the test procedures.

4.1.1 Pretest Preparation. All the components shall be maintained and calibrated according to the procedure described in APTD-0576, unless otherwise specified herein.

Weigh several 200 to 300 g portions of silica gel in air-tight containers to the nearest 0.5 g. Record the total weight of the silica gel plus container, on each container. As an alternative, the silica gel need not be preweighed, but may be weighed directly in its impinger or sampling holder just prior to train assembly.

Check filters visually against light for irregularities and flaws or pinhole leaks. Label filters of the proper diameter on the back side near the edge using numbering machine ink. As an alternative, label the shipping containers (glass or plastic petri dishes) and keep the filters in these containers at all times except during sampling and weighing.

Desiccate the filters at 20±5.6° C (68±10° F) and ambient pressure for at least 24 hours and weigh at intervals of at least 6 hours to a constant weight, i.e., <0.5 mg change from previous weighing; record results to the nearest 0.1 mg. During each weighing the filter must not be exposed to the laboratory atmosphere for a period greater than 2 minutes and a relative humidity above 50 percent. Alternatively (unless otherwise specified by the Administrator), the filters may be oven dried at 105° C (220° F) for 2 to 3 hours, desiccated for 2 hours, and weighed. Procedures other than those described, which account for relative humidity effects, may be used, subject to the approval of the Administrator.

4.1.2 Preliminary Determinations. Select the sampling site and the minimum number of sampling points according to Method 1 or as specified by the Administrator. Determine the stack pressure, temperature, and the range of velocity heads using Method 2; it is recommended that a leak-check of the pitot lines (see Method 2, Section 3.1) be performed. Determine the moisture content using Approximation Method 4 or its alternatives for the purpose of making isokinetic sampling rate settings. Determine the stack gas dry molecular weight, as described in Method 2, Section 3.6; if integrated Method 3 sampling is used for molecular weight determination, the integrated bag sample shall be taken simultaneously with, and for the same total length of time as, the particulate sample run.

Select a nozzle size based on the range of velocity heads, such that it is not necessary to change the nozzle size in order to maintain isokinetic sampling rates. During the run, do not change the nozzle size. Ensure that the proper differential pressure gauge is chosen for the range of velocity heads encountered (see Section 2.2 of Method 2).

Select a suitable probe liner and probe length such that all traverse points can be sampled. For large stacks, consider sampling from opposite sides of the stack to reduce the length of probes.

Select a total sampling time greater than or equal to the minimum total sampling time specified in the test procedures for the specific industry such that (1) the sampling time per point is not less than 2 min (or some greater time interval as specified by the Administrator), and (2) the sample volume taken (corrected to standard conditions) will exceed the required minimum total gas sample volume. The latter is based on an approximate average sampling rate.

It is recommended that the number of minutes sampled at each point be an integer or an integer plus one-half minute, in order to avoid timekeeping errors.

In some circumstances, e.g., batch cycles, it may be necessary to sample for shorter times at the traverse points and to obtain smaller gas sample volumes. In these cases, the Administrator's approval must first be obtained.

4.1.3 Preparation of Collection Train. During preparation and assembly of the sampling train, keep all openings where contamination can occur covered until just prior to assembly or until sampling is about to begin.

Place 100 ml of water in each of the first two impingers, leave the third impinger empty, and transfer approximately 200 to 300 g of preweighed silica gel from its container to the fourth impinger. More silica gel may be used, but care should be taken to ensure that it is not entrained and carried out from the impinger during sampling. Place the container in a clean place for later use in the sample recovery. Alternatively, the weight of the silica gel plus impinger may be determined to the nearest 0.5 g and recorded.

Using a tweezer or clean disposable surgical gloves, place a labeled (identified) and weighed filter in the filter holder. Be sure that the filter is properly centered and the gasket properly placed so as to prevent the sample gas stream from circumventing the filter. Check the filter for tears after assembly is completed.

When glass liners are used, install the selected nozzle using a Viton A O-ring when stack temperatures are less than 260° C (500° F) and an asbestos string gasket when temperatures are higher. See APTD-0576 for details. Other connecting systems using either 316 stainless steel or Teflon ferrules may be used. When metal liners are used, install the nozzle as above or by a leak-free direct mechanical connection. Mark the probe with heat resistant tape or by some other method to denote the proper distance into the stack or duct for each sampling point.

Set up the train as in Figure 5-1, using (if necessary) a very light coat of silicone grease on all ground glass joints, greasing only the outer portion (see APTD-0576) to avoid possibility of contamination by the silicone grease. Subject to the approval of the Administrator, a glass cyclone may be used between the probe and filter holder when the total particulate catch is expected to exceed 100 mg or when water droplets are present in the stack gas.

Place crushed ice around the impingers.

4.1.4 Leak-Check Procedures.

4.1.4.1 Pretest Leak-Check. A pretest leak-check is recommended, but not required. If the tester opts to conduct the pretest leak-check, the following procedure shall be used.

After the sampling train has been assembled, turn on and set the filter and probe heating systems at the desired operating temperatures. Allow time for the temperatures to stabilize. If a Viton A O-ring or other leak-free connection is used in assembling the probe nozzle to the probe liner, leak-check the train at the sampling site by plugging the nozzle and pulling a 380 mm Hg (15 in. Hg) vacuum.

NOTE.—A lower vacuum may be used, provided that it is not exceeded during the test.

If an asbestos string is used, do not connect the probe to the train during the leak-check. Instead, leak-check the train by first plugging the inlet to the filter holder (cyclone, if applicable) and pulling a 380 mm Hg (15 in. Hg) vacuum (see Note immediately above). Then connect the probe to the train and leak-check at about 25 mm Hg (1 in. Hg) vacuum; alternatively, the probe may be leak-checked with the rest of the sampling train, in one step, at 380 mm Hg (15 in. Hg) vacuum. Leakage rates in excess of 4 percent of the average sampling rate or 0.00057 m³/min (0.02 cfm), whichever is less, are unacceptable.

The following leak-check instructions for the sampling train described in APTD-0576 and APTD-0581 may be helpful. Start the pump with bypass valve fully open and coarse adjust valve completely closed. Partially open the coarse adjust valve and slowly close the bypass valve until the desired vacuum is reached. Do not reverse direction of bypass valve; this will cause water to back up into the filter holder. If the desired vacuum is exceeded, either leak-check at this higher vacuum or end the leak check as shown below and start over.

When the leak-check is completed, first slowly remove the plug from the inlet to the probe, filter holder, or cyclone (if applicable) and immediately turn off the vacuum pump. This prevents the water in the impingers from being forced backward into the filter holder and silica gel from being entrained backward into the third impinger.

4.1.4.2 Leak-Checks During Sample Run. If, during the sampling run, a component (e.g., filter assembly or impinger) change becomes necessary, a leak-check shall be conducted immediately before the change is made. The leak-check shall be done according to the procedure outlined in Section 4.1.4.1 above, except that it shall be done at a vacuum equal to or greater than the maximum value recorded up to that point in the test. If the leakage rate is found to be no greater than 0.00057 m³/min (0.02 cfm) or 4 percent of the average sampling rate (whichever is less), the results are acceptable, and no correction will need to be applied to the total volume of dry gas metered; if, however, a higher leakage rate is obtained, the tester shall either record the leakage rate and plan to correct the sample volume as shown in Section 6.3 of this method, or shall void the sampling run.

Immediately after component changes, leak-checks are optional; if such leak-checks are done, the procedure outlined in Section 4.1.4.1 above shall be used.

4.1.4.3 Post-test Leak-Check. A leak-check is mandatory at the conclusion of each sampling run. The leak-check shall be done in accordance with the procedures outlined in Section 4.1.4.1, except that it shall be conducted at a vacuum equal to or greater than the maximum value reached during the sampling run. If the leakage rate is found to be no greater than 0.00057 m³/min (0.02 cfm) or 4 percent of the average sampling rate (whichever is less), the results are acceptable, and no correction need be applied to the total volume of dry gas metered. If, however, a higher leakage rate is obtained, the tester shall either record the leakage rate and correct the sample volume as shown in Section 6.3 of this method, or shall void the sampling run.

4.1.5 Particulate Train Operation. During the sampling run, maintain an isokinetic sampling rate (within 10 percent of true isokinetic unless otherwise specified by the Administrator) and a temperature around the filter of 120±14° C (248±25° F), or such other temperature as specified by an applicable subpart of the standards or approved by the Administrator.

For each run, record the data required on a data sheet such as the one shown in Figure 5-2. Be sure to record the initial dry gas meter reading. Record the dry gas meter readings at the beginning and end of each sampling time increment, when changes in flow rates are made, before and after each leak check, and when sampling is halted.

Take other readings required by Figure 5-2 at least once at each sample point during each time increment and additional readings when significant changes (20 percent variation in velocity head readings) necessitate additional adjustments in flow rate. Level and zero the manometer. Because the manometer level and zero may drift due to vibrations and temperature changes, make periodic checks during the traverse.

Clean the portholes prior to the test run to minimize the chance of sampling deposited material. To begin sampling, remove the nozzle cap, verify that the filter and probe heating systems are up to temperature, and that the pitot tube and probe are properly positioned. Position the nozzle at the first traverse point with the tip pointing directly into the gas stream. Immediately start the pump and adjust the flow to isokinetic conditions. Nomographs are available, which aid in the rapid adjustment of the isokinetic sampling rate without excessive computations. These nomographs are designed for use when the Type S pitot tube coefficient is 0.85±0.02, and the stack gas equivalent density (dry molecular weight) is equal to 29±4. APTD-0576 details the procedure for using the nomographs. If C_p and M_d are outside the above stated ranges do not use the nomographs unless appropriate steps (see Citation 7 in Section 7) are taken to compensate for the deviations.

PLANT _____

LOCATION _____

OPERATOR _____

DATE _____

RUN NO. _____

SAMPLE BOX NO. _____

METER BOX NO. _____

METER ΔH@ _____

C FACTOR _____

PITOT TUBE COEFFICIENT, C_p _____

SCHEMATIC OF STACK CROSS SECTION

AMBIENT TEMPERATURE _____

BAROMETRIC PRESSURE _____

ASSUMED MOISTURE, % _____

PROBE LENGTH, m (ft) _____

NOZZLE IDENTIFICATION NO. _____

AVERAGE CALIBRATED NOZZLE DIAMETER, cm (in.) _____

PROBE HEATER SETTING _____

LEAK RATE, m^3/min. (cfm) _____

PROBE LINER MATERIAL _____

STATIC PRESSURE, mm Hg (in. Hg) _____

FILTER NO. _____

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	VACUUM mm Hg (in. Hg)	STACK TEMPERATURE (T_S) °C (°F)	VELOCITY HEAD (ΔP_S), mm(in.)H_2O	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER mm H_2O (in. H_2O)	GAS SAMPLE VOLUME m^3 (ft^3)	GAS SAMPLE TEMPERATURE AT DRY GAS METER		FILTER HOLDER TEMPERATURE, °C (°F)	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER, °C (°F)
							INLET °C (°F)	OUTLET °C (°F)		
TOTAL							Avg.	Avg.		
AVERAGE							Avg.			

Figure 5-2. Particulate field data.

When the stack is under significant negative pressure (height of impinger stem), take care to close the coarse adjust valve before inserting the probe into the stack to prevent water from backing into the filter holder. If necessary, the pump may be turned on with the coarse adjust valve closed.

When the probe is in position, block off the openings around the probe and porthole to prevent unrepresentative dilution of the gas stream.

Traverse the stack cross-section, as required by Method 1 or as specified by the Administrator, being careful not to bump the probe nozzle into the stack walls when sampling near the walls or when removing or inserting the probe through the portholes; this minimizes the chance of extracting deposited material.

During the test run, make periodic adjustments to keep the temperature around the filter holder at the proper level; add more ice and, if necessary, salt to maintain a temperature of less than 20° C (68° F) at the condenser/silica gel outlet. Also, periodically check the level and zero of the manometer.

If the pressure drop across the filter becomes too high, making isokinetic sampling difficult to maintain, the filter may be replaced in the midst of a sample run. It is recommended that another complete filter assembly be used rather than attempting to change the filter itself. Before a new filter assembly is installed, conduct a leak-check (see Section 4.1.4.2). The total particulate weight shall include the summation of all filter assembly catches.

A single train shall be used for the entire sample run, except in cases where simultaneous sampling is required in two or more separate ducts or at two or more different locations within the same duct, or, in cases where equipment failure necessitates a change of trains. In all other situations, the use of two or more trains will be subject to the approval of the Administrator.

Note that when two or more trains are used, separate analyses of the front-half and (if applicable) impinger catches from each train shall be performed, unless identical nozzle sizes were used on all trains, in which case, the front-half catches from the individual trains may be combined (as may the impinger catches) and one analysis of front-half catch and one analysis of impinger catch may be performed. Consult with the Administrator for details concerning the calculation of results when two or more trains are used.

At the end of the sample run, turn off the coarse adjust valve, remove the probe and nozzle from the stack, turn off the pump, record the final dry gas meter reading, and conduct a post-test leak-check, as outlined in Section 4.1.4.3. Also, leak-check the pitot lines as described in Method 2, section 3.1; the lines must pass this leak-check, in order to validate the velocity head data.

4.1.5 Calculation of Percent Isokinetic. Calculate percent isokinetic (see Calculations, Section 6) to determine whether the run was valid or another test run should be made. If there was difficulty in maintaining isokinetic rates due to source conditions, consult with the Administrator for possible variance on the isokinetic rates.

4.2 Sample Recovery. Proper cleanup procedure begins as soon as the probe is removed from the stack at the end of the sampling period. Allow the probe to cool.

When the probe can be safely handled, wipe off all external particulate matter near the tip of the probe nozzle and place a cap over it to prevent losing or gaining particulate matter. Do not cap off the probe tip tightly while the sampling train is cooling down as this would create a vacuum in the filter holder, thus drawing water from the impingers into the filter holder.

Before moving the sample train to the cleanup site, remove the probe from the sample train, wipe off the silicone grease, and cap the open outlet of the probe. Be careful not to lose any condensate that might be present. Wipe off the silicone grease from the filter inlet where the probe was fastened and cap it. Remove the umbilical cord from the last impinger and cap the impinger. If a flexible line is used between the first impinger or condenser and the filter holder, disconnect the line at the filter holder and let any condensed water or liquid drain into the impingers or condenser. After wiping off the silicone grease, cap off the filter holder outlet and impinger inlet. Either ground-glass stoppers, plastic caps, or serum caps may be used to close these openings.

Transfer the probe and filter-impinger assembly to the cleanup area. This area should be clean and protected from the wind so that the chances of contaminating or losing the sample will be minimized.

Save a portion of the acetone used for cleanup as a blank. Take 200 ml of this acetone directly from the wash bottle being used and place it in a glass sample container labeled "acetone blank."

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

Container No. 1. Carefully remove the filter from the filter holder and place it in its identified petri dish container. Use a pair of tweezers and/or clean disposable surgical gloves to handle the filter. If it is necessary to fold the filter, do so such that the particulate cake is inside the fold. Carefully transfer to the petri dish any particulate matter and/or filter fibers which adhere to the filter holder gasket, by using a dry nylon bristle brush and/or a sharp-edged blade. Seal the container.

Container No. 2. Taking care to see that dust on the outside of the probe or other exterior surfaces does not get into the sample, quantitatively recover particulate matter or any condensate from the probe nozzle, probe

fitting, probe liner, and front half of the filter holder by washing these components with acetone and placing the wash in a glass container. Distilled water may be used instead of acetone when approved by the Administrator and shall be used when specified by the Administrator; in these cases, save a water blank and follow the Administrator's directions on analysis. Perform the acetone rinses as follows:

Carefully remove the probe nozzle and clean the inside surfaces by rinsing with acetone from a wash bottle and brushing with a nylon bristle brush. Brush until the acetone rinse shows no visible particles, after which make a final rinse of the inside surface with acetone.

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

Rinse the probe liner with acetone by tilting and rotating the probe while squirting acetone into its upper end so that all inside surfaces will be wetted with acetone. Let the acetone drain from the lower end into the sample container. A funnel (glass or polyethylene) may be used to aid in transferring liquid washes to the container. Follow the acetone rinse with a probe brush. Hold the probe in an inclined position, squirt acetone into the upper end as the probe brush is being pushed with a twisting action through the probe; hold a sample container underneath the lower end of the probe, and catch any acetone and particulate matter which is brushed from the probe. Run the brush through the probe three times or more until no visible particulate matter is carried out with the acetone or until none remains in the probe liner on visual inspection. With stainless steel or other metal probes, run the brush through in the above prescribed manner at least six times since metal probes have small crevices in which particulate matter can be entrapped. Rinse the brush with acetone, and quantitatively collect these washings in the sample container. After the brushing, make a final acetone rinse of the probe as described above.

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

After ensuring that all joints have been wiped clean of silicone grease, clean the inside of the front half of the filter holder by rubbing the surfaces with a nylon bristle brush and rinsing with acetone. Rinse each surface three times or more if needed to remove visible particulate. Make a final rinse of the brush and filter holder. Carefully rinse out the glass cyclone, also (if applicable). After all acetone washings and particulate matter have been collected in the sample container, tighten the lid on the sample container so that acetone will not leak out when it is shipped to the laboratory. Mark the height of the fluid level to determine whether or not leakage occurred during transport. Label the container to clearly identify its contents.

Container No. 3. Note 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 its original container and seal. A funnel may make it easier to pour the silica gel without spilling. A rubber policeman may be used as an aid in removing the silica gel from the impinger. It is not necessary to remove the small amount of dust particles that may adhere to the impinger wall and are difficult to remove. Since the gain in weight is to be used for moisture calculations, do not use any water or other liquids to transfer the silica gel. If a balance is available in the field, follow the procedure for container No. 3 in Section 4.3.

Impinger Water. Treat the impinger as follows. Make a notation of any color or film in the liquid catch. Measure the liquid which is in the first three impingers to within ±1 ml by using a graduated cylinder or by weighing it to within ±0.5 g by using a balance (if one is available). Record the volume or weight of liquid present. This information is required to calculate the moisture content of the effluent gas.

Discard the liquid after measuring and recording the volume or weight, unless analysis of the impinger catch is required (see Note, Section 2.1.7).

If a different type of condenser is used, measure the amount of moisture condensed either volumetrically or gravimetrically.

Whenever possible, containers should be shipped in such a way that they remain upright at all times.

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

Container No. 1. Leave the contents in the shipping container or transfer the filter and any loose particulate from the sample container to a tared glass weighing dish. Desiccate for 24 hours in a desiccator containing anhydrous calcium sulfate. Weigh to a constant weight and report the results to the nearest 0.1 mg. For purposes of this Section, 4.3, the term "constant weight" means a difference of no more than 0.5 mg or 1 percent of total weight less tare weight, whichever is greater, between two consecutive weighings, with no less than 6 hours of desiccation time between weighings.

Plant _____

Date _____

Run No. _____

Filter No. _____

Amount liquid lost during transport _____

Acetone blank volume, ml _____

Acetone wash volume, ml _____

Acetone blank concentration, mg/mg (equation 5-4) _____

Acetone wash blank, mg (equation 5-5) _____

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED, mg		
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
1			
2			
TOTAL			
		Less acetone blank	
		Weight of particulate matter	

	VOLUME OF LIQUID WATER COLLECTED		
	IMPINGER VOLUME, ml	SILICA GEL WEIGHT, g	
FINAL			
INITIAL			
LIQUID COLLECTED			
TOTAL VOLUME COLLECTED		g*	ml

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

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

Figure 5-3. Analytical data.

Alternatively, the sample may be oven dried at 105° C (220° F) for 2 to 3 hours, cooled in the desiccator, and weighed to a constant weight, unless otherwise specified by the Administrator. The tester may also opt to oven dry the sample at 105 ° C (220 ° F) for 2 to 3 hours, weigh the sample, and use this weight as a final weight.

Container No. 3. Note the level of liquid in the container and confirm on the analysis sheet whether or not leakage occurred during transport. If a noticeable amount of leakage has occurred, either void the sample or use methods, subject to the approval of the Administrator, to correct the final results. Measure the liquid in this container either volumetrically to ±1 ml or gravimetrically to ±0.5 g. Transfer the contents to a tared 250-ml beaker and evaporate to dryness at ambient temperature and pressure. Desiccate for 24 hours and weigh to a constant weight. Report the results to the nearest 0.1 mg.

Container No. 4. Weigh the spent silica gel (or silica gel plus impinger) to the nearest 0.5 g using a balance. This step may be conducted in the field.

"Acetone Blank" Container. Measure acetone in this container either volumetrically or gravimetrically. Transfer the acetone to a tared 250-ml beaker and evaporate to dryness at ambient temperature and pressure. Desiccate for 24 hours and weigh to a constant weight. Report the results to the nearest 0.1 mg.

NOTE.—At the option of the tester, the contents of Container No. 2 as well as the acetone blank container may be evaporated at temperatures higher than ambient. If evaporation is done at an elevated temperature, the temperature must be below the boiling point of the solvent; also, to prevent "bumping," the evaporation process must be closely supervised, and the contents of the beaker must be swirled occasionally to maintain an even temperature. Use extreme care, as acetone is highly flammable and has a low flash point.

5. *Calibration*

Maintain a laboratory log of all calibrations.

5.1 Probe Nozzle. Probe nozzles shall be calibrated before their initial use in the field. Using a micrometer, measure the inside diameter of the nozzle to the nearest 0.025 mm (0.001 in.). Make three separate measurements using different diameters each time, and obtain the average of the measurements. The difference between the high and low numbers shall not exceed 0.1 mm (0.004 in.). When nozzles become nicked, dented, or corroded, they shall be reshaped, sharpened, and recalibrated before use. Each nozzle shall be permanently and uniquely identified.

5.2 Pitot Tube. The Type S pitot tube assembly shall be calibrated according to the procedure outlined in Section 4 of Method 2.

5.3 Metering System. Before its initial use in the field, the metering system shall be calibrated according to the procedure outlined in APTD-0576. Instead of physically adjusting the dry gas meter dial readings to correspond to the wet test meter readings, calibration factors may be used to mathematically correct the gas meter dial readings to the proper values. Before calibrating the metering system, it is suggested that a leak-check be conducted. For metering systems having diaphragm pumps, the normal leak-check procedure will not detect leakages within the pump. For these cases the following leak-check procedure is suggested: make a 10-minute calibration run at 0.00057 m³/min (0.02 cfm); at the end of the run, take the difference of the measured wet test meter and dry gas meter volumes; divide the difference by 10, to get the leak rate. The leak rate should not exceed 0.00057 m³/min (0.02 cfm).

After each field use, the calibration of the metering system shall be checked by performing three calibration runs at a single, intermediate orifice setting (based on the previous field test), with the vacuum set at the maximum value reached during the test series. To adjust the vacuum, insert a valve between the wet test meter and the inlet of the metering system. Calculate the average value of the calibration factor. If the calibration has changed by more than 5 percent, recalibrate the meter over the full range of orifice settings, as outlined in APTD-0576.

Alternative procedures, e.g., using the orifice meter coefficients, may be used, subject to the approval of the Administrator.

NOTE.—If the dry gas meter coefficient values obtained before and after a test series differ by more than 5 percent, the test series shall either be voided, or calculations for the test series shall be performed using whichever meter coefficient value (i.e., before or after) gives the lower value of total sample volume.

5.4 Probe Heater Calibration. The probe heating system shall be calibrated before its initial use in the field according to the procedure outlined in APTD-0576. Probes constructed according to APTD-0581 need not be calibrated if the calibration curves in APTD-0576 are used.

5.5 Temperature Gauges. Use the procedure in Section 4.3 of Method 2 to calibrate in-stack temperature gauges. Dial thermometers, such as are used for the dry gas meter and condenser outlet, shall be calibrated against mercury-in-glass thermometers.

5.6 Leak Check of Metering System Shown in Figure 5-1. That portion of the sampling train from the pump to the orifice meter should be leak checked prior to initial use and after each shipment. Leakage after the pump will result in less volume being recorded than is actually sampled. The following procedure is suggested (see Figure 5-4): Close the main valve on the meter box. Insert a one-hole rubber stopper with rubber tubing attached into the orifice exhaust pipe. Disconnect and vent the low side of the orifice manometer. Close off the low side orifice tap. Pressurize the system to 13 to 18 cm (5 to 7 in.) water column by blowing into the rubber tubing. Pinch off the tubing and observe the manometer for one minute. A loss of pressure on the manometer indicates a leak in the meter box; leaks, if present, must be corrected.

5.7 Barometer. Calibrate against a mercury barometer.

6. *Calculations*

Carry out calculations, retaining at least one extra decimal figure beyond that of the acquired data. Round off figures after the final calculation. Other forms of the equations may be used as long as they give equivalent results.

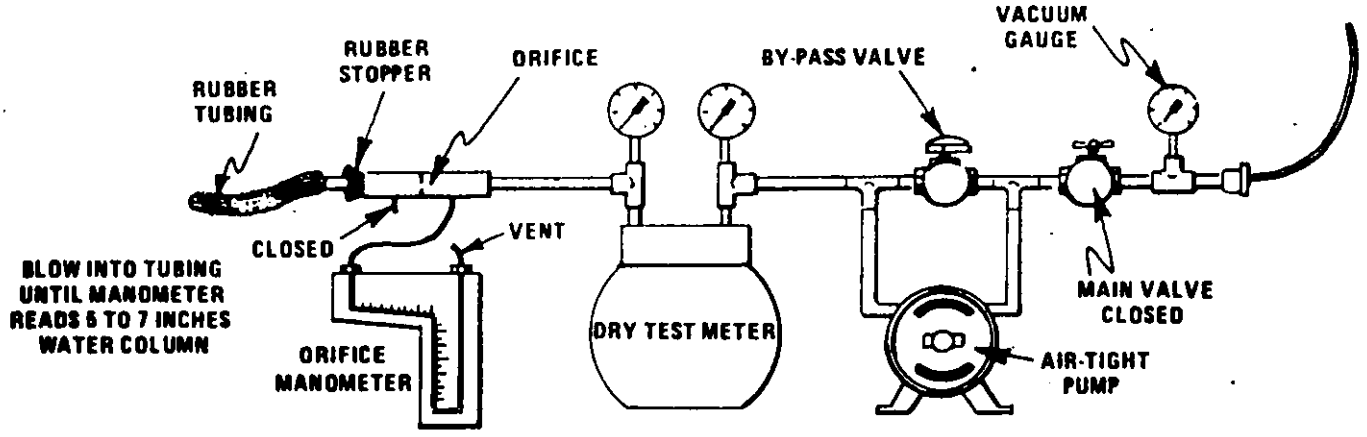

Figure 5-4. Leak check of meter box.

6.1 Nomenclature

A_n = Cross-sectional area of nozzle, m² (ft²).
B_{ws} = Water vapor in the gas stream, proportion by volume.
C_a = Acetone blank residue concentration, mg/g.
c_s = Concentration of particulate matter in stack gas, dry basis, corrected to standard conditions, g/dscm (g/dscf).
I = Percent of isokinetic sampling.
L_a = Maximum acceptable leakage rate for either a pretest leak check or for a leak check following a component change; equal to 0.00057 m³/min (0.02 cfm) or 4 percent of the average sampling rate, whichever is less.
L_i = Individual leakage rate observed during the leak check conducted prior to the "i^{th}" component change (i=1, 2, 3 . . . . n), m³/min (cfm).
L_p = Leakage rate observed during the post-test leak check, m³/min (cfm).
m_a = Total amount of particulate matter collected, mg.
M_w = Molecular weight of water, 18.0 g/g-mole (18.0 lb/lb-mole).
m_a = Mass of residue of acetone after evaporation, mg.
P_{bar} = Barometric pressure at the sampling site, mm Hg (in. Hg).
P_s = Absolute stack gas pressure, mm Hg (in. Hg).
P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).
R = Ideal gas constant, 0.06236 mm Hg-m³/°K-g-mole (21.85 in. Hg-ft³/°R-lb-mole).
T_m = Absolute average dry gas meter temperature (see Figure 5-2), °K (°R).
T_s = Absolute average stack gas temperature (see Figure 5-2), °K (°R).
T_{std} = Standard absolute temperature, 293° K (528° R).
V_a = Volume of acetone blank, ml.
V_{aw} = Volume of acetone used in wash, ml.
V_{lc} = Total volume of liquid collected in impingers and silica gel (see Figure 5-3), ml.
V_m = Volume of gas sample as measured by dry gas meter, dcm (dcf).
$V_{m(std)}$ = Volume of gas sample measured by the dry gas meter, corrected to standard conditions, dscm (dscf).
$V_{w(std)}$ = Volume of water vapor in the gas sample, corrected to standard conditions, scm (scf).
V_s = Stack gas velocity, calculated by Method 2, Equation 2-9, using data obtained from Method 5, m/sec (ft/sec).
W_a = Weight of residue in acetone wash, mg.
Y = Dry gas meter calibration factor.
ΔH = Average pressure differential across the orifice meter (see Figure 5-2), mm H_2O (in. H_2O).
ρ_a = Density of acetone, mg/ml (see label on bottle).
ρ_w = Density of water, 0.9982 g/ml (0.002201 lb/ml).
θ = Total sampling time, min.
θ_i = Sampling time interval, from the beginning of a run until the first component change, min.
θ_i = Sampling time interval, between two successive component changes, beginning with the interval between the first and second changes, min.
θ_p = Sampling time interval, from the final (n^{th}) component change until the end of the sampling run, min.
13.6 = Specific gravity of mercury.
60 = Sec/min.
100 = Conversion to percent.

6.2 Average dry gas meter temperature and average orifice pressure drop. See data sheet (Figure 5-2).

6.3 Dry Gas Volume. Correct the sample volume measured by the dry gas meter to standard conditions (20° C, 760 mm Hg or 68° F, 29.92 in. Hg) by using Equation 5-1.

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

$$= K_1 V_m Y \frac{P_{bar} + (\Delta H/13.6)}{T_m}$$

Equation 5-1

where:
K_3 = 0.3858 °K/mm Hg for metric units
= 17.64 °R/in. Hg for English units

NOTE.—Equation 5-1 can be used as written unless the leakage rate observed during any of the mandatory leak checks (i.e., the post-test leak check or leak checks conducted prior to component changes) exceeds L_a. If L_p or L_c exceeds L_a, Equation 5-1 must be modified as follows:

(a) Case I. No component changes made during sampling run. In this case, replace V_m in Equation 5-1 with the expression:

$$V_m - (L_p - L_a)\theta]$$

(b) Case II. One or more component changes made during the sampling run. In this case, replace V_m in Equation 5-1 by the expression:

$$\left[V_m - (L_1 - L_a)\theta_1 - \sum_{i=2}^{n} (L_i - L_a)\theta_i - (L_p - L_a)\theta_p\right]$$

and substitute only for those leakage rates (L_i or L_p) which exceed L_a.

6.4 Volume of water vapor.

$$V_{w(std)} = V_{lc}\left(\frac{\rho_w}{M_w}\right)\left(\frac{RT_{std}}{P_{std}}\right) = K_2 V_{lc}$$

Equation 5-2

where:
K_2 = 0.001333 m³/ml for metric units
= 0.04707 ft³/ml for English units.

6.5 Moisture Content.

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

Equation 5-3

NOTE.—In saturated or water droplet-laden gas streams, two calculations of the moisture content of the stack gas shall be made, one from the impinger analysis (Equation 5-3), and a second from the assumption of saturated conditions. The lower of the two values of B_{ws} shall be considered correct. The procedure for determining the moisture content based upon assumption of saturated conditions is given in the Note of Section 1.2 of Method 4. For the purposes of this method, the average stack gas temperature from Figure 5-2 may be used to make this determination, provided that the accuracy of the in-stack temperature sensor is ± 1° C (2° F).

6.6 Acetone Blank Concentration.

$$C_a = \frac{m_a}{V_a \rho_a}$$

Equation 5-4

6.7 Acetone Wash Blank

$$W_a = C_a V_{aw} \rho_a$$

Equation 5-5

6.8 Total Particulate Weight. Determine the total particulate catch from the sum of the weights obtained from containers 1 and 2 less the acetone blank (see Figure 5-3). NOTE.—Refer to Section 4.1.5 to assist in calculation of results involving two or more filter assemblies or two or more sampling trains.

6.9 Particulate Concentration.

$$c_s = (0.001\ g/mg)\ (m_n/V_{m(std)})$$

Equation 5-6

6.10 Conversion Factors:

From	To	Multiply by
ft^3	m^3	0.02832
gr/ft^3	gr/ft^3	15.43
g/ft^3	lb/ft^3	2.205×10^{-3}
g/ft^3	g/m^3	35.31

6.11 Isokinetic Variation.

6.11.1 Calculation From Raw Data.

$$I = \frac{100\, T_s [K_3 V_{lc} + (V_m/T_m)(P_{bar} + \Delta H/13.6)]}{60\, \theta v_s P_s A_n}$$

Equation 5-7

where:
K_3 = 0.003454 mm Hg-m^3/ml-°K for metric units.
= 0.002669 in. Hg-ft^3/ml-°R for English units.

6.11.2 Calculation From Intermediate Values.

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

$$= K_4 \frac{T_s V_{m(std)}}{P_s v_s A_n \theta (1 - B_{ws})}$$

Equation 5-8

where:
K_4 = 4.320 for metric units
= 0.09450 for English units.

6.12 Acceptable Results. If 90 percent $\leq I \leq$ 110 percent, the results are acceptable. If the results are low in comparison to the standard and I is beyond the acceptable range, or, if I is less than 90 percent, the Administrator may opt to accept the results. Use Citation 4 to make judgments. Otherwise, reject the results and repeat the test.

7. *Bibliography*

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METHOD 6—DETERMINATION OF SULFUR DIOXIDE EMISSIONS FROM STATIONARY SOURCES

1. *Principle and Applicability*

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

1.2 Applicability. This method is applicable for the determination of sulfur dioxide emissions from stationary sources. The minimum detectable limit of the method has been determined to be 3.4 milligrams (mg) of SO_2/m^3 (2.12×10^{-7} lb/ft^3). Although no upper limit has been established, tests have shown that concentrations as high as 80,000 mg/m^3 of SO_2 can be collected efficiently in two midget impingers, each containing 15 milliliters of 3 percent hydrogen peroxide, at a rate of 1.0 lpm for 20 minutes. Based on theoretical calculations, the upper concentration limit in a 20-liter sample is about 93,300 mg/m^3.

Possible interferents are free ammonia, water-soluble cations, and fluorides. The cations and fluorides are removed by glass wool filters and an isopropanol bubbler, and hence do not affect the SO_2 analysis. When samples are being taken from a gas stream with high concentrations of very fine metallic fumes (such as in inlets to control devices), a high-efficiency glass fiber filter must be used in place of the glass wool plug (i.e., the one in the probe) to remove the cation interferents.

Free ammonia interferes by reacting with SO_2 to form particulate sulfite and by reacting with the indicator. If free ammonia is present (this can be determined by knowledge of the process and noticing white particulate matter in the probe and isopropanol bubbler), alternative methods, subject to the approval of the Administrator, U.S. Environmental Protection Agency, are required.

2. *Apparatus*

those required by standards of performance for new sources.

Finally, States are free under Section 116 of the Act to establish even more stringent emission limits than those established under Section 111 or those necessary to attain or maintain the NAAQS under Section 110. Accordingly, new sources may in some cases be subject to limitations more stringent than EPA's standards of performance under Section 111, and prospective owners and operators of new sources should be aware of this possibility in planning for such facilities.

This regulation will be reviewed 4 years from the date of promulgation as required by the Clean Air Act. This review will include an assessment of such factors as the need for integration with other programs, the existence of alternative methods, enforceability, improvements in emission control technology, and reporting requirements. The reporting requirements in the regulation will be reviewed as required under EPA's sunset policy for reporting requirements in regulations.

Under Executive Order 12291, EPA must judge whether a regulation is "Major" and therefore subject to the requirement of a Regulatory Impact Analysis. This regulation is not Major because: (1) The national annualized compliance costs, including capital charges resulting from the standards total less than $100 million; (2) the standards do not cause a major increase in prices or production costs; and (3) the standards do not cause significant adverse effects on domestic competition, employment, investment, productivity, innovation or competition in foreign markets. This regulation was submitted to the Office of Management and Budget (OMB) for review as required by Executive Order 12291.

Section 317 of the Clean Air Act requires the Administrator to prepare an economic impact assessment for any new source standard of performance promulgated under Section 111(b) of the Act. An economic impact assessment was prepared for the promulgated regulations and for other regulatory alternatives. All aspects of the assessment were considered in the formulation of the promulgated standards to insure that the standards would represent the best system of emission reduction considering costs. The economic impact assessment is included in the background information document.

List of Subjects in 40 CFR Part 60

Air pollution control, Aluminum, Ammonium sulfate plants, Cement industry, Coal, Copper, Electric power-plants, Glass and glass products, Grains, Intergovernmental relations, Iron, Lead, Metals, Motor vehicles, Nitric acid plants, Paper and paper products industry, Petroleum, Phosphate, Sewage disposal, Steel, Sulfuric acid plants, Waste treatment and disposal, Zinc.

Dated: April 9, 1982.

Note.—The regulation does not involve a "collection of information" as defined under the Paperwork Reduction Act of 1980. Therefore, the provisions of the Paperwork Reduction Act applicable to collections of information do not apply to this regulation.

Anne M. Gorsuch,

Administrator.

PART 60—STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES

40 CFR Part 60 is amended by adding a new Subpart KK and by adding a new reference method to Appendix A as follows:

1. A new subpart is added as follows:

Subpart KK—Standards of Performance for Lead-Acid Battery Manufacturing Plants

Sec.

Authority: Sec. 111, 301(a) of the Clean Air Act as amended (42 U.S.C. 7411, 7601(a)), and additional authority as noted below.

Subpart KK—Standards of Performance for Lead-Acid Battery Manufacturing Plants

§ 60.370 Applicability and designation of affected facility.

(a) The provisions of this subpart are applicable to the affected facilities listed in paragraph (b) of this section at any lead-acid battery manufacturing plant that produces or has the design capacity to produce in one day (24 hours) batteries containing an amount of lead equal to or greater than 5.9 Mg (6.5 tons).

(b) The provisions of this subpart are applicable to the following affected facilities used in the manufacture of lead-acid storage batteries:

(1) Grid casting facility.
(2) Paste mixing facility.
(3) Three-process operation facility.
(4) Lead oxide manufacturing facility.
(5) Lead reclamation facility.
(6) Other lead-emitting operations.

(c) Any facility under paragraph (b) of this section the construction or modification of which is commenced after January 14, 1980, is subject to the requirements of this subpart.

§ 60.371 Definitions.

As used in this subpart, all terms not defined herein shall have the meaning given them in the Act and in Subpart A of this part.

(a) "Grid casting facility" means the facility which includes all lead melting pots and machines used for casting the grid used in battery manufacturing.

(b) "Lead-acid battery manufacturing plant" means any plant that produces a storage battery using lead and lead compounds for the plates and sulfuric acid for the electrolyte.

(c) "Lead oxide manufacturing facility" means a facility that produces lead oxide from lead, including product recovery.

(d) "Lead reclamation facility" means the facility that remelts lead scrap and casts it into lead ingots for use in the battery manufacturing process, and which is not a furnace affected under Subpart L of this part.

(e) "Other lead-emitting operation" means any lead-acid battery manufacturing plant operation from which lead emissions are collected and ducted to the atmosphere and which is not part of a grid casting, lead oxide manufacturing, lead reclamation, paste mixing, or three-process operation facility, or a furnace affected under Subpart L of this part.

(f) "Paste mixing facility" means the facility including lead oxide storage, conveying, weighing, metering, and charging operations; paste blending, handling, and cooling operations; and plate pasting, takeoff, cooling, and drying operations.

(g) "Three-process operation facility" means the facility including those processes involved with plate stacking, burning or strap casting, and assembly of elements into the battery case.

§ 60.372 Standards for lead.

(a) On and after the date on which the performance test required to be conducted by § 60.8 is completed, no owner or operator subject to the provisions of this subpart shall cause to be discharged into the atmosphere:

(1) From any grid casting facility any gases that contain lead in excess of 0.40 milligram of lead per dry standard cubic meter of exhaust (0.000176 gr/dscf).

(2) From any paste mixing facility any gases that contain in excess of 1.00 milligram of lead per dry standard cubic meter of exhaust (0.00044 gr/dscf).

(3) From any three-process operation facility any gases that contain in excess of 1.00 milligram of lead per dry

standard cubic meter of exhaust (0.00044 gr/dscf).

(4) From any lead oxide manufacturing facility any gases that contain in excess of 5.0 milligrams of lead per kilogram of lead feed (0.010 lb/ton).

(5) From any lead reclamation facility any gases that contain in excess of 4.50 milligrams of lead per dry standard cubic meter of exhaust (0.00198 gr/dscf).

(6) From any other lead-emitting operation any gases that contain in excess of 1.00 milligram per dry standard cubic meter of exhaust (0.00044 gr/dscf).

(7) From any affected facility other than a lead reclamation facility any gases with greater than 0 percent opacity (measured according to Method 9 and rounded to the nearest whole percentage).

(8) From any lead reclamation facility any gases with greater than 5 percent opacity (measured according to Method 9 and rounded to the nearest whole percentage).

(b) When two or more facilities at the same plant (except the lead oxide manufacturing facility) are ducted to a common control device, an equivalent standard for the total exhaust from the commonly controlled facilities shall be determined as follows:

$$S_e = \sum_{a=1}^{N} S_a(Q_{sd_a}/Q_{sd_t})$$

Where:

S_e = is the equivalent standard for the total exhaust stream.

S_a = is the actual standard for each exhaust stream ducted to the control device.

N = is the total number of exhaust streams ducted to the control device.

Q_{sd_a} = is the dry standard volumetric flow rate of the effluent gas stream from each facility ducted to the control device.

Q_{sd_t} = is the total dry standard volumetric flow rate of all effluent gas streams ducted to the control device.

§ 60.373 Monitoring of emissions and operations.

The owner or operator of any lead-acid battery manufacturing facility subject to the provisions of this subpart and controlled by a scrubbing system(s) shall install, calibrate, maintain, and operate a monitoring device(s) that measures and records the pressure drop across the scrubbing system(s) at least once every 15 minutes. The monitoring device shall have an accuracy of ±5 percent over its operating range.

(Sec. 114 of the Clean Air Act as amended (42 U.S.C. 7414))

§ 60.374 Test methods and procedures.

(a) Reference methods in Appendix A of this part, except as provided under § 60.8(b), shall be used to determine compliance according to § 60.8 as follows:

(1) Method 12 for the measurement of lead concentrations,

(2) Method 1 for sample and velocity traverses,

(3) Method 2 for velocity and volumetric flow rate, and

(4) Method 4 for stack gas moisture.

(b) For Method 12, the sampling time for each run shall be at least 60 minutes and the sampling rate shall be at least 0.85 dscm/h (0.53 dscf/min), except that shorter sampling times, when necessitated by process variables or other factors, may be approved by the Administrator.

(c) When different operations in a three-process operation facility are ducted to separate control devices, the lead emission concentration from the facility shall be determined using the equation:

$$C_{Pb_T} = \sum_{a=1}^{N} (C_{Pb_a} Q_{sd_a}/Q_{sd_t})$$

Where:

C_{Pb_T} = is the facility emission concentration for the entire facility.

N = is the number of control devices to which separate operations in the facility are ducted.

C_{Pb_a} = is the emission concentration from each control device.

Q_{sd_a} = is the dry standards volumetric flow rate of the effluent gas stream from each control device.

Q_{sd_t} = is the total dry standard volumetric flow rate from all of the control devices.

(d) For lead oxide manufacturing facilities, the average lead feed rate to a facility, expressed in kilograms per hour, shall be determined for each test run as follows:

(1) Calculate the total amount of lead charged to the facility during the run by multiplying the number of lead pigs (ingots) charged during the run by the average mass of a pig in kilograms or by another suitable method.

(2) Divide the total amount of lead charged to the facility during the run by the duration of the run in hours.

(e) Lead emissions from lead oxide manufacturing facilities, expressed in milligrams per kilogram of lead charged, shall be determined using the following equation:

$$E_{Pb} = C_{Pb} Q_{sd}/F$$

Where:

E_{Pb} = is the lead emission rate from the facility in milligrams per kilogram of lead charged.

C_{Pb} = is the concentration of lead in the exhaust stream in milligrams per dry standard cubic meter as determined according to paragraph (a)(1) of this section.

Q_{sd} = is the dry standard volumetric flow rate in dry standard cubic meters per hour as determined according to paragraph (a)(3) of this section.

F = is the lead feed rate to the facility in kilograms per hour as determined according to paragraph (d) of this section.

(Sec. 114 of the Clean Air Act as amended (42 U.S.C. 7414))

2. Appendix A to Part 60 is amended by adding new Reference Method 12 as follows:

Appendix A—Reference Methods

* * * * *

Method 12. Determination of Inorganic Lead Emissions From Stationary Sources

1. *Applicability and Principle.*

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 manufacturing 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.

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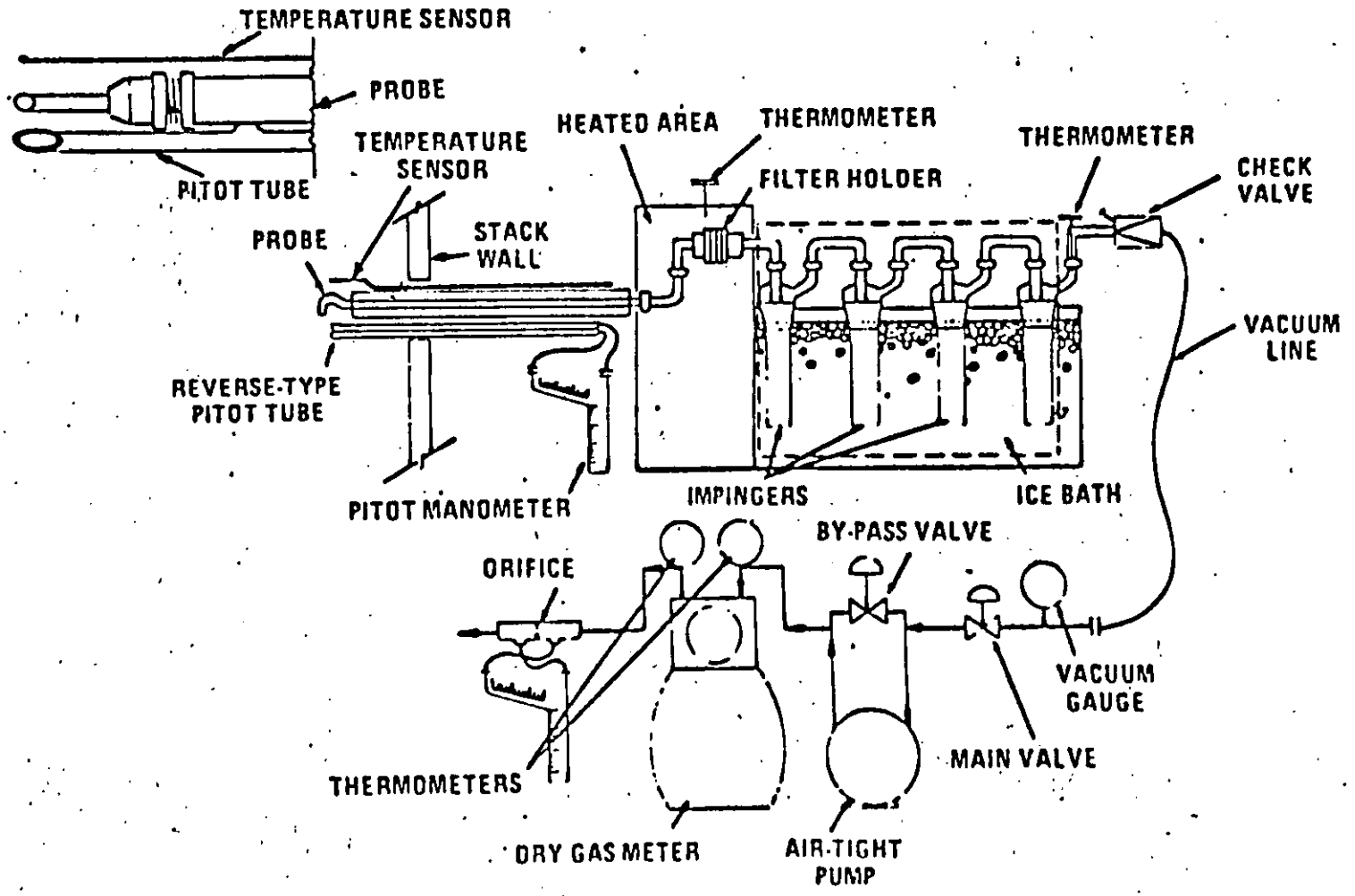

Figure 12-1. Inorganic lead sampling train.

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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 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 2 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 S.

3.3.4 Membrane Filters. Millipore SCWP 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 D 2986-71 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, Section 3.1.2, 3.1.4, and 3.1.5, respectively.

4.1.3 Water. Deionized distilled, to conform to ASTM Specification D 1193-74, 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 390 ml of concentrated HNO_3 to 1 liter with deionized distilled water.

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

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

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 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 12-2.

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 sapling 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 suface 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 toal 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 Mandatory Check for Matrix Effects on the Lead Results. The analysis for Pb by atomic absorption is sensitive to the chemical compositon and to the physical properties (viscosity, pH) of the sample (matrix effects). Since the Pb procedure described here will be applied to many different sources, many sample matrices will be encountered. Thus, check (mandatory) at least one sample from each source using the Method of Additions to ascertain that the chemical composition and physical properties of the sample did not cause erroneous analytical results.

Three acceptable "Method of Additions" procedures are described in the General Procedure Section of the Perkin Elmer Corporation Manual (see Citation 9.1). If the results of the Method of Additions procedure on the source sample do not agree within 5 percent of the value obtained by the conventional atomic absorption analysis, then the tester must reanalyze all samples from the source using the 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:

$$C_{Pb} = K \frac{C'_{Pb}}{V_{m(std)}}$$

Where:

K = 0.001 mg/μg for metric units.

= 2.205 lb/μg 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_3 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*

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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, N.C. (Presented at National APCA Meeting. Houston. June 26, 1978).

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

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

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RECOMMENDED PROCEDURE FOR SAMPLE TRAVERSES IN DUCTS SMALLER THAN 12 INCHES IN DIAMETER

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INTRODUCTION

In source sampling, stack gas velocity is usually measured with a Type-S pitot tube. In many field applications, the pitot tube is attached to a sampling probe, equipped with a nozzle and thermocouple. This combination is called a pitobe assembly. Most conventional pitobe assemblies* have a cylindrical sampling probe of 1-inch diameter, but, occasionally, an assembly has an external cylindrical sheath of about 2-1/2 inches in diameter, encasing the probe, pitot tube and thermocouple. When a pitobe assembly is used to traverse a duct that is 36 inches or less in diameter, the pitobe assembly can "block" a significant part of the duct cross section, as illustrated in the projected-area models, Figures 1a and 1b. This reduction in the effective cross-sectional area of the duct causes a temporary, local increase in the average velocity of the flowing fluid. In most pitobe assemblies, the impact opening of the Type-S pitot tube liesin approximately the same plane as the probe sheath (Figure 2) and, whenever appreciable sheath blockage exists, velocity head (ΔP) readings made with the pitot tube tend to reflect the local increase in gas velocity, and are not truly representative of the mainstream velocity. Recent studies[1, 2] have shown that, for sample traverses in ducts having diameters or equivalent diameters between 12 and 36 inches, blockage effects are not particularly severe, and a simple

*Designed according to the specifications outlined in APTD-0581 (Reference 3), or allowable modifications thereof.

adjustment in the value of the Type-S pitot tube coefficient (C_p) can be made to compensate for the pseudo-high ΔP readings (Figure 3). When the duct diameter (D_s) is less than 12 inches, however, probe sheath blockage effects intensify, and the adjustment technique illustrated in Figure 3 no longer applies. Therefore, alternative methodology must be used in order to obtain representative sample traverses in ducts of this size. The purpose of this paper is to propose a method by which satisfactory sample traverses can be conducted when D_s is between 4 and 12 inches.

PROPOSED METHOD FOR SAMPLE TRAVERSES WHEN 4 in. $\leq D_s <$ 12 in.

METHODOLOGY

To conduct representative sample traverses in ducts having diameters between 4 and 12 inches, it is recommended that the arrangement illustrated in Figure 4 be used. In Figure 4, velocity head (ΔP) readings are taken downstream of the actual sampling site. The purpose of the straight run of duct between the sampling and velocity measurement sites is to allow the flow profile, temporarily disturbed by the presence of the sample probe, to redevelop and stabilize. The pitot tube and sampling nozzle shown in Figure 4 are different from those of a conventional pitobe assembly;[3] construction details of these components are discussed below.

A. Pitot tube.

A standard pitot tube shall be used, instead of a Type-S, to monitor stack gas velocity. When D_s is less than 12 inches, a Type-S pitot tube can begin to block a significant part of the duct cross section and yield

pseudo-high ΔP values. Cross-section blockage is not a serious problem with a standard pitot tube, however, for two reasons: (1) the impact and static pressure openings of a standard pitot tube, unlike those of a Type-S, follow a 90° bend, and are located well upstream of the stem of the tube (compare Figures 2 and 5); and (2) when properly aligned, the sensing head of a standard pitot tube is parallel, not perpendicular, to the flow streamlines in the duct.

The preferred design for the standard pitot tube is the hemispherical-nosed design (Figure 5). Pitot tubes constructed according to the criteria illustrated in Figure 5 will have coefficients of 0.99 ± 0.01[4, 5]. Note, however, that for convenient tubing diameters (dimension "D" Figure 5), the static and impact sensing holes of the hemispherical-type pitot tube will be very small, thus making the tube susceptible to plugging, in particulate or liquid droplet-laden gas streams. Therefore, whenever these conditions are encountered, either of the following can be done: (1) a "back purge" system of some kind can be used to clean out, periodically, the static and impact holes; or (2) a modified hemispherical-nosed pitot tube (Figure 6), which features a shortened stem and enlarged impact and static pressure holes, can be used instead of the conventional hemispherical type. It has recently been demonstrated that the coefficients of the conventional and modified hemispherical-nosed tubes are essentially the same.[6]

B. Sampling nozzle.

The sampling nozzle can either be of the buttonhook or elbow design. The nozzle shall meet the general design criteria specified in Section 2.1.1 of the revised version of EPA Method 5, except that the entry plane of the

nozzle must be at least 2 nozzle diameters (i.d.) upstream of the probe sheath blockage plane (see Figure 7).

PROCEDURES

The following procedures shall be used to perform sample traverses using the arrangement illustrated in Figure 4:

A. Location of sampling site.

Select a sampling site that is at least 8 duct diameters downstream and 10 diameters upstream from the nearest flow disturbances; this allows the velocity measurement site to be located 8 diameters downstream of the sampling location and 2 diameters upstream of the nearest flow disturbance (see Figure 4). For rectangular stacks, use an equivalent diameter, calculated from the following equation, to determine the upstream and downstream distances:

$$D_e = \frac{2LW}{L + W} \qquad \text{(Equation 1)}$$

Where:

D_e = Equivalent diameter

L = Length of cross section

W = Width of cross section

If a sampling site located 8 diameters downstream and 10 diameters upstream from the nearest disturbances is not available, select a site that meets these criteria as nearly as possible. Under no circumstances, however, shall a sampling site be chosen which is less than 2 diameters downstream and 2.5 diameters upstream from the nearest disturbances; this guarantees a minimum

of 2 diameters of straight run between the sampling and velocity measurement sites, and 0.5 diameters between the velocity measurement site and the nearest flow disturbance.

B. Number of traverse points.

The correct number of traverse points shall be determined from Figure 8. To use Figure 8, proceed as follows: first, determine the three distances, "A", "B", and "C", and express each distance in terms of duct diameters; second, read from Figure 8 the number of traverse points corresponding to each of these three distances; third, select the highest of the three numbers of traverse points, or a greater number, so that for circular ducts the number is a multiple of 4; for rectangular ducts, the number should be chosen so that it is one of those shown in Table 2.

C. Location of traverse points, circular cross sections.

For circular stacks, locate the traverse points on 2 perpendicular diameters, according to Table 1 and the example of Figure 9a. Any traverse point located less than 1/2 inch from the stack wall will not be acceptable for use as a sampling point; all such traverse points shall be "adjusted" by relocating them to a distance of 1/2 inch from the wall. In some cases, this relocation process may involve combining two adjacent traverse points to form a single "adjusted" point; thus, in some instances, the number of points actually used for sampling may be less than the number of traverse points obtained from Figure 8.

D. Location of traverse points, rectangular cross sections.

For rectangular stacks, divide the cross section into as many equal rectangular elemental areas as traverse points (as

determined in Section "B" above), according to Table 2. Locate a traverse point at the centroid of each elemental area, according to the example of Figure 9b.

E. Sampling.

Sample at each non-adjusted traverse point for the time interval specified in the method being used (e.g., Method 5). If two successive traverse points have been relocated to a single "adjusted" traverse point, sample twice as long at the adjusted point as at non-adjusted points, taking twice as many readings, but record the data as though two separate points had been sampled, each for half of the total time interval. During the sample run, velocity head (ΔP) readings shall be taken at points downstream of, but directly in line with, the sampling points. The sampling rate through the nozzle shall be set based upon the ΔP readings; if a nomograph is used, be sure when setting it to use the correct value (~ 0.99) of the pitot tube coefficient.[7]

ALTERNATIVE SAMPLING STRATEGY (STEADY-FLOW ONLY)

If the average total volumetric flow rate in a duct is constant with time, it is unnecessary to monitor stack gas velocity during a sample run. Thus, whenever time-invariant flow is believed to exist in a stack (e.g., for a steady-state process), the following traverse procedures can be used in lieu of those outlined in the preceding sections:

A. Location of Sampling-Velocity Measurement Site.

When steady flow is believed to exist in a duct, the sample and velocity traverses can be conducted non-simultaneously; therefore, the sampling and velocity measurement sites need not be separate. Rather, a

single location can be used for both sampling and velocity measurement (see Figure 10).

Select a sampling-velocity measurement site that is at least 8 duct diameters downstream and 2 diameters upstream from the nearest flow disturbances. For rectangular stacks, use an equivalent diameter (Equation 2) to determine the upstream and downstream distances. If a sampling-velocity measurement site located 8 diameters downstream and 2 diameters upstream from the nearest disturbances is not available, choose a site that meets these criteria as nearly as possible. Under no circumstances, however, should a sampling-velocity measurement site be chosen that is less than 2 diameters downstream and 0.5 diameter upstream from the nearest disturbances.

B. Number of Traverse Points.

The correct number of traverse points shall be determined from Figure 11. To use Figure 11, proceed as follows: first, determine the distances "A" and "B" and express each distance in terms of duct diameters; second, read from Figure 11 the number of traverse points corresponding to each of these distances; third, select the higher of these two numbers of traverse points, or a greater number, so that for circular ducts the number is a multiple of 4 and, for rectangular ducts, the number is one of those shown in Table 2.

C. Location of Traverse Points, Circular Cross Sections

For circular stacks, locate the traverse points on 2 perpendicular diameters, according to Table 1 and the example of Figure 9a. Any traverse point located less than 1/2 inch from the stack wall will be unacceptable

for use, either as a velocity traverse point or as a sample point; all such points shall be "adjusted" by relocating them to a distance of 1/2 inch from the wall. In some cases, this relocation process may involve combining two adjacent traverse points to form a single "adjusted" point; thus, the number of traverse points actually used will sometimes be less than the number of points obtained from Figure 11.

D. Location of Traverse Points, Rectangular Cross Sections.

For rectangular stacks, divide the cross section into as many equal rectangular elemental areas as traverse points (as determined in Section "B" above), according to Table 2. Locate a traverse point at the centroid of each elemental area, according to the example of Figure 9b.

E. Preliminary Velocity Traverse.

Perform a preliminary velocity traverse of the duct. Take velocity head (ΔP) readings at each traverse point, using a standard pitot tube (designed as shown in Figure 5 or Figure 6). Calculate the average velocity in the duct, using Equation 2-2 in the December 23, 1971 Federal Register.[8]

F. Sampling

Sample at each non-adjusted traverse point for the time interval specified in the method being used (e.g., Method 5). If two successive traverse points have been relocated to a single "adjusted" traverse point, sample twice as long at the adjusted point as at non-adjusted points, taking twice as many readings, but record the data as though two separate points had been sampled, each for half of the total time interval. Time-invariant

flow is assumed; therefore, the sampling rate at each point shall be set based on the ΔP reading obtained at that point during the preliminary velocity traverse.

6. Post-Test Velocity Traverse.

Perform a second velocity traverse of the duct, at the end of the sample run. Calculate the average velocity in the duct (V_s) avg., using Equation 2-2 of the December 23, 1971 Federal Register.[8] If the value of (V_s) avg. is within ± 10 percent of the value obtained in the preliminary traverse, the assumption of time-invariant flow is valid, and the results are acceptable. If the difference between the pre-test and post-test values of (V_s) avg. is greater than ± 10 percent, reject the results and repeat the run, monitoring velocity during sampling, as shown in Figure 4.

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1. Vollaro, R. F. The Effects of the Presence of a Probe Sheath on Type-S Pitot Tube Accuracy. Environmental Protection Agency, Emission Measurement Branch. Research Triangle Park, N. C. August 1975.

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3. Martin, Robert M. Construction Details of Isokinetic Source-Sampling Equipment. Environmental Protection Agency, Research Triangle Park, N.C. Publication No. APTD-0851, April 1971.

4. Perry, Robert H., Cecil H. Chilton, and Sidney D. Kirkpatrick (ed.). Chemical Engineers' Handbook, Fourth Edition. New York, McGraw-Hill Book Company, 1963.

5. Fluid Meters, Their Theory and Application. New York, Published by the American Society of Mechanical Engineers. 5th Edition, 1959.

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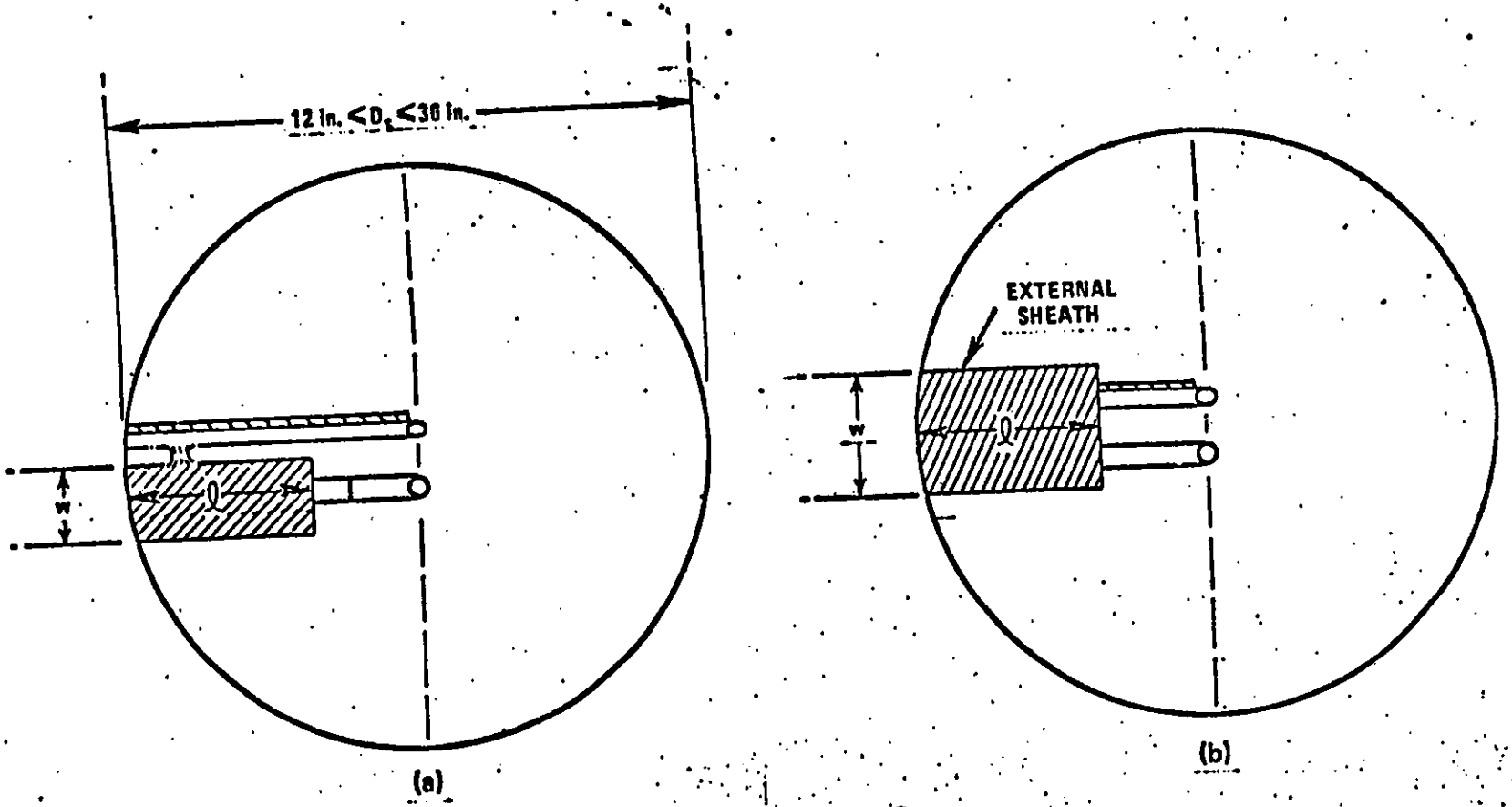
7. Shigehara, R. T. Adjustments in the EPA Nomograph for Different Pitot Tube Coefficients and Dry Molecular Weights. Environmental Protection Agency. Emission Measurement Branch. Research Triangle Park, N.C. August 1974.

8. Standards of Performance for New Stationary Sources. Federal Register. 36 (247). December 23, 1971.



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

Figure 1. Projected-area models for typical pitobe assemblies; shaded area represents approximate average sheath blockage for a sample traverse.

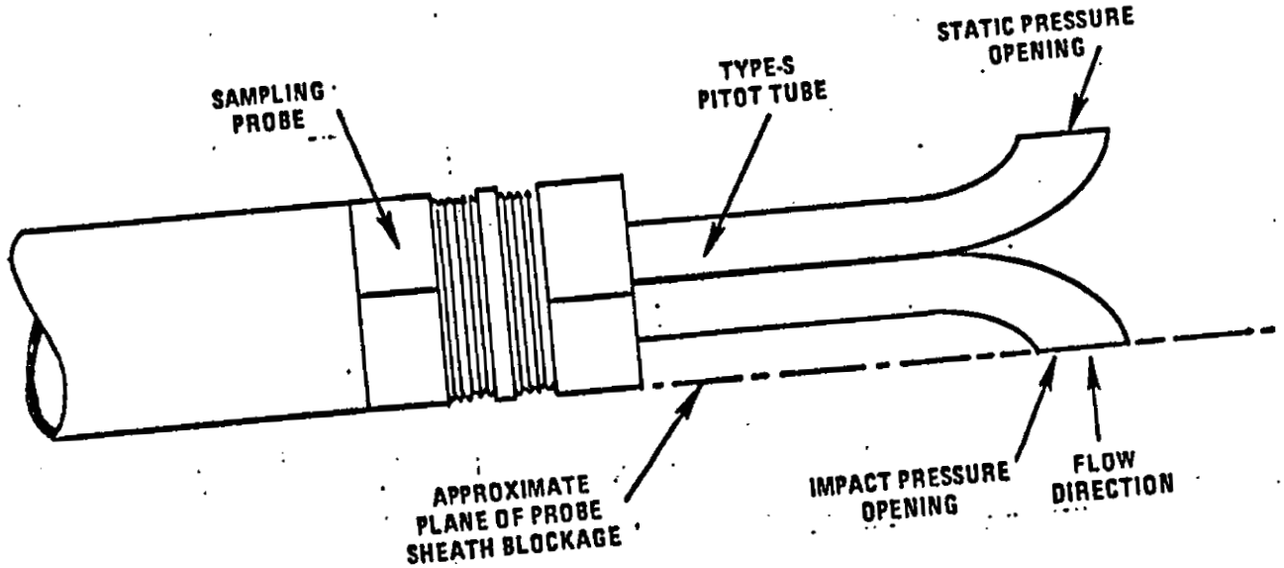


Figure 2. Type-S pitot tube, attached to a sampling probe, showing that the pitot impact opening and probe sheath lie in approximately the same plane.

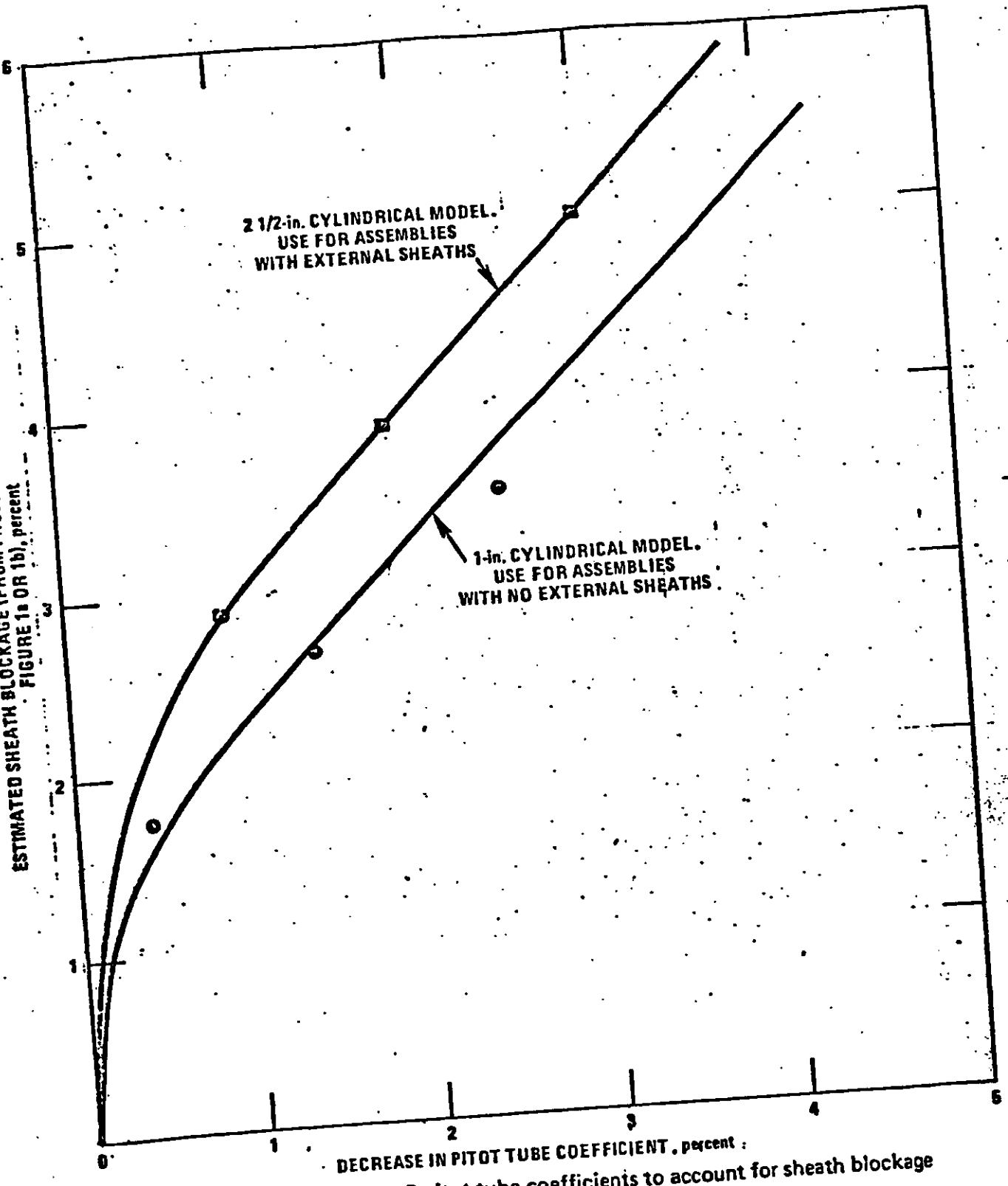


Figure 3. Adjustment of Type-S pitot tube coefficients to account for sheath blockage (12 in. $\leq D_s \leq$ 36 in).

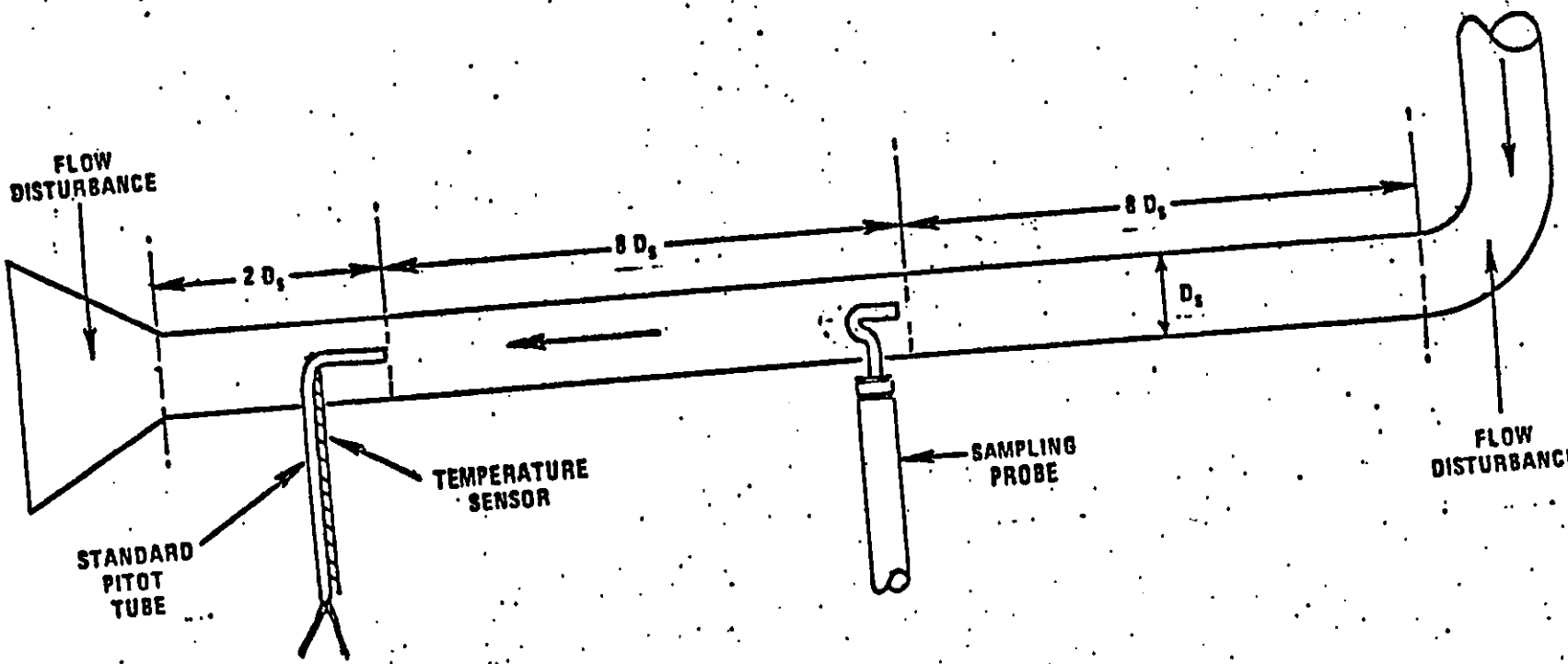


Figure 4. Recommended sampling arrangement, when 4 in. $\leq D_s \leq$ 12 in.

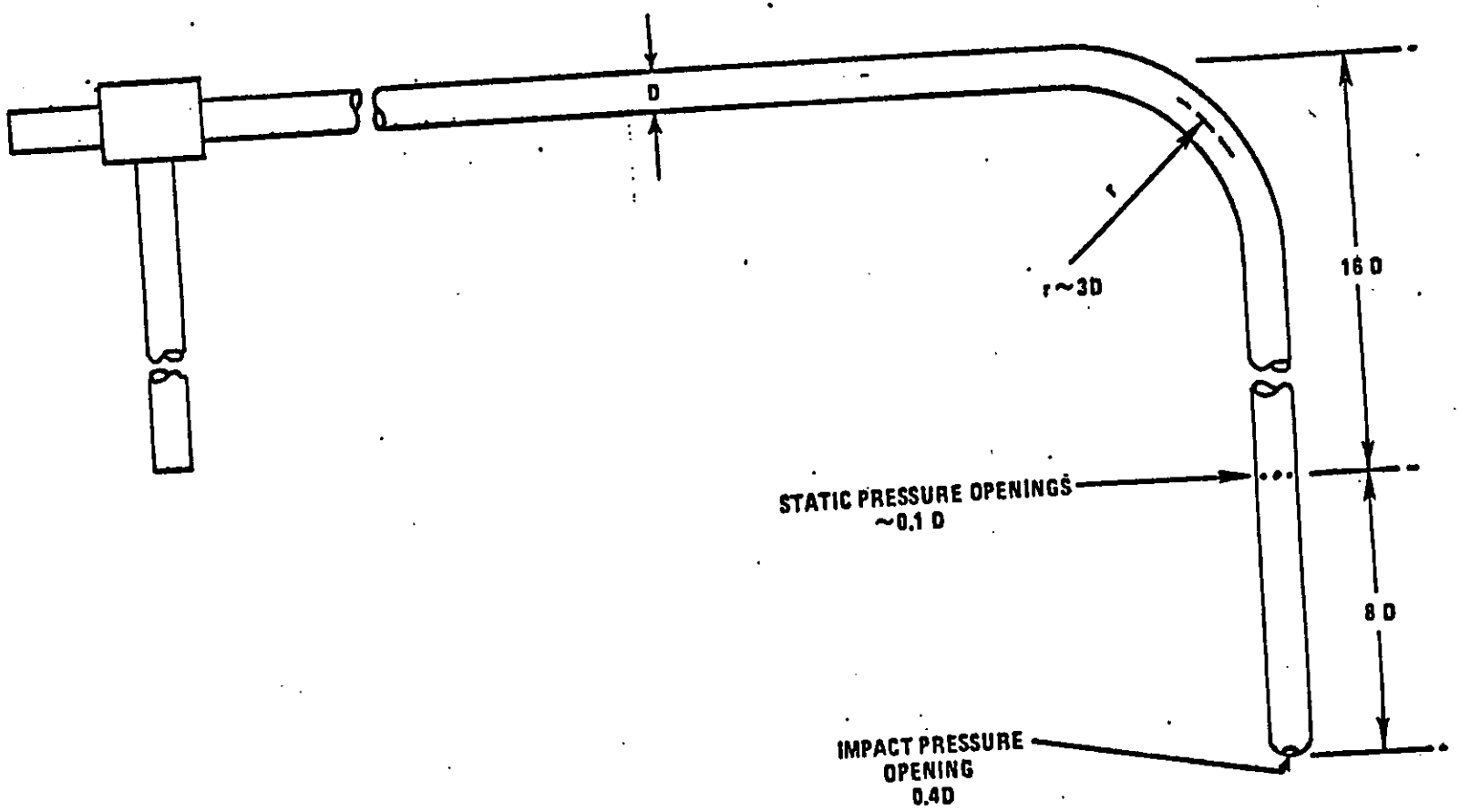


Figure 5. Hemispherical-nosed standard pitot tube.

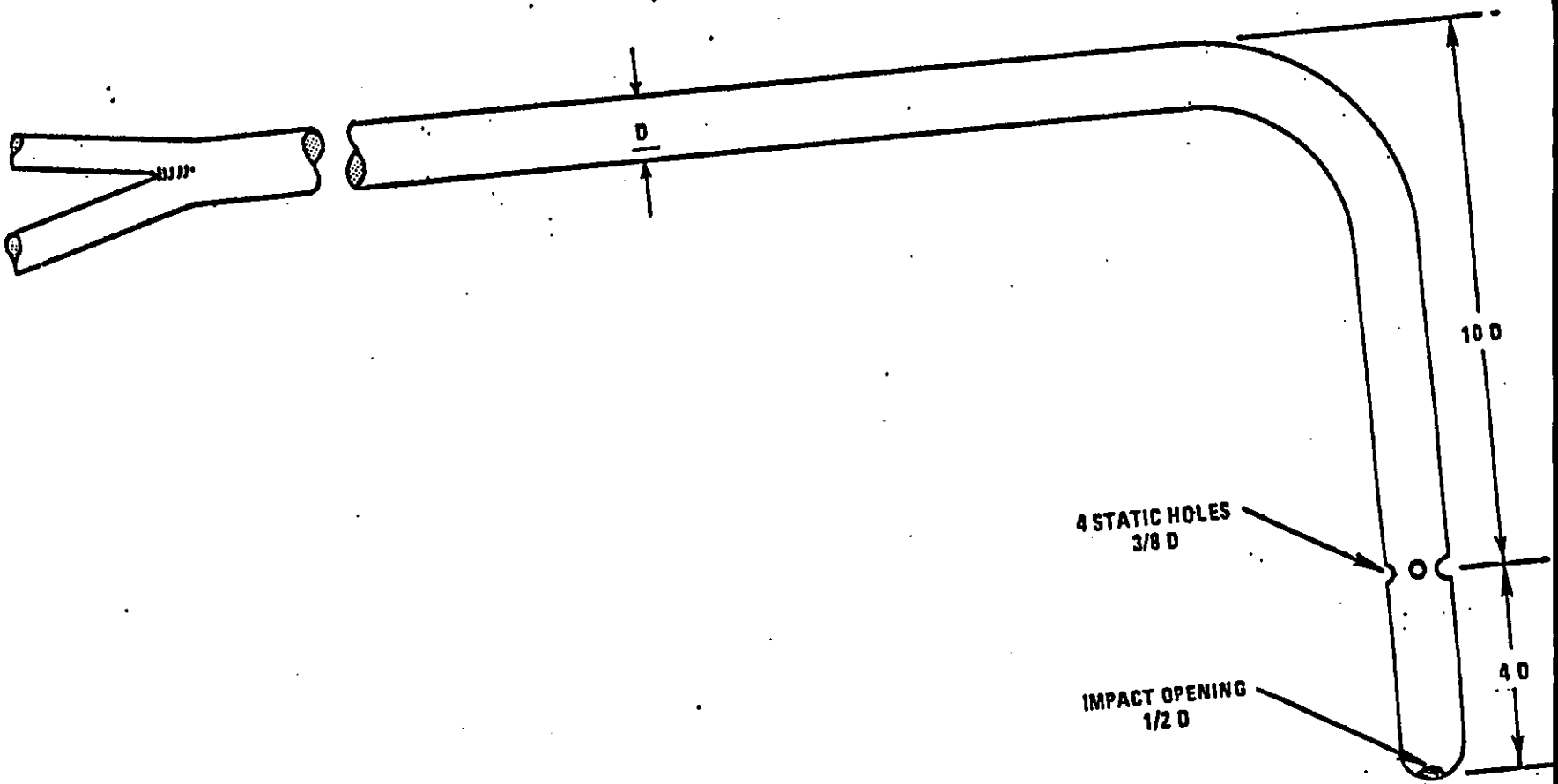


Figure 6. Modified hemispherical-nosed pitot tube.

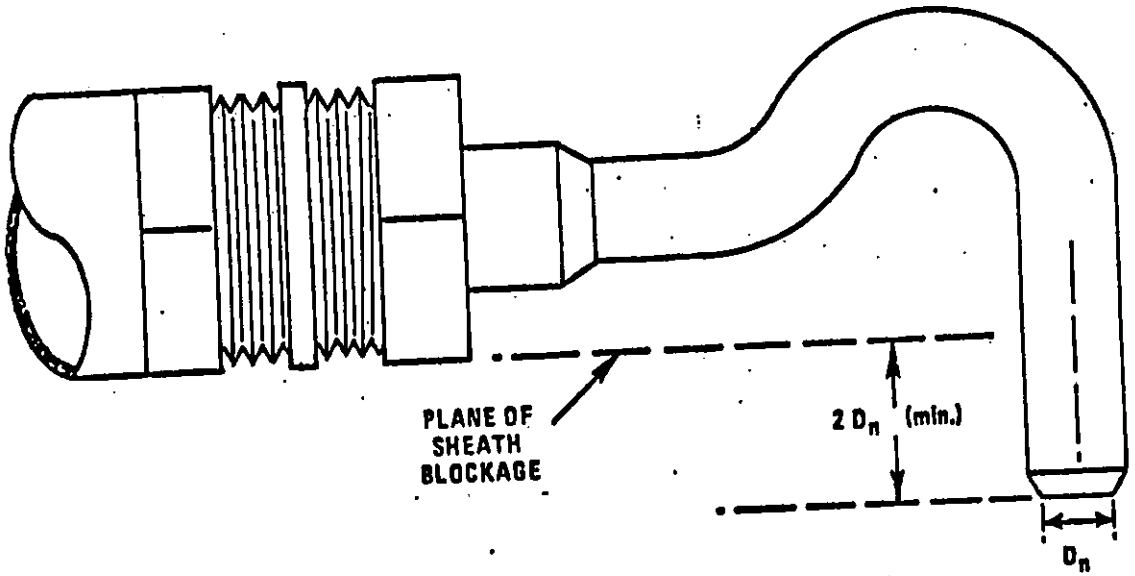


Figure 7. Recommended sampling nozzle design for use when 4 in. $\leq D_s < 12$ in.

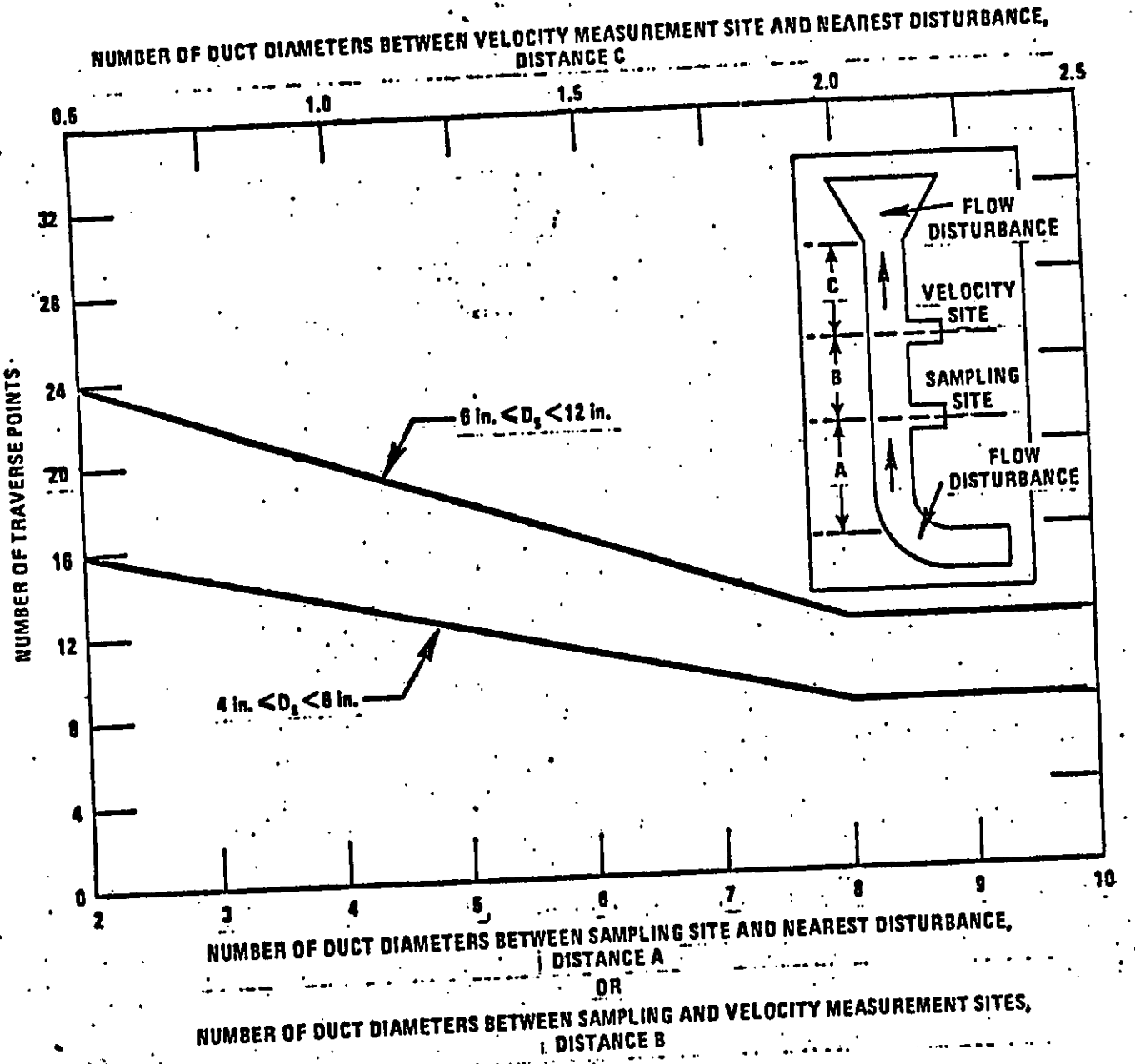


Figure 8. Minimum number of traverse points, 4 in. < D_s < 12 in.

Table 1. LOCATION OF TRAVERSE POINTS IN CIRCULAR STACKS (PERCENT OF STACK DIAMETER FROM INSIDE WALL TO TRAVERSE POINT)

Traverse point number on a diameter	Number of traverse points on a diameter											
	2	4	6	8	10	12	14	16	18	20	22	24
1	14.6	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	85.4	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3		75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4		93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5			85.4	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6			95.6	80.6	65.8	35.6	26.9	22.0	18.8	16.5	14.6	13.2
7				89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1
8				96.8	85.4	65.0	63.4	37.5	29.6	25.0	21.8	19.4
9					91.8	82.3	73.1	62.5	38.2	30.6	26.2	23.0
10					97.4	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11						93.3	85.4	78.0	70.4	61.2	39.3	32.3
12						97.9	90.1	83.1	76.4	69.4	60.7	39.8
14							94.3	87.5	81.2	75.0	68.5	60.2
15							98.2	91.5	85.4	79.6	73.8	67.7
16								95.1	89.1	83.5	78.2	72.8
17								98.4	92.5	87.1	82.0	77.0
18									95.6	90.3	85.4	80.6
19									98.6	93.3	88.4	83.9
20										96.1	91.3	86.8
21										98.7	94.0	89.5
22											96.5	92.1
23											98.9	94.5
24												96.8
												98.9

Table 2. CROSS-SECTIONAL LAYOUT FOR RECTANGULAR STACKS

No. of traverse points	Layout
9	3 x 3
12	4 x 3
16	4 x 4
20	5 x 4
25	5 x 5
30	6 x 5
36	6 x 6
42	7 x 6
49	7 x 7

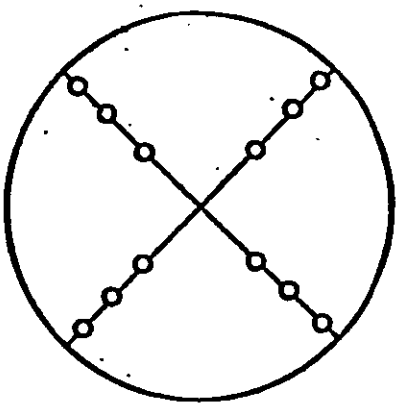


Figure 9a. Cross section of circular stack divided into 12 equal areas, showing location of traverse points.

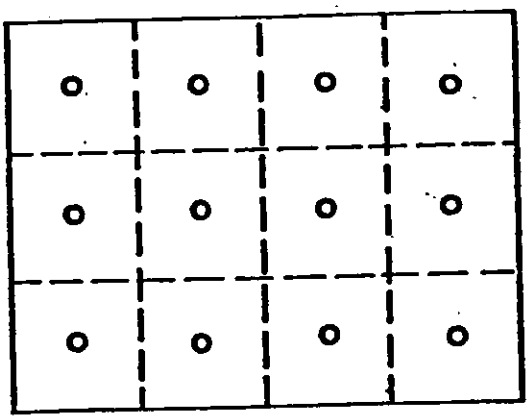


Figure 9b. Cross section of rectangular stack divided into 12 equal areas, with traverse points at centroid of each area.

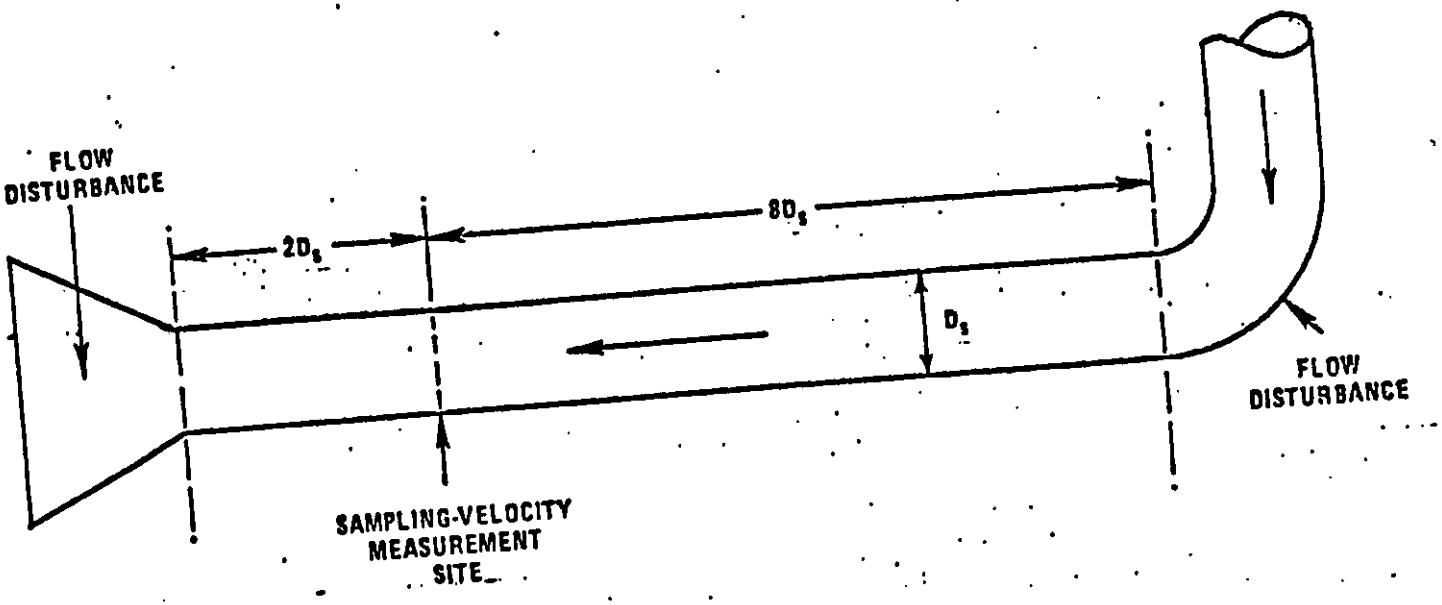


Figure 10. Recommended sampling arrangement; 4 in. $\leq D_s \leq$ 12 in.; steady-flow only.

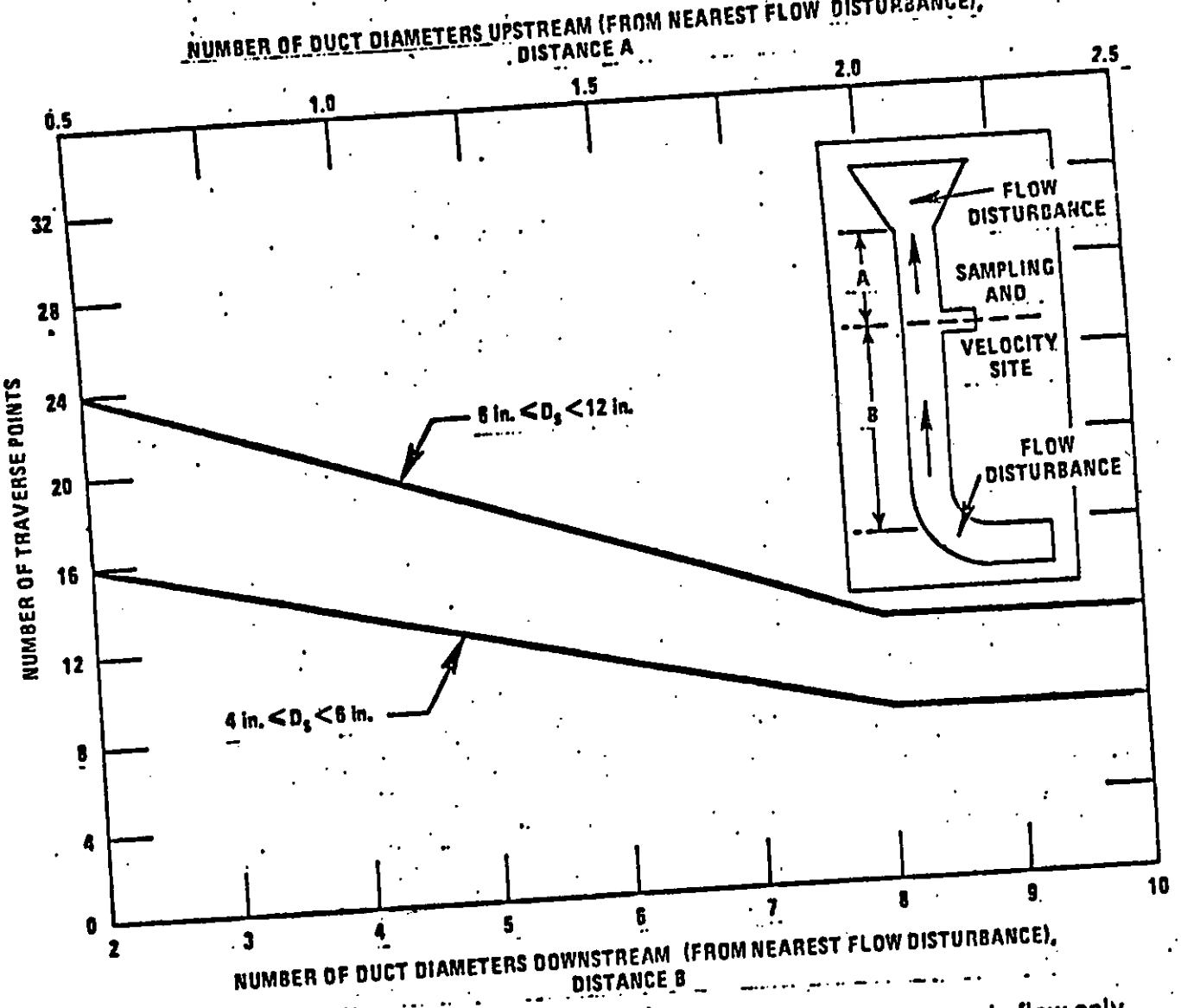


Figure 11. Minimum number of traverse points; 4 in. ≤ D_s < 12 in.; steady-flow only.

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.

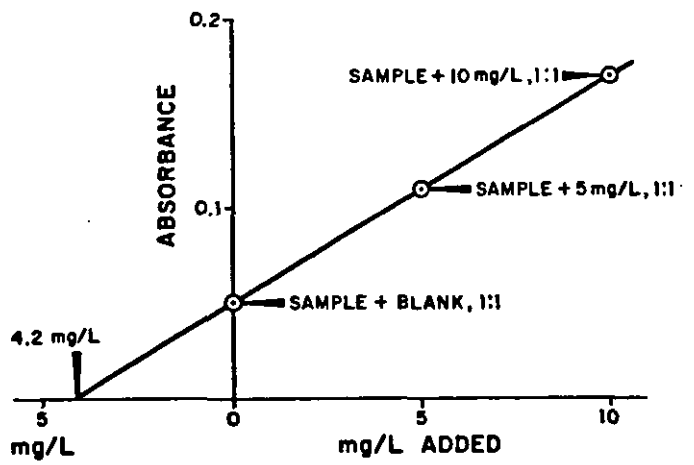


Figure 9.4
Method of Additions

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.

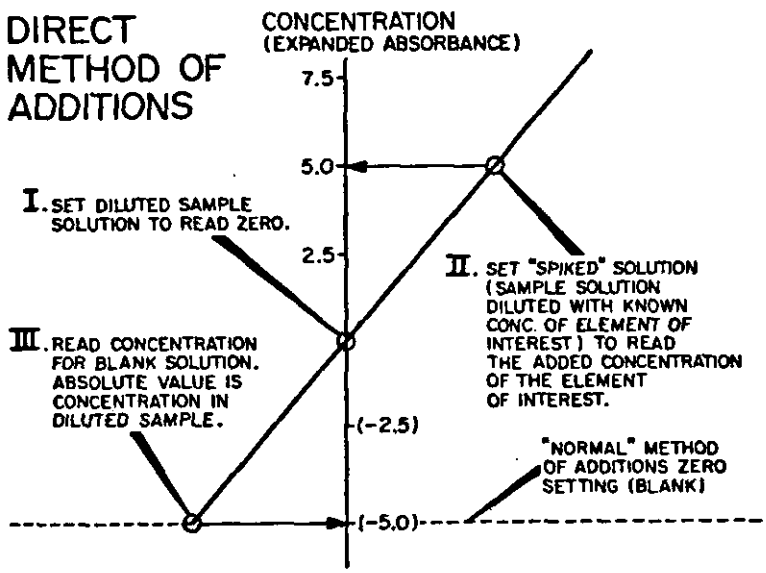


Figure 9.5
Direct Method of Additions

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.

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.

South Ventilation Dashouse

environmental testing inc.

METHOD 5 PRETEST - POSTEST CALIBRATION CHECKS

Plant Johnson Controls, Inc. Calibrated by RBMc
Meter box number 1348 Date 10/28/88 11/1/88

Dry Gas Meter
Pretest meter calibration factor, Y = 1.00 (within ± 2%)
Postest meter calibration factor, Y = 1.006 (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, 546 °R
Temperature of ref. thermometer for recalibration #1 555 #2 —— °R
(within ± 10% of the average stack temperature)
Temperature of stack thermometer for recalibration #1 553 #2 —— °R
Diff. between ref. and stack thermometer temps. #1 2 #2 —— °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? .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	29.392	29.435
Field	29.40	29.44
Difference	.008	.005

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

Nozzle #1:	0.339	0.339	0.340	0.339	0.338	: Average	0.339
Nozzle #2:	0.336	0.336	0.336	0.335	0.336	: Average	0.336
Nozzle #3:	0.339	0.339	0.340	0.339	0.338	: Average	0.339
Nozzle #4	0.336	0.336	0.336	0.335	0.336	"	0.336

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

environmental testing inc.

Melting Pot South

METHOD 5 PRETEST - POSTEST CALIBRATION CHECKS

Plant Johnson Controls, Inc. Calibrated by RBMa
Meter box number 134B Date 10/28/88 11/8/88

Dry Gas Meter
Pretest meter calibration factor, Y = 1.00 (within ± 2%)
Postest meter calibration factor, Y = 1.06 (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, 563 °R
Temperature of ref. thermometer for recalibration #1 560 #2 — °R
(within ± 10% of the average stack temperature)
Temperature of stack thermometer for recalibration #1 555 #2 — °R
Diff. between ref. and stack thermometer temps. #1 5 #2 — °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? .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	29.392	29.435
Field	29.40	29.44
Difference	.008	.005

Nozzle
Was the nozzle calibrated to the nearest .001 in.? Circle one: (yes) or no
Nozzle #1: 0.404 0.405 0.405 0.405 0.405 : Average 0.405
Nozzle #2: 0.404 0.405 0.405 0.405 0.405 : Average 0.405
Nozzle #3: 0.404 0.405 0.405 0.405 0.405 : Average 0.405

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

environmental testing inc.

Process Baghouse South

METHOD 5 PRETEST – POSTEST CALIBRATION CHECKS

Plant Johnson Controls, Inc. Calibrated by RBMc
Meter box number 1348 Date 10/28/88 11/5/88

Dry Gas Meter
Pretest meter calibration factor, Y = 1.00 (within ± 2%)
Postest meter calibration factor, Y = 1.006 (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, 684 °R
Temperature of ref. thermometer for recalibration #1 690 #2 —— °R (within ± 10% of the average stack temperature)
Temperature of stack thermometer for recalibration #1 682 #2 —— °R
Diff. between ref. and stack thermometer temps. #1 8 #2 —— °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? .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	29.392	29.435
Field	29.40	29.44
Difference	.008	.005

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

Nozzle #1:	0.186	0.188	0.188	0.187	0.187	: Average 0.187
Nozzle #2:	0.189	0.189	0.189	0.190	0.190	: Average 0.189
Nozzle #3:	0.185	0.186	0.186	0.186	0.186	: Average 0.186

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 11/8/88 Meter Box No. 1348 Plant Johnson Controls, Middletown DE

Barometric Pressure, P_b = 29.254 in. Hg Dry Gas Meter No. 1 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	$Y_i = \frac{V_w P_b (t_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6})(t_w + 460)}$
1.65	10	10.65	68.5	121	98	109.5	14:58	6.0	1.008	$\frac{10 \times 29.254 (109.5 + 460)}{10.65 (29.254 + \frac{1.65}{13.6})(68.5 + 460)}$
1.65	10	10.66	68.5	121	98	109.5	14:60	6.0	1.007	$\frac{10 \times 29.254 (109.5 + 460)}{10.66 (29.254 + \frac{1.65}{13.6})(68.5 + 460)}$
1.65	10	10.71	68.5	121	98.5	109.75	14:63	6.0	1.003	$\frac{10 \times 29.254 (109.75 + 460)}{10.71 (29.254 + \frac{1.65}{13.6})(68.5 + 460)}$
										1.006

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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South Ventilation Baghouse

POSTEST DRY GAS METER CALIBRATION DATA FORM (English Units)

Test Number 1 Date 11/8/88 Meter Box No. 1348 Plant Johnson Controls, Middletown DE

Barometric Pressure, P_b = 29.254 in. Hg Dry Gas Meter No. 1 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	$\frac{Y_i V_w P_b (t_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6})(t_w + 460)}$
1.65	10	10.65	68.5	121	98	109.5	14:58	6.0	1.008	$\frac{10 \times 29.254 (109.5 + 460)}{10.65 (29.254 + \frac{1.65}{13.6})(68.5 + 460)}$
1.65	10	10.66	68.5	121	98	109.5	14:60	6.0	1.007	$\frac{10 \times 29.254 (109.5 + 460)}{10.66 (29.254 + \frac{1.65}{13.6})(68.5 + 460)}$
1.65	10	10.71	68.5	121	98.5	109.75	14:63	6.0	1.002	$\frac{10 \times 29.254 (109.75 + 460)}{10.71 (29.254 + \frac{1.65}{13.6})(68.5 + 460)}$
									1.006	

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.

environmental testing inc.

Mellins Rd South

POSTEST DRY GAS METER CALIBRATION DATA FORM (English Units)

Test Number 1 Date 11/8/88 Meter Box No. 1348 Plant Johnson Controls, Middletown DE

Barometric Pressure, P_b = 29.254 in. Hg Dry Gas Meter No. 1 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	$\frac{Y_i V_w P_b (t_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6})(t_w + 460)}$
1.65	10	10.65	68.5	121	98	109.5	14:58	6.0	1.008	$\frac{10 \times 29.254 (109.5 + 460)}{10.65 (29.254 + \frac{1.65}{13.6})(68.5 + 460)}$
1.65	10	10.66	68.5	121	98	109.5	14:60	6.0	1.007	$\frac{10 \times 29.254 (109.5 + 460)}{10.66 (29.254 + \frac{1.65}{13.6})(68.5 + 460)}$
1.65	10	10.71	68.5	121	98.5	109.75	14:63	6.0	1.003	$\frac{10 \times 29.254 (109.75 + 460)}{10.71 (29.254 + \frac{1.65}{13.6})(68.5 + 460)}$
									1.006	

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.

environmental testing inc.

Process Baghouse South

PRETEST - POSTEST THERMOMETER CALIBRATION

Client Johnson Controls, Inc. Date 10/28/88 + 11/8/88

Location Middletown DE Ref. Thermometer #5

Thermometer	Pretest		Postest	
	Temp., °F	Ref. Temp., °F	Temp., °F	Ref. Temp., °F
DGM # 1348	70/70	70	69/69	69/69
DGM # 1965	69/70	70	69/69	69
DGM # 1401	70/70	70	—	—
DGM # 1264	70/70	70	—	—
Impinger #1	70	70	69	69
Impinger #2	71	70	70	69
Impinger #3	70	70	70	69
Impinger #4	69	70	70	69
Impinger #5	70	70	69	69
WB # 1/2	70/69	70	69/69	69
DB # 1/2	70/70	70	69/69	69
Box #1	70	70	68	69
Box #2	70	70	69	69
Box #3	69	70	70	69
Box #4	70	70	69	69
Box #5	70	70	69	69
Box #6	71	70	69	69
WB Omega 873	70	70	69	69
DB Omega 873	70	70	69	69
WB Omega #1/2	69/70	70	70/69	69
DB Omega #1/2	70/70	70	70/69	69
Probe 4' #1	70	70	69	69
Probe 4' #2	70	70	69	69
Probe ' #1	—	—	—	—
Probe ' #2	—	—	—	—
—	—	—	—	—

RAC STAKSAMPLR CALIBRATION SHEET

Meter Box Serial Number: 1348 Barometric Pressure (P_b): 29.522

Leak Check @ 6.2 in. H_2O: OK Date: 09-16-88 Calibrated by: PRJ

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_m	CF_d	T_m	IT_d	OT_d	T_d ave.	Time t
0.5	5	5.31	71.0	111.0	97.0	104.00	12.74
1.0	5	5.30	71.0	113.0	97.0	105.00	9.24
1.5	10	10.62	71.0	116.5	98.5	107.50	15.31
2.0	10	10.68	71.0	122.0	101.0	111.50	13.28
3.0	10	10.68	71.0	124.0	102.0	113.00	10.93
4.0	10	10.68	71.0	127.0	103.0	115.00	9.61

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

$$Y = \frac{CF_m P_b (T_{d\ ave.} + 460)}{CF_d (P_b + \Delta H/13.6)(T_m + 460)} = 1.00 \qquad \Delta H_@ = \frac{0.0317\ \Delta H}{P_b (T_d + 460)} \left(\frac{(T_m + 460)\ t}{CF_m}\right)^2 = 1.86$$

Tolerances: $Y = 0.90 - \underline{1.00} - 1.10$ Y +/- 0.02Y $\qquad \Delta H_@ = 1.6 - \underline{1.84} - 2.1$ $\Delta H_@$ +/- 0.15 in.

CALIBRATION CALCULATIONS PUMP AND ORIFICE METER

Manometer Delta H 0.5 in. H_2O

$$Y = \frac{5 \times 29.522\ (104.00 + 460)}{5.31\ (29.522 + 0.0368)(71.0 + 460)} = 0.999 \qquad \Delta H_@ = \frac{0.01585}{29.522\ (104.00 + 460)} \left(\frac{(71.0 + 460)\ 12.74}{5}\right)^2 = 1.743$$

Manometer Delta H 1.0 in. H_2O

$$Y = \frac{5 \times 29.522\ (105.00 + 460)}{5.30\ (29.522 + 0.0737)(71.0 + 460)} = 1.001 \qquad \Delta H_@ = \frac{0.03170}{29.522\ (105.00 + 460)} \left(\frac{(71.0 + 460)\ 9.24}{5}\right)^2 = 1.830$$

Manometer Delta H 1.5 in. H_2O

$$Y = \frac{10 \times 29.522\ (107.50 + 460)}{10.62\ (29.522 + 0.1103)(71.0 + 460)} = 1.003 \qquad \Delta H_@ = \frac{0.04755}{29.522\ (107.50 + 460)} \left(\frac{(71.0 + 460)\ 15.31}{10}\right)^2 = 1.876$$

Manometer Delta H 2.0 in. H_2O

$$Y = \frac{10 \times 29.522\ (111.50 + 460)}{10.68\ (29.522 + 0.1471)(71.0 + 460)} = 1.003 \qquad \Delta H_@ = \frac{0.06340}{29.522\ (111.50 + 460)} \left(\frac{(71.0 + 460)\ 13.28}{10}\right)^2 = 1.869$$

Manometer Delta H 3.0 in. H_2O

$$Y = \frac{10 \times 29.522\ (113.00 + 460)}{10.68\ (29.522 + 0.2206)(71.0 + 460)} = 1.003 \qquad \Delta H_@ = \frac{0.09510}{29.522\ (113.00 + 460)} \left(\frac{(71.0 + 460)\ 10.93}{10}\right)^2 = 1.894$$

Manometer Delta H 4.0 in. H_2O

$$Y = \frac{10 \times 29.522\ (115.00 + 460)}{10.68\ (29.522 + 0.2941)(71.0 + 460)} = 1.004 \qquad \Delta H_@ = \frac{0.12680}{29.522\ (115.00 + 460)} \left(\frac{(71.0 + 460)\ 9.61}{10}\right)^2 = 1.945$$

TYPE S PITOT TUBE INSPECTION DATA FORM

Date: 09-15-88
Calibrator: PRJ

Specifications:
1.) Pitot tube assembly must be level.
2.) If pitot tube is damaged explain under comments section.
3.) z = A sin τ (<0.125) and w = A sin θ (<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	2.0	2.0	1.0	1.0	1.5	0.5	0.778	0.020	0.00679	0.389	0.389	0.376
36''- 2	2.0	1.0	1.5	1.5	0.0	0.5	1.152	0.000	0.01005	0.576	0.576	0.376
40''- 1	1.0	2.0	1.0	1.0	0.0	0.5	1.098	0.000	0.00958	0.549	0.549	0.389
54''- 1	3.0	2.5	1.0	0.5	1.0	1.0	1.005	0.018	0.01754	0.502	0.503	0.379
66''- 1	1.0	0.5	3.5	0.0	0.0	1.5	1.042	0.000	0.02728	0.521	0.521	0.385
96''- 1	1.5	0.5	2.5	2.5	2.0	1.0	0.908	0.032	0.01585	0.454	0.454	0.376
4' - 1	1.0	2.5	1.0	3.5	0.5	0.5	0.967	0.008	0.00844	0.483	0.484	0.376
4' - 2	2.0	2.0	1.0	1.0	0.5	1.0	0.893	0.008	0.01558	0.446	0.447	0.371
4' - 3	4.0	2.0	1.5	3.0	1.0	1.0	0.877	0.015	0.01531	0.438	0.439	0.375
4' - 4	1.0	3.5	3.0	1.0	0.5	0.5	0.839	0.007	0.00732	0.419	0.420	0.375
4' - 5	1.0	1.0	2.0	2.0	0.5	0.5	0.865	0.007	0.00755	0.432	0.433	0.372
4' - 6	2.0	1.5	1.5	0.0	1.0	0.5	0.955	0.017	0.00833	0.477	0.478	0.375
5' - 1	2.5	1.0	1.0	0.5	1.0	1.0	1.000	0.017	0.01745	0.500	0.500	0.377
5' - 2	2.0	2.0	1.0	0.0	0.0	1.5	1.044	0.000	0.02733	0.522	0.522	0.376
5' - 3	1.0	1.0	1.0	1.0	1.0	0.5	1.049	0.018	0.00915	0.524	0.524	0.375
5' - 4	0.5	2.0	1.0	0.0	2.0	1.0	1.038	0.036	0.01812	0.519	0.519	0.380
6' - 1	0.0	0.0	1.5	0.5	0.5	1.0	0.996	0.009	0.01738	0.498	0.498	0.381
6' - 2	1.0	0.5	0.0	0.0	1.0	1.5	1.004	0.018	0.02628	0.502	0.502	0.377
6' - 3	1.0	1.0	1.0	1.0	0.5	0.5	1.006	0.009	0.00878	0.503	0.503	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	1.5	3.0	2.0	3.0	1.0	0.845	0.044	0.01475	0.423	0.422	0.378
8' - 2	0.0	1.0	2.0	2.0	0.0	1.5	0.905	0.000	0.02369	0.452	0.453	0.380
8' - 3	4.0	6.0	3.0	0.0	0.0	1.5	0.932	0.000	0.02440	0.466	0.466	0.376
8' - 4	1.5	2.0	1.5	1.0	0.0	0.5	1.017	0.000	0.00887	0.509	0.508	0.379
8' - 5	2.0	1.0	0.0	0.0	1.0	1.0	0.985	0.017	0.01719	0.492	0.493	0.379
8' - 6	0.0	0.0	0.5	3.0	1.0	0.5	0.925	0.016	0.00807	0.462	0.463	0.378
8'9''	1.0	2.0	0.5	0.5	0.0	2.0	0.895	0.000	0.03124	0.447	0.448	0.380
9'7''-1	2.0	2.0	0.0	2.0	0.0	1.0	0.918	0.000	0.01602	0.459	0.459	0.382
9'7''-2	1.0	3.0	1.0	2.5	1.5	1.0	0.960	0.025	0.01675	0.480	0.480	0.375
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.

environmental testing inc.

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

DATE: 09/15/88 BAROMETRIC PRESSURE: 29.34
AMBIENT TEMPERATURE, F : 70 REFERENCE THERMOMETER # 22
CALIBRATOR: PRJ

REFERENCE POINT #		SOURCE	REFERENCE THERMOMETER TEMPERATURE,F	THERMOCOUPLE POTENTIOMETER TEMPERATURE,F	TEMPERATURE DIFFERENCE, %
Omega Temp HH-2 #1					
Db1	A.	water bath	70	70	0.00
	B.	oil bath	120	120	0.00
	C.	oil bath	177	176	0.16
	D.	oil bath	220	221	-.15
	E.	oil bath	265	265	0.00
Wb1	A.	water bath	70	70	0.00
	B.	oil bath	120	121	-.17
	C.	oil bath	177	178	-.16
	D.	oil bath	220	221	-.15
	E.	oil bath	265	265	0.00
Omega Temp HH-2 #2					
Db2	A.	water bath	70	71	-.19
	B.	oil bath	120	121	-.17
	C.	oil bath	178	178	0.00
	D.	oil bath	221	222	-.15
	E.	oil bath	267	267	0.00
Wb2	A.	water bath	70	69	0.19
	B.	oil bath	120	121	-.17
	C.	oil bath	178	179	-.16
	D.	oil bath	221	222	-.15
	E.	oil bath	267	268	-.14
Omega Temp 873-F					
Db1	A.	water bath	71	71	0.00
	B.	oil bath	121	122	-.17
	C.	oil bath	178	179	-.16
	D.	oil bath	222	223	-.15
	E.	oil bath	268	270	-.27
Wb1	A.	water bath	71	71	0.00
	B.	oil bath	121	121	0.00
	C.	oil bath	178	178	0.00
	D.	oil bath	222	223	-.15
	E.	oil bath	268	269	-.14
Omega Temp 873-F High Temp					
	A.	oil bath	380	381	-.12
	B.	M. Furnace	435	437	-.22
	C.	M. Furnace	560	561	-.10
	D.	M. Furnace	812	814	-.16
	E.	M. Furnace	1130	1132	-.13

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

environmental testing inc.

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

DATE: 09/15/88 BAROMETRIC PRESSURE: 29.34
AMBIENT TEMPERATURE, F : 70 REFERENCE THERMOMETER # 22
CALIBRATOR: PRJ

REFERENCE POINT #		SOURCE	REFERENCE THERMOMETER TEMPERATURE,F	THERMOCOUPLE POTENTIOMETER TEMPERATURE,F	TEMPERATURE DIFFERENCE, %
Bimetallic					
Wb1	A.	water bath	70	70	0.00
	B.	oil bath	120	120	0.00
	C.	oil bath	177	179	-.31
	D.	oil bath	221	222	-.15
	E.	oil bath	265	266	-.14
Db1	A.	water bath	70	71	-.19
	B.	oil bath	120	121	-.17
	C.	oil bath	177	178	-.16
	D.	oil bath	221	222	-.15
	E.	oil bath	265	266	-.14
Wb2	A.	water bath	70	70	0.00
	B.	oil bath	120	120	0.00
	C.	oil bath	177	176	0.16
	D.	oil bath	221	222	-.15
	E.	oil bath	265	265	0.00
Db2	A.	water bath	70	69	0.19
	B.	oil bath	120	119	0.17
	C.	oil bath	177	178	-.16
	D.	oil bath	221	221	0.00
	E.	oil bath	265	266	-.14
Nox	A.	water bath	71	71	0.00
	B.	oil bath	121	121	0.00
	C.	oil bath	179	178	0.16
	D.	oil bath	222	223	-.15
	E.	oil bath	267	267	0.00
Hot Box	A.	water bath	71	71	0.00
	B.	oil bath	122	123	-.17
	C.	oil bath	179	178	0.16
	D.	oil bath	223	223	0.00
	E.	oil bath	267	266	0.14

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

environmental testing inc.

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

DATE: 09/15/88
AMBIENT TEMPERATURE, F : 70
CALIBRATOR: PRJ

BAROMETRIC PRESSURE: 29.34
REFERENCE THERMOMETER # 22 & #5

REFERENCE POINT #		SOURCE	REFERENCE THERMOMETER TEMPERATURE, F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, F	TEMPERATURE DIFFERENCE, %
Probe - #					
4'-1	A.	oil bath	97	97	0.00
	B.	oil bath	255	254	0.14
	C.	oil bath	376	377	-.12
4'-2	A.	oil bath	97	98	-.18
	B.	oil bath	255	255	0.00
	C.	oil bath	376	378	-.24
5'-1	A.	oil bath	97	97	0.00
	B.	oil bath	255	256	-.14
	C.	oil bath	376	377	-.12
5'-2	A.	oil bath	98	98	0.00
	B.	oil bath	257	258	-.14
	C.	oil bath	377	378	-.12
6'-1	A.	oil bath	98	98	0.00
	B.	oil bath	257	256	0.14
	C.	oil bath	377	377	0.00
6'-2	A.	oil bath	98	97	0.18
	B.	oil bath	257	257	0.00
	C.	oil bath	377	376	0.12
8'-1	A.	oil bath	99	99	0.00
	B.	oil bath	258	259	-.14
	C.	oil bath	378	377	0.12
8'-2	A.	oil bath	99	99	0.00
	B.	oil bath	258	259	-.14
	C.	oil bath	378	376	0.24
8'-3	A.	oil bath	100	100	0.00
	B.	oil bath	259	258	0.14
	C.	oil bath	379	380	-.12
8' 9"	A.	oil bath	100	101	-.18
	B.	oil bath	260	261	-.14
	C.	oil bath	379	380	-.12
9' 7"	A.	oil bath	100	99	0.18
	B.	oil bath	260	261	-.14
	C.	oil bath	380	379	0.12

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

environmental testing inc.

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

DATE: 09/15/88 BAROMETRIC PRESSURE: 29.34
AMBIENT TEMPERATURE, F : 70 REFERENCE THERMOMETER # 22
CALIBRATOR: PRJ

REFERENCE POINT #		SOURCE	REFERENCE THERMOMETER TEMPERATURE,F	THERMOCOUPLE POTENTIOMETER TEMPERATURE,F	TEMPERATURE DIFFERENCE, %
Meter Box					
1264A	A.	ice bath	34	34	0.00
	B.	water bath	70	70	0.00
	C.	oil bath	120	121	-.17
	D.	oil bath	177	178	-.16
1264B	A.	ice bath	34	35	-.20
	B.	water bath	70	71	-.19
	C.	oil bath	120	121	-.17
	D.	oil bath	177	178	-.16
1348A	A.	ice bath	34	35	-.20
	B.	water bath	70	71	-.19
	C.	oil bath	120	120	0.00
	D.	oil bath	177	178	-.16
1348B	A.	ice bath	34	34	0.00
	B.	water bath	70	71	-.19
	C.	oil bath	121	121	0.00
	D.	oil bath	177	177	0.00
1401A	A.	ice bath	35	35	0.00
	B.	water bath	71	71	0.00
	C.	oil bath	121	120	0.17
	D.	oil bath	178	178	0.00
1401B	A.	ice bath	35	34	0.20
	B.	water bath	71	70	0.19
	C.	oil bath	121	122	-.17
	D.	oil bath	178	179	-.16
1965A	A.	ice bath	35	35	0.00
	B.	water bath	71	72	-.19
	C.	oil bath	122	121	0.17
	D.	oil bath	178	177	0.16
1965B	A.	ice bath	35	35	0.00
	B.	water bath	71	72	-.19
	C.	oil bath	122	121	0.17
	D.	oil bath	178	179	-.16

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

environmental testing inc.

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

DATE: 09/15/88 BAROMETRIC PRESSURE: 29.34
AMBIENT TEMPERATURE, F : 70 REFERENCE THERMOMETER # 22
CALIBRATOR: PRJ

REFERENCE POINT #		SOURCE	REFERENCE THERMOMETER TEMPERATURE,F	THERMOCOUPLE POTENTIOMETER TEMPERATURE,F	TEMPERATURE DIFFERENCE, %
Impinger					
#1	A.	ice bath	34	34	0.00
	B.	water bath	70	70	0.00
	C.	oil bath	102	101	0.18
#2	A.	ice bath	34	34	0.00
	B.	water bath	70	71	-.19
	C.	oil bath	102	101	0.18
#3	A.	ice bath	34	33	0.20
	B.	water bath	70	70	0.00
	C.	oil bath	102	101	0.18
#4	A.	ice bath	34	34	0.00
	B.	water bath	70	71	-.19
	C.	oil bath	102	101	0.18
#5	A.	ice bath	34	33	0.20
	B.	water bath	71	70	0.19
	C.	oil bath	102	102	0.00

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

environmental testing inc.

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

DATE: 09/15/88 BAROMETRIC PRESSURE: 29.34
AMBIENT TEMPERATURE, F : 70 REFERENCE THERMOMETER # 22
CALIBRATOR: PRJ

REFERENCE POINT #		SOURCE	REFERENCE THERMOMETER TEMPERATURE,F	THERMOCOUPLE POTENTIOMETER TEMPERATURE,F	TEMPERATURE DIFFERENCE, %
Sample Box					
#1	A.	water bath	70	70	0.00
	B.	oil bath	122	121	0.17
	C.	oil bath	178	177	0.16
	D.	oil bath	222	223	-.15
	E.	oil bath	266	265	0.14
#2	A.	water bath	70	69	0.19
	B.	oil bath	121	122	-.17
	C.	oil bath	177	178	-.16
	D.	oil bath	222	220	0.29
	E.	oil bath	266	265	0.14
#3	A.	water bath	71	71	0.00
	B.	oil bath	122	121	0.17
	C.	oil bath	178	177	0.16
	D.	oil bath	223	222	0.15
	E.	oil bath	266	263	0.41
#4	A.	water bath	71	70	0.19
	B.	oil bath	122	123	-.17
	C.	oil bath	178	177	0.16
	D.	oil bath	223	221	0.29
	E.	oil bath	267	266	0.14
#5	A.	water bath	71	70	0.19
	B.	oil bath	123	123	0.00
	C.	oil bath	178	176	0.31
	D.	oil bath	223	221	0.29
	E.	oil bath	267	266	0.14
#6	A.	water bath	72	71	0.19
	B.	oil bath	123	124	-.17
	C.	oil bath	178	177	0.16
	D.	oil bath	223	221	0.29
	E.	oil bath	267	265	0.28
#7	A.	water bath	72	72	0.00
	B.	oil bath	123	124	-.17
	C.	oil bath	179	178	0.16
	D.	oil bath	224	223	0.15
	E.	oil bath	268	267	0.14
#8	A.	water bath	72	71	0.19
	B.	oil bath	124	124	0.00
	C.	oil bath	179	178	0.16
	D.	oil bath	224	223	0.15
	E.	oil bath	268	267	0.14

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

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

Allen R. Fuller
Product Engineering Supervisor

b10012

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.

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

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

WEIGHT TRACEABILITY CERTIFICATE

TO: Environmental Testing, Inc.
1700 Univ. Commercial Dr.
Charlotte, NC 28213

The balances listed below have been serviced by our representative on December 21, 1987

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:	13	
Mettler calibration date of test weights used:	8-1-87	
National Bureau of Standards test number:	737/0670-49	

Model and serial number of balances serviced:

AE163- C57742	
H54AR- 677277	

Kevin Z. Bff
Mettler Service Representative

1-17-88
Date of Issue

Mettler
Mettler Instrument Corporation
Box 71, Hightstown, NJ 08520
(609) 448-3000

F-124 (1/88)

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

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 ≤ 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

pace laboratories, inc.
PROFESSIONAL ANALYTICAL CHEMISTRY & ENGINEERING

Offices:
Minneapolis, Minnesota
Tampa, Florida

5460 Beaumont Center Blvd. ☐ Tampa, Florida 33634 ☐ (813) 884-8268

TEST REPORT

Particulate and Lead
EMISSION RATE

Central Vacuum System #2 (158B)
10215 North 30th Street
Tampa, Florida 33687

Test Date: September 16, 1987

Project Number: 270923.401

Report Prepared for:

Johnson Controls, Inc.
P. O. Box 16068
Tampa, Florida 33687

Report Prepared by:

PACE Laboratories, Inc.
5460 Beaumont Center Boulevard
Tampa, Florida 33634

October 20, 1987

TABLE OF CONTENTS

SECTION 1.0

TEST SUMMARY

pace laboratories, inc.
PROFESSIONAL ANALYTICAL CHEMISTRY & ENGINEERING

Offices:
Minneapolis, Minnesota
Tampa, Florida

5460 Beaumont Center Blvd. ☐ Tampa, Florida 33634 ☐ (813) 884-8268

On September 16, 1987, PACE Laboratories, Inc. conducted Particulate and Lead emissions tests at Johnson Controls, Inc., 10215 North 30th Street, Tampa, Florida. Tests were conducted on the Central Vacuum System #2 (S/N 158B).

Test team personnel for this test include:

Thomas A. Jackman, Ph.D.	Technical Director
Timothy M. O'Dell	Team Leader
Michael C. Jackman	V.E. Observer
James E. Franklin	Technician
Ronald F. Brock	Technician

The results of the Particulate and Lead emissions tests are summarized in the following table.

Date	Operation	Parameter	Actual Emission Rate*
9/16/87	CVS #2	Particulate	3.06×10^{-3}
9/16/87	CVS #2	Lead	2.13×10^{-4}
9/16/87	CVS #2	Opacity	0

* = gr/dscf except for opacity (%)

Respectfully submitted,

PACE Laboratories, Inc.

Timothy M. O'Dell
Project Manager

Thomas A. Jackman, Ph.D.
Director, Florida Division

pace laboratories, inc.

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa

PACE LABORATORIES, INC.
Source Test Summary

Company Name: Johnson Controls,Inc.

Source Identification: Central Vacuuming System #2 (S/N 158 B)

Test Parameter: Particulate

Process Weight Rate: 15.5 Pounds / Hour

Test Date: September 16, 1987

RUN NUMBER	1	2	3	Average
SCF	4.2127E+01	4.2795E+01	4.0186E+01	4.1703E+01
ACFM	2.24E+03	2.22E+03	2.09E+03	2.18E+03
WATER, %	5.68E+00	6.18E+00	5.21E+00	5.69E+00
ISOKINETIC, %	1.06E+02	1.07E+02	1.08E+02	1.07E+02
EMISSIONS, GR/DSCF	4.47E-03	2.99E-03	1.73E-03	3.06E-03
EMISSIONS, LB/HR	6.81E-02	4.58E-02	2.47E-02	4.62E-02

EMISSION SUMMARY:

Particulate, gr/dscf

Actual: 3.06E-03

pace laboratories, inc.

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa

PACE LABORATORIES, INC.
Source Test Summary

Company Name: Johnson Controls,Inc.

Source Identification: Central Vacuuming System #2 (S/N 158 B)

Test Parameter: Lead

Process Weight Rate: 15.5 Pounds / Hour

Test Date: September 16, 1987

RUN NUMBER	1	2	3	Average
SCF	4.2127E+01	4.2795E+01	4.0186E+01	4.1703E+01
ACFM	2.24E+03	2.22E+03	2.09E+03	2.18E+03
WATER, %	5.68E+00	6.18E+00	5.21E+00	5.69E+00
ISOKINETIC, %	1.06E+02	1.07E+02	1.08E+02	1.07E+02
EMISSIONS, GR/DSCF	3.66E-04	2.05E-04	6.91E-05	2.13E-04
EMISSIONS, LB/HR	5.59E-03	3.15E-03	9.88E-04	3.24E-03

EMISSION SUMMARY:

Lead, gr/dscf

Actual: 2.13E-04 ✓

SECTION 2.0

Source Description

SOURCE DESCRIPTION

Johnson Controls, Inc., Globe Battery Division, operates a lead-acid storage battery manufacturing facility at 10215 North 30th Street, Tampa, Florida.

At this location, lead pigs are received, melted and cast to form lead grids. Bulk lead oxide is received from off site and is also produced on site in a ball mill. Lead oxide is mixed with sulfuric acid and is applied as a paste to the lead grids. These grids are then used in the production of lead-acid storage batteries for automotive and marine applications.

Central Vacuum System #2 (S/N 158B)

The Central Vacuum System #2 (S/N 158B) is used for cleaning the floor and equipment. The emissions are controlled by a baghouse which is part of this vacuuming system. Air is exhausted from the baghouse through a twelve inch diameter circular duct to the atmosphere.

SECTION 3.0

Methodology

3.1 GENERAL SAMPLING METHODOLOGY

Sampling methodologies as described in the latest revision of the Florida Department of Environmental Regulation publication Standard Sampling Techniques and Methods of Analysis for the Determination of Air Pollutants from Point Sources and U. S. Environmental Protection Agency Regulations found in 40CFR Part 60 (Standards of Performance for New Stationary Sources) Appendix A, Reference Methods, were used in conducting this test.

The test was conducted using a Lear Siegler Model PM100 Manual Stack Sampler.

Gas stream velocity is measured using a Type S pitot tube. Differential pressures for velocity determinations and in maintaining the proper orifice pressure are measured using a five inch incline manometer. The probe nozzle, probe liner, and pitot tubes are all constructed of type 316 stainless steel.

A Whatman EMS 2000 glass fiber filter is supported in a borosilicate glass heated filter holder for particulate collection. During a test run, the temperature of the filter assembly is maintained at 248 $\pm$ 25°F. The condenser train consists of four impingers connected in series. The first, third, and fourth impingers are of the modified Greenburg-Smith type while the second impinger is of standard design. In all testing situations, the fourth impinger contains a known weight of silica gel (typically 200g). The contents of the first and second impingers depends on the nature of the test being conducted. The third impinger is usually empty. The condenser system is immersed in an ice bath to maintain the gas exit temperature at or below 68°F during all sampling runs.

A leak check is performed before and after each run by blocking the nozzle and drawing the appropriate vacuum. All leakages are below 0.02 CFM at a vacuum exceeding the maximum vacuum encountered during the test cycle.

Prior to the first run, a velocity traverse was performed and appropriate calculations were made to determine the most suitable test conditions. The moisture content used for these calculations is based on the results of previous test on the same or similar sources.

At the end of each test run, the volume of water collected in the first, second, and third impingers was measured. Where appropriate, the contents of the impingers is transferred to a container for laboratory analysis. The silica gel desiccant in the fourth impinger is transferred to a tared bottle for transfer to the laboratory. The

filter assembly is removed intact and transferred to the laboratory for filter removal. All components in the front half of the sample train (probe nozzle, probe liner, transfer lines) are rinsed with acetone or appropriate solution when specified by a particular methodology and the washings saved for further analysis. A fresh filter assemble is installed and the train assembled for the next run.

3.2 SPECIFIC SAMPLING METHODOLOGY

Central Vacuum System #2 (S/N 158B)

Two (2) sampling ports are installed in a 12 inch diameter circular duct. The ports are positioned at 90° angles and are located 3.0 duct diameters from the closest upstream flow disturbance and greater than 10 duct diameters from the closest downstream flow disturbance.

During each test run, 16 test points were sampled along two traverses. Each point was sampled for four (4) minutes.

3.3 ANALYTICAL METHODOLOGY

Particulate and Lead Methodology

Particulate and lead emissions are determined using the Alternative Test Method for Inorganic Lead described in paragraph 8.1 of U.S.E.P.A. Reference Method 12. In this method, the front half of the sampling train is analyzed as in U.S.E.P.A. Reference Method 5. However, the contents of impingers one, two, and three are analyzed for lead content as described in Reference Method 12 paragraph 5.4 The analytical methodology employed is described below.

The laboratory procedures for the particulate emission determination was conducted according to U.S.E.P.A. Reference Method 5 and is described below:

> Upon receipt in the laboratory, the filter and loose particulate from each run are transferred into clean, tared glass containers. Each sample is oven dried at 105°C to constant weight (difference of less than 0.5 mg between weighings).
>
> The volume of the probe wash is measured volumetrically to the nearest one milliliter. The acetone wash is transferred to a clean, tared beaker and evaporated to near dryness on a hot plate. The residue is desiccated for 24 hours and weighed to a constant weight. The weight of the residue is corrected for any residue left after the evaporation of a 0.1N Nitric Acid blank.

The silica gel in the last impinger is weighed to the nearest 0.5 gram.

The laboratory procedure for the lead emission determination is described below:

After the particulate determination described above, the filter and probe wash residue were retained for lead analysis. The volume of the impinger catch was reduced to approximately ten (10) milliliters. This liquid was then quantitatively combined with the probe wash residue and the particulate filter (cut in strips) and the resulting mixture was taken to dryness. The dried residue of each sample was digested with 1:1 nitric acid and 3% hydrogen peroxide. This solution was filtered and this filtrate diluted to 250 ml. A blank containing 0.1 N nitric acid and a blank filter was treated similarly.

The solutions generated above were analyzed for lead content by atomic absorption spectrophotometry using the Method of Standard Additions. The analysis was performed on an Instrumentation Laboratories Model 251 Atomic Absorption Spectrophotometer at the analytical wavelength for lead (217.0 nm).

3.4 STACK SAMPLING EQUIPMENT DESCRIPTION

a. Nozzle

Stainless steel, type 316, with a 0.226 inch diameter orifice as measure on site with a vernier caliper.

b. Probe

Five (5) foot type 316 stainless steel with a heater type 316 stainless steel liner.

c. Thermocouple

Chromel-Alumel K-type

d. Pitot Tube

Five foot type 316 stainless steel Strauschribe type.

e. Sample Collection Assembly

Contains separate hot and cold modules. The hot box houses the filter holder and is designed to maintain a temperature of 248±25°F. This temperature is monitored periodically during each test run. The cold box module houses the impinger train and ice bath. Impingers one,

three, and four are modified Greenburg-Smith and the second is of standard design.

f. Lear Siegler Control Unit

This unit contains a diaphragm vacuum pump, dry gas meter, digital pyrometer, temperature controllers, and dual Dwyer Inclined Manometers (five inch).

3.5 LABORATORY PREPARATION

a. Glassware

Washed and dried prior to each stack test.

b. Filters

Oven dried at 105°C to constant weight (four hours minimum) and weighed to the nearest 0.5 mg. Tared filters are stored in a desiccator until used in a test.

c. Silica Gel

Dried at 250°F for two hours and stored in air tight containers until used.

d. Control Unit

Check operation of all systems.

3.6 SAMPLE RECOVER EQUIPMENT

a. Probe Brush

b. Water Wash Bottles

c. Sample Storage Bottles

d. Graduated Cylinder

e. Desiccator

f. Analytical Balances

1. Mettler EL

2. Mettler H10w

g. Filters

Whatman EMS 2000 borosilicate glass fiber filters

(10.16 cm diameter)

h. Silica Gel

Indicating type, 6-16 mesh, dried at 350°F immediately before test.

i. Acetone, ACS Reagent Grade

j. Nitric Acid, ACS, Reagent Grade

k. Water, Deionized

l. Ice

SECTION 4.0

Test Data and Calculations

Source Testing Nomenclature and Dimensions

ACFM	=	Actual ft^3/min
A_n	=	Probe nozzle tip area, ft^2
A_s	=	Area of stack, ft^2
B_{ws}	=	Proportion of water vapor in gas stream by volume, dimensionless
C_p	=	Pitot Coefficient
Delta H	=	Average pressure differential across the orifice meter
I	=	Percent of Isokinetic sampling
M_d	=	Molecular weight of stack gas, dry basis
M_s	=	Molecular weight of stack gas, wet basis
$(\text{Delta p})^{1/2}$	=	Square root of velocity head, inches of H_2O
P_b	=	Barometric pressure, inches of Hg
P_s	=	Absolute stack pressure, inches of Hg
Q_{std}	=	Dry volumetric stack gas flow rate corrected to standard conditions
θ	=	Sampling time, minutes
SCF	=	V_m (standard)
SCFM	=	Q_{std}
T_m	=	Absolute meter temperature
T_s	=	Absolute stack temperature
V_f	=	Final volume of condenser water, ml
V_i	=	Initial volume, if any, of condenser water
V_m	=	Volume of total sample metered under actual conditions, ft^3
$V_m(std)$	=	Dry gas volume measured by the dry gas meter, corrected to standard conditions (dscf)
V_s	=	Gas stream velocity, ft/sec.

$V_{wc}(std)$	=	Volume of water vapor condensed corrected to standard conditions, scf.
Y	=	Dry gas meter calibration factor

EQUATIONS

Water Vapor Volume of Moisture Condensate

$$V_{wc}(std) = 0.047\ (V_t - V_i)$$

Moisture in Gas Stream

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

Wet Molecular Weight of Gas

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

Gas Stream Velocity

$$V_s = 85.49\ (C_p)\ (\text{Delta P})^{1/2}\text{avg}\ \left(\frac{T_s}{P_s M_s}\right)^{1/2}$$

Sample Gas Volume Corrected to Std. Conditions

$$V_m(std) = \frac{17.64\ V_m Y\ (P_b + \text{Delta H}/13.6)}{T_m}$$

% Isokinetic

$$I = 0.09450\ \frac{T_s V_m(std)}{P_s V_s A_n \theta\ (1-B_{ws})}$$

Stack Volumetric Flow Rate (ACFM)

$$ACFM = A_s \times V_s \times 60$$

Stack Volumetric Flow Rate (SCFM) corrected to std. cdts.

$$Q_{sd} = 60\ (1-B_{ws}) V_s A_s\ \left(\frac{528}{T_s}\right)\ \left(\frac{P_s}{29.92}\right)$$

pace laboratories, inc.
5460 Beaumont Center Blvd.
Tampa, Florida 33634
Phone: (813) 884-8268

TRAVERSE - Point Location and Velocity Data

CLIENT Johnson Controls

BY Tim ODell DATE 9/16/87

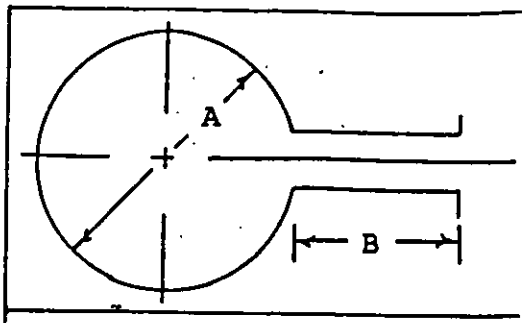
Sampling Location Central Vac East

Stack Diameter (A) 12"

Inside of Near Wall to Outside of Nipple (B) 3 1/2

Closest Upstream Disturbance 3.5 S.D.

Closest Downstream Disturbance >10 S.D.



Schematic of Sampling Location

	PT. NO.	% STK DIA	TRAV PT LOC	VEL HEAD ΔP	STACK TEMP	
NE	1	3.2	1/2	0.43	156	
	2	10.5	1 1/4	0.43	156	
	3	19.4	2 5/16	0.43	160	
	4	32.3	3 7/8	0.48	162	
	5	67.7	8 1/8	0.58	163	0.32 static
	6	80.6	9 11/16	0.58	162	
	7	89.5	10 3/4	0.53	161	
	8	96.8	11 5/8 ⇒ 11 1/2	0.53	161	
NW	9	3.2	1/2	0.29	156	
	10	10.5	1 1/4	0.32	157	
	11	19.4	2 5/16	0.32	160	
	12	32.3	3 7/8	0.36	160	
	13	67.7	8 1/8	0.44	163	
	14	80.6	9 11/16	0.46	163	0.20 static
	15	89.5	10 3/4	0.46	163	
	16	96.8	11 5/8 ⇒ 11 1/2	0.46	163	
						Avg 0.26
				Avg	Avg	
				0.44	160	

pace laboratories, inc.
5460 Beaumont Center Blvd.
Tampa, Florida 33634
Phone: (813) 884-8268

PROJECT Johnson Controls
SUBJECT CVS East
COMPUTED BY Tim Odell DATE 9/16/97
PAGE

NOMOGRAPH DATA

PLANT Globe Battery Div

DATE 9/16/97

SAMPLING LOCATION Central Vac East

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	1.70
AVERAGE METER TEMPERATURE (AMBIENT + 20 °F), °F	$T_{m_{avg.}}$	120
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B_{wo}	3
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	29.92
STATIC PRESSURE IN STACK, in. Hg ($P_m \pm 0.073$ x STACK GAUGE PRESSURE in in. H_2O)	P_s	29.94
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	1.00
AVERAGE STACK TEMPERATURE, °F	$T_{s_{avg.}}$	160
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	0.44
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	6.58
C FACTOR		1.05
CALCULATED NOZZLE DIAMETER, in.		0.256
ACTUAL NOZZLE DIAMETER, in.		0.224
REFERENCE Δp, in. H_2O		0.75

pace laboratories, inc.

EPA Method 5 Field Data Sheet

ΔP Ref = 0.75

Project Johnson Controls
Sample Location Central Vac East
Date 5/16/07 Test ___ Run 1
Operators O'Dell, Ickeringill, Brock

Train No. ___
Meter Coef. γ ___
ΔH @ 1.70
Nozzle No. ___ Dn 0.224

Pitot Tube No. ___ Cp ___
Bar. Pres. ___ Ins. Hg
Static Pres. ___ Ins. H_2O
Estimated MC 3 %

Leak Check:
Pretest: 0.000 @ 15 Ins. Hg
Post-test: 0.000 @ 15 Ins. Hg

Point Number	Time ΔT	Meter Vol. V_m cu. ft.	Velocity Head-ΔP Ins. H_2O	Orifice Meter-ΔH Ins. H_2O	Desired ΔH	Desired Running V_m	Vacuum Ins. Hg	Stack Temp. °F	Sampling Train Temperatures - °F					Clock Time	
									Filter	Probe	Imp. Out	M/In	M/Out		
	(0)	(747.373)													
1	4	746.0	0.55	1.33	1.15		0	163	238	234	56	92	88	1100	
2	8	748.3	0.46	1.12	1.06		0	164	239	239	55	106	86	1104	
3	12	750.9	0.60	1.48	1.21		0	166	237	241	55	108	88	1108	
4	16	753.5	0.50	1.21	1.10		0	171	239	251	54	108	88	1112	
5	20	756.3	0.77	1.90	1.38		0	170	242	254	54	108	88	1116	
6	24	759.6	0.77	1.90	1.38		0	168	244	245	55	110	88	1120	
7	28	762.5	0.70	1.70	1.30		0	167	248	243	57	112	90	1124	
8	32	765.8	0.68	1.62	1.27		0	166	248	240	57	112	92	1128	
9	36	767.7	0.44	1.08	1.04		0	156	250	262	58	108	92	1136	
10	40	770.3	0.50	1.21	1.10		0	163	249	241	59	111	92	1140	
11	44	772.8	0.55	1.33	1.15		0	167	249	239	58	112	92	1144	
12	48	775.2	0.55	1.33	1.15		0	168	249	241	58	112	92	1148	
13	52	777.7	0.50	1.21	1.10		0	174	248	243	59	114	92	1152	
14	56	780.4	0.58	1.40	1.18		0	177	254	244	59	114	92	1156	
15	60	783.2	0.65	1.59	1.26		0	174	259	244	59	116	94	1200	
16	64	785.950	0.65	1.59	1.26		0	172	257	241	66	116	95	1204	
		42.577			19.09			2686				32	09		
			P=0.77												
				1.44											

Θ = ___ V_m = 42.577 $\sqrt{\Delta H}$ = 1.19 T_s = 168 T_m = 100

Samples Recovered: Filter Number ___ ; ☐ Probe Wash ; ☐ Wet Catch ; ☐ ___

Gas Sampling Data:

Box No. ___
Bag No. ___
Bag Vol. ___ Liters

Bag Material ___
Leak Check ___ cc @ 15" Hg
Post Test O_2 Reading ___ %
320 P No. ___

Moisture Recovery Data:

Impinger No.	1	2	3	4	Desiccant	Total
Final Vol.	157	49	1	256.7		
Initial Vol.	100	100	0	207.9		
Difference	57	51	1	48.8		158.8

pace laboratories, inc.

EPA Method 5 Field Data Sheet

Ref ΔP = 0.75

Project Johnson Controls
Sample Location Central Plant East
Date 7/16/97 Test ___ Run 2
Operators ODell, Jackman, Brack, Franklin

Train No. ___
Meter Coef. γ ___
ΔH @ ___
Nozzle No. ___ D_n ___

Pitot Tube No. ___ C_p ___
Bar. Pres. ___ Ins. Hg
Static Pres. ___ Ins. H_2O
Estimated MC ___ %

Leak Check: 16
Pretest: 0.000 @ ~~15~~ Ins. Hg
Post-test: 0.000 @ 15 Ins. Hg

Point Number	Time ΔT	Meter Vol. V_m cu. ft.	Velocity Head-ΔP Ins. H_2O	Orifice Meter-ΔH Ins. H_2O	Desired $\Delta H \sqrt{\Delta P}$	Desired Running V_m	Vacuum Ins. Hg	Stack Temp. °F	Sampling Train Temperatures - °F: Filter	Probe	Imp. Out	M/In	M/Out	Clock Time
	(0)	(793.507)												
1	4	796.0	0.50	1.21	1.10		0	100	263	241	61	110	100	1316
2	8	~~798~~	0.52	1.28	1.13		0	103	262	242	60	118	100	1320
3	12	801.0	0.50	1.21	1.10		0	113	253	243	60	118	100	1324
4	16	803.5	0.45	1.10	1.05		0	171	254	237	61	118	100	1328
5	20	806.4	0.76	1.85	1.36		0	177	256	235	63	120	100	1332
6	24	809.0	0.75	1.83	1.35		0	186	252	243	64	120	100	1336
7	28	812.5	0.75	1.83	1.35		0	187	256	236	64	122	102	1340
8	32	815.557	0.67	1.80	1.34		0	186	254	232	65	122	102	1344
9	36	818.2	0.51	1.22	1.10		0	128	254	260	68	120	102	1352
10	40	820.9	0.52	1.28	1.13		0	113	253	249	64	120	102	1356
11	44	823.6	0.54	1.32	1.15		0	165	251	249	63	120	102	1360 1400
12	48	826.2	0.56	1.40	1.18		0	172	253	253	64	120	102	1364 1404
13	52	828.8	0.52	1.28	1.13		0	180	253	253	66	120	102	1368 1408
14	56	831.5	0.61	1.51	1.23		0	184	255	253	67	120	102	1372 1412
15	60	834.5	0.72	1.78	1.33		0	185	258	252	67	120	102	1376 1416
16	64	837.526	0.68	1.90	1.38		0	183	248	250	68	120	102	1420
					19.41			2533				35	30	
			$\sqrt{P}$ = 0.77	1.49										
				1.49										

θ = ___ V_m = 44.019 $\overline{\Delta H}$ = 1.21 $\overline{T_s}$ = 158 $\overline{T_m}$ = 110

Samples Recovered: Filter Number ___ ; ☐ Probe Wash ; ☐ Wet Catch ; ☐ ___

Gas Sampling Data:

Box No. ___
Bag No. ___
Bag Vol. ___ Liters

Bag Material ___
Leak Check ___ cc @ 15" Hg
Post Test O_2 Reading ___ %
320 P No. ___

Moisture Recovery Data:

Impinger No.	1	2	3	4	Desiccant	Total
Final Vol.	161	48	1	23.7		
Initial Vol.	100	100	0	100.1		
Difference	+61	-52	+1	-76.4		

Pace Laboratories, Inc.

Ref ΔP = 0.75

EPA Method 5 Field Data Sheet

Project Johnson Controls — Train No. ____ — Pitot Tube No. ____ C_p ____ — Leak Check:
Sample Location Central Vac Cyc — Meter Coef. γ ____ — Bar. Pres. ____ Ins. Hg — Pretest: 0000 @ 15 Ins. Hg
Date 9-16-81 — Test 1 — Run 3 — ΔH @ ____ — Static Pres. ____ Ins. H_2O — Post-test: 0000 @ 15 Ins. Hg
Operators G.D.H., Jack Knox, Brock, Franklin — Nozzle No. ____ Dn ____ — Estimated MC ____ %

Point Number	Time ΔT	Meter Vol. V_m cu. ft.	Velocity Head – ΔP Ins. H_2O	Orifice Meter – ΔH Ins. H_2O	Desired ΔVm	Desired Running V_m	Vacuum Ins. Hg	Stack Temp. °F	Sampling Train Temperatures – °F: Filter	Probe	Imp. Out	M/In	M/Out	Clock Time	
	(0)	(838.506)													
1	4	842.3	0.47	1.15	1.07		0	113	237	270	62	118	100	1511	
2	8	843.5	0.48	1.1	1.09		0	164	244	237	61	122	102	1515	
3	12	845.7	0.35	0.86	0.93		0	130	247	250	64	122	102	1519	
4	16	847.5	0.24	0.54	0.77		0	185	250	248	67	112	102	1523	3:36
5	20	850.2	0.74	1.71	0.32		0	132	268	257	61	116	98	1527.5	3:40
6	24	853.1	0.71	1.73	1.31		0	177	256	248	56	118	98	1531.5	
7	28	856.1	0.66	1.51	1.23		0	174	253	242	57	120	100	1535.5	
8	32	859.104	0.64	1.50	1.22		0	175	256	253	59	120	100	1539.5	
9	36	861.7	0.50	1.22	1.10		0	150	268	267	59	112	96	1607	
10	40	864.3	0.51	1.25	1.12		0	154	249	236	58	114	96	1611	
11	44	866.7	0.53	1.30	1.14		0	171	252	251	59	116	96	1615	
12	48	869.5	0.53	1.45	1.20		0	175	248	252	59	116	96	1619	
13	52	871.8	0.40	0.98	0.99		0	178	245	252	60	116	96	1623	
14	56	874.4	0.50	1.32	1.10		0	180	247	250	59	116	96	1627	
15	60	877.0	0.54	1.32	1.15		0	179	248	250	59	116	96	1631	
16	64	879.717	0.61	1.50	1.22		0	177	248	250	59	116	96	1635	
17														1639	
					17.96			2717				34	48		
			$\sqrt{P}$ =												
			0.72	1.28											

θ = ____ V_m = 41.211 — $\sqrt{\Delta H}$ = 1.12 — $\overline{T_s}$ = 176 — $\overline{T_m}$ = 108

Samples Recovered: Filter Number ____ ; ☐ Probe Wash ; ☐ Wet Catch ; ☐ ____

Gas Sampling Data:

Box No. ____
Bag No. ____
Bag Vol. ____ Liters

Bag Material ____
Leak Check ____ cc @ 15" Hg
Post Test O_2 Reading ____ %
320 P No. ____

Moisture Recovery Data:

Impinger No.	1	2	3	4	Desiccant	Total
Final Vol.	151	48	1	328.0		
Initial Vol.	100	100	0	230.7		
Difference	+51	-52	+1	+97.3		97

pace laboratories, inc.

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa

REPORT OF LABORATORY ANALYSIS

ANALYTICAL DATA
Probe and Filter

Client: Johnson Controls, Inc.
Source Identification: Central Vacuuming System #2 (S/N 158 B)
Test Date: September 16, 1987
Analyst: Tim O'Dell

RUN 1

Identification Marks		Final Weight (grams)	Initial Weight (grams)	Weight Gain (grams)
Filter #	7	0.7263	0.7210	0.0053
Probe Wash	Run 1	99.1773	99.1702	0.0071
			Total	0.0124
			Acid Blank	0.0002
			Particulate Weight	0.0122

ANALYST: _____

RUN 2

Identification Marks		Final Weight (grams)	Initial Weight (grams)	Weight Gain (grams)
Filter #	4	0.7252	0.7194	0.0058
Probe Wash	Run 2	98.5946	98.5920	0.0026
			Total	0.0084
			Acid Blank	0.0001
			Particulate Weight	0.0083

ANALYST: _____

RUN 3

Identification Marks		Final Weight (grams)	Initial Weight (grams)	Weight Gain (grams)
Filter #	120	0.7209	0.7206	0.0003
Probe Wash	Run 3	97.6900	97.6857	0.0043
			Total	0.0046
			Acid Blank	0.0001
			Particulate Weight	0.0045

ANALYST: _____

FILTER.MAS
Rev052384

References: FF-131

pace laboratories, inc.

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa

REPORT OF LABORATORY ANALYSIS

ANALYTICAL DATA
Impinger Train

Client: Johnson Controls, Inc.
Source Identification: Central Vacuuming System #2 (S/N 1588)
Test Date: September 16, 1987
Analyst: Tim O'Dell

RUN 1

Impinger Number	Final Volume (mls)	Initial Volume (mls)	Volume Change (mls)
1	157	100	57
2	49	100	-51
3	1	0	1
4	257	210	47
		Total Water	54

ANALYST: _____

RUN 2

Impinger Number	Final Volume (mls)	Initial Volume (mls)	Volume Change (mls)
1	161	100	61
2	48	100	-52
3	1	0	1
4	240	190	50
		Total Water	60

ANALYST: _____

RUN 3

Impinger Number	Final Volume (mls)	Initial Volume (mls)	Volume Change (mls)
1	151	100	51
2	48	100	-52
3	1	0	1
4	278	231	47
		Total Water	47

ANALYST: _____

IMPINGER.MAS
Rev052384

References: FF-131

pace laboratories, inc.

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa

PACE LABORATORIES, INC.
Source Test Data Summation

Company Name:	Johnson Controls, Inc.
Source Identification:	Central Vacuuming System #2 (S/N 158 B)
Source Test For:	Particulate
Test Date:	September 16, 1987

	RUN NUMBER	1	2	3
V(w)	Volume of moisture collected, ml	5.40E+01	6.00E+01	4.70E+01
T(m)	Average Meter Temperature, °F	100	110	108
V(m)	Actual Sample Volume, cu. ft.	4.2577E+01	4.4019E+01	4.1211E+01
GC	Dry Gas Meter Coefficient	1.04E+00	1.04E+00	1.04E+00
P(b)	Barometric Pressure, inches Hg	30.01	30.01	30.01
P(m)	Pressure across orifice, in Hg	1.44	1.49	1.28
A(s)	Stack Diameter, inches	12.0	12.0	12.0
A(n)	Probe Nozzle Diameter, inches	0.224	0.224	0.224
T(s)	Stack Temperature, ave °F	168	158	170
mg	Weight of Particulate, mg	12.20	8.30	4.50
t	Sampling Time, min.	64	64	64
√dP	Velocity Head, √(ave), in. water	0.770	0.770	0.720
P(s)	Stack Pressure, Ave inches Hg	30.029	30.029	30.029

CALCULATIONS

RUN NUMBER	1	2	3
SCF Sampled	4.2127E+01	4.2795E+01	4.0186E+01
Water, %	5.6822	6.1821	5.2105
Gas Molecular Weight	28.34	28.29	28.39
Gas Stream Velocity	4.75E+01	4.72E+01	4.44E+01
ACFM	2.24E+03	2.22E+03	2.09E+03
SCFM	1.78E+03	1.79E+03	1.67E+03
Isokinetic, %	106	107	108
Emissions, gr/dscf	4.47E-03	2.99E-03	1.73E-03
Emissions, lb/hr	6.81E-02	4.58E-02	2.47E-02

pace laboratories, inc.

REPORT OF LABORATORY ANALYSIS

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa

PACE LABORATORIES, INC.
Source Test Data Summation

Company Name:	Johnson Controls,Inc.
Source Identification:	Central Vacuuming System #2 (S/N 158 B)
Source Test For:	Lead
Test Date:	September 16, 1987

	RUN NUMBER	1	2	3
V(W)	Volume of moisture collected, ml	5.40E+01	6.00E+01	4.70E+01
T(m)	Average Meter Temperature, °F	100	110	108
V(m)	Actual Sample Volume, cu. ft.	4.2577E+01	4.4019E+01	4.1211E+01
GC	Dry Gas Meter Coefficient	1.04E+00	1.04E+00	1.04E+00
P(b)	Barometric Pressure, inches Hg	30.01	30.01	30.01
P(m)	Pressure across orifice, in Hg	1.44	1.49	1.28
A(s)	Stack Diameter, inches	12.0	12.0	12.0
A(n)	Probe Nozzle Diameter, inches	0.224	0.224	0.224
T(s)	Stack Temperature, ave °F	168	158	170
mg	Weight of Lead, mg	1.00	0.57	0.18
t	Sampling Time, min.	64	64	64
√dP	Velocity Head, √(ave), in. water	0.770	0.770	0.720
P(s)	Stack Pressure, Ave inches Hg	30.029	30.029	30.029

CALCULATIONS

RUN NUMBER	1	2	3
SCF Sampled	4.2127E+01	4.2795E+01	4.0186E+01
Water, %	5.6822	6.1821	5.2105
Gas Molecular Weight	28.34	28.29	28.39
Gas Stream Velocity	4.75E+01	4.72E+01	4.44E+01
ACFM	2.24E+03	2.22E+03	2.09E+03
SCFM	1.78E+03	1.79E+03	1.67E+03
Isokinetic, %	106	107	108
Emissions, gr/dscf	3.66E-04	2.05E-04	6.91E-05
Emissions, lb/hr	5.59E-03	3.15E-03	9.88E-04

SECTION 5.0

Opacity

pace laboratories, inc.

VISIBLE EMISSIONS OBSERVATION

5460 Beaumont Center Blvd.
Tampa, Florida 33634
Phone: (813) 884-8268

SOURCE NAME: Johnson Controls

ADDRESS: 10215 N. 30th Street Tampa

STATE: FL | ZIP: | TELEPHONE: 971-1065

SOURCE ID NUMBER: Central Vacuum East | OBSERVATION DATE: 9-16-87

PROCESS: | OPERATING MODE:

CONTROL EQUIPMENT: | OPERATING MODE:

DESCRIBE EMISSION POINT: 12" Stack

HEIGHT ABOVE GROUND LEVEL: ~65' | HEIGHT RELATIVE TO OBSERVER: ~15'

DISTANCE FROM OBSERVER: ~25' | DIRECTION FROM OBSERVER: S W

DESCRIBE EMISSIONS: None

EMISSION COLOR: None | PLUME TYPE ☐ INTERMITTENT ☐ CONTINUOUS ☐ FUGITIVE ☐

DROPLETS PRESENT YES ☐ | IF YES, IS PLUME ATTACHED ☐ DETACHED ☐

AT WHAT POINT WAS OPACITY DETERMINED: ~6" from stack opening

DESCRIBE BACKGROUND: SKY

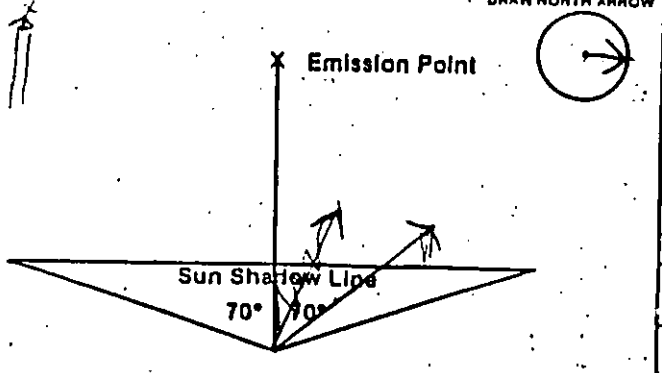
BACKGROUND COLOR: BLUE | SKY CONDITIONS: Clear

WIND SPEED: 1-3 | WIND DIRECTION: S

AMBIENT TEMPERATURE: 85° | RELATIVE HUMIDITY: 65%

COMMENTS:

SOURCE LAYOUT SKETCH — DRAW NORTH ARROW



OBSERVER'S SIGNATURE: Michael C. Jackman | DATE: 10-20-87

VERIFIED BY:

OBSERVER'S NAME (PRINT): Michael Jackman

ORGANIZATION: PACE LABORATORIES

CERTIFIED BY: Eastern Technical Assoc | DATE: 9-8-87

START TIME: 1100 | STOP TIME: 1200

	0	15	30	45		0	15	30	45
1	0	0	0	0	31	0	0	0	0
2	0	0	0	0	32	0	0	0	0
3	0	0	0	0	33	0	0	0	0
4	0	0	0	0	34	0	0	0	0
5	0	0	0	0	35	0	0	0	0
6	0	0	0	0	36	0	0	0	0
7	0	0	0	0	37	0	0	0	0
8	0	0	0	0	38	0	0	0	0
9	0	0	0	0	39	0	0	0	0
10	0	0	0	0	40	0	0	0	0
11	0	0	0	0	41	0	0	0	0
12	0	0	0	0	42	0	0	0	0
13	0	0	0	0	43	0	0	0	0
14	0	0	0	0	44	0	0	0	0
15	0	0	0	0	45	0	0	0	0
16	0	0	0	0	46	0	0	0	0
17	0	0	0	0	47	0	0	0	0
18	0	0	0	0	48	0	0	0	0
19	0	0	0	0	49	0	0	0	0
20	0	0	0	0	50	0	0	0	0
21	0	0	0	0	51	0	0	0	0
22	0	0	0	0	52	0	0	0	0
23	0	0	0	0	53	0	0	0	0
24	0	0	0	0	54	0	0	0	0
25	0	0	0	0	55	0	0	0	0
26	0	0	0	0	56	0	0	0	0
27	0	0	0	0	57	0	0	0	0
28	0	0	0	0	58	0	0	0	0
29	0	0	0	0	59	0	0	0	0
30	0	0	0	0	60	0	0	0	0

~~Stop 1130~~

AVERAGE OPACITY FOR FOR HIGHEST PERIOD: 0 | NUMBER OF READINGS ABOVE: 0 % WERE 0

RANGE OF OPACITY READINGS: MINIMUM 0 MAXIMUM 0

I HAVE RECEIVED A COPY OF THESE OPACITY OBSERVATIONS

SIGNATURE:

pace laboratories, inc.

VISIBLE EMISSIONS OBSERVATION

5460 Beaumont Center Blvd.
Tampa, Florida 33634
Phone: (813) 884-8268

SOURCE NAME: Johnson Controls

ADDRESS: 10215 N. 30th St Tampa

STATE: FL | ZIP: | TELEPHONE: 971-1085

SOURCE ID NUMBER: Central Vacuum East | OBSERVATION DATE: 9-16-87

PROCESS: | OPERATING MODE:

CONTROL EQUIPMENT: | OPERATING MODE:

DESCRIBE EMISSION POINT: 12" stack

HEIGHT ABOVE GROUND LEVEL: ~65' | HEIGHT RELATIVE TO OBSERVER: ~20'

DISTANCE FROM OBSERVER: ~20' | DIRECTION FROM OBSERVER: NW

DESCRIBE EMISSIONS: None

EMISSION COLOR: None | PLUME TYPE ☐ INTERMITTENT ☐ CONTINUOUS ☐ FUGITIVE ☐

WATER DROPLETS PRESENT YES ☐ | IF YES, IS PLUME ATTACHED ☐ DETACHED ☐

AT WHAT POINT WAS OPACITY DETERMINED: ~6" Above stack

DESCRIBE BACKGROUND: SKY

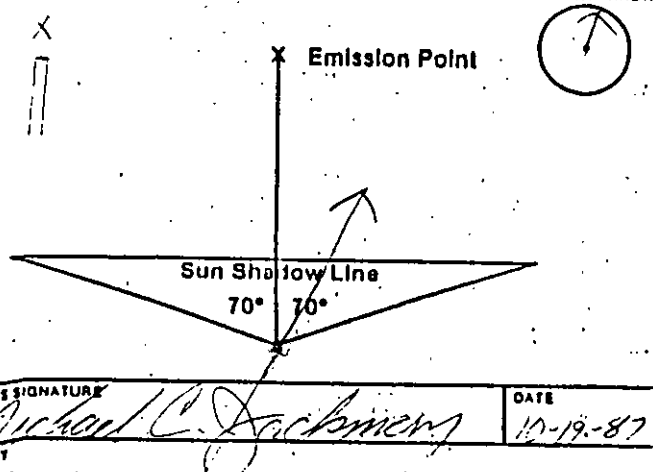
BACKGROUND COLOR: BLUE | SKY CONDITIONS: 30% Clouds

WIND SPEED: 1-3 | WIND DIRECTION: S

AMBIENT TEMPERATURE: 90° | RELATIVE HUMIDITY: 85%

COMMENTS:

SOURCE LAYOUT SKETCH — DRAW NORTH ARROW



OBSERVER'S SIGNATURE: Michael C. Jackman | DATE: 11-19-87

VERIFIED BY:

OBSERVER'S NAME (PRINT): Michael Jackman

ORGANIZATION: PACE LABORATORIES INC

CERTIFIED BY: Eastern Technical Ass. | DATE: 9-8-87

START TIME: 1316 | STOP TIME: 1416

	0	15	30	45		0	15	30	45
1	0	0	0	0	31	0	0	0	0
2	0	0	0	0	32	0	0	0	0
3	0	0	0	0	33	0	0	0	0
4	0	0	0	0	34	0	0	0	0
5	0	0	0	0	35	0	0	0	0
6	0	0	0	0	36	0	0	0	0
7	0	0	0	0	37	0	0	0	0
8	0	0	0	0	38	0	0	0	0
9	0	0	0	0	39	0	0	0	0
10	0	0	0	0	40	0	0	0	0
11	0	0	0	0	41	0	0	0	0
12	0	0	0	0	42	0	0	0	0
13	0	0	0	0	43	0	0	0	0
14	0	0	0	0	44	0	0	0	0
15	0	0	0	0	45	0	0	0	0
16	0	0	0	0	46	0	0	0	0
17	0	0	0	0	47	0	0	0	0
18	0	0	0	0	48	0	0	0	0
19	0	0	0	0	49	0	0	0	0
20	0	0	0	0	50	0	0	0	0
21	0	0	0	0	51	0	0	0	0
22	0	0	0	0	52	0	0	0	0
23	0	0	0	0	53	0	0	0	0
24	0	0	0	0	54	0	0	0	0
25	0	0	0	0	55	0	0	0	0
26	0	0	0	0	56	0	0	0	0
27	0	0	0	0	57	0	0	0	0
28	0	0	0	0	58	0	0	0	0
29	0	0	0	0	59	0	0	0	0
30	0	0	0	0	60	0	0	0	0

AVERAGE OPACITY FOR FOR HIGHEST PERIOD: 0 | NUMBER OF READINGS ABOVE 0 % WERE 0

RANGE OF OPACITY READINGS — MINIMUM: 0 | MAXIMUM: 0

I HAVE RECEIVED A COPY OF THESE OPACITY OBSERVATIONS

SIGNATURE:

TITLE:

pace laboratories, inc.

VISIBLE EMISSIONS OBSERVATION

5460 Beaumont Center Blvd.
Tampa, Florida 33634
Phone: (813) 884-8268

SOURCE NAME: Johnson Controls Globe Battery

ADDRESS: 10215 N. 30th street Tampa

STATE: FL | ZIP: | TELEPHONE: 971-1085

SOURCE ID NUMBER: Central Vacuum System East | OBSERVATION DATE: 9-16-87

PROCESS: | OPERATING MODE:

CONTROL EQUIPMENT: | OPERATING MODE:

DESCRIBE EMISSION POINT: 12" Stack

HEIGHT ABOVE GROUND LEVEL: ~65' | HEIGHT RELATIVE TO OBSERVER: ~15'

DISTANCE FROM OBSERVER: ~30' | DIRECTION FROM OBSERVER: E

DESCRIBE EMISSIONS: None

EMISSION COLOR: None | PLUME TYPE ☐ INTERMITTENT ☐ CONTINUOUS ☐ FUGITIVE ☐

WATER DROPLETS PRESENT ☐ YES ☐ | IF YES, IS PLUME ☐ ATTACHED ☐ DETACHED

POINT WHAT POINT WAS OPACITY DETERMINED: ~6" above Stack

DESCRIBE BACKGROUND: Metal Building

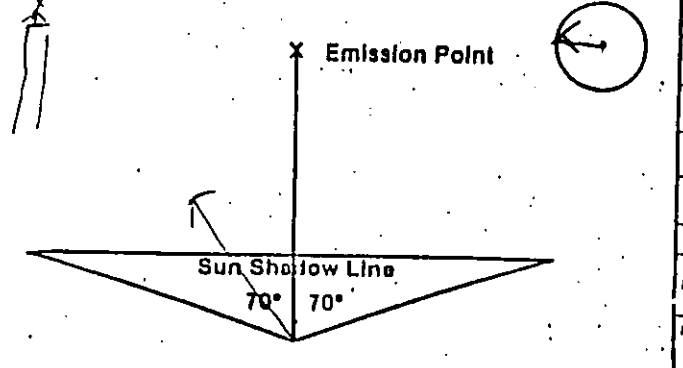
BACKGROUND COLOR: Tan + Rust | SKY CONDITIONS: 40% Clouds

WIND SPEED: 1-3 | WIND DIRECTION: S

AMBIENT TEMPERATURE: 92°C | RELATIVE HUMIDITY: 85%

COMMENTS: Stack Lost Velocity @ 15:15 due to Clogged Intake Port. Unclogged and Test resumed @ 1540

SOURCE LAYOUT SKETCH — DRAW NORTH ARROW



OBSERVER'S NAME (PRINT): Michael Tackman

ORGANIZATION: ~~Eastern Technical Associates~~

CERTIFIED BY: EASTERN Technical Assoc | DATE: 9-8-87

START TIME: 1510 | STOP TIME: 1635

	0	15	30	45		0	15	30	45
1	0	0	0	0	31	0	0	0	0
2	0	0	0	0	32	0	0	0	0
3	0	0	0	0	33	0	0	0	0
4	0	0	0	0	34	0	0	0	0
5	0	0	0	0	35	0	0	0	0
6	0	0	0	0	36	0	0	0	0
7	0	0	0	0	37	0	0	0	0
8	0	0	0	0	38	0	0	0	0
9	0	0	0	0	39	0	0	0	0
10	0	0	0	0	40	0	0	0	0
11	0	0	0	0	41	0	0	0	0
12	0	0	0	0	42	0	0	0	0
13	0	0	0	0	43	0	0	0	0
14	0	0	0	Stop	44	0	0	0	0
15	Resume 0	3:10 0	0	0	45	0	0	0	0
16	0	0	0	0	46	0	0	0	0
17	0	0	0	0	47	0	0	0	0
18	0	0	0	0	48	0	0	0	0
19	0	0	0	0	49	0	0	0	0
20	0	0	0	0	50	0	0	0	0
21	0	0	0	0	51	0	0	0	0
22	0	0	0	0	52	0	0	0	0
23	0	0	0	0	53	0	0	0	0
24	0	0	0	0	54	0	0	0	0
25	0	0	0	0	55	0	0	0	0
26	0	0	0	0	56	0	0	0	0
27	0	0	0	0	57	0	0	0	0
28	0	0	0	0	58	0	0	0	0
29	0	0	0	0	59	0	0	0	0
30	0	0	0	0	60	0	0	0	0

AVERAGE OPACITY FOR FOR HIGHEST PERIOD: 0 | NUMBER OF READINGS ABOVE: 0 % WERE 0

RANGE OF OPACITY READINGS — MINIMUM: 0 | MAXIMUM: 0

I HAVE RECEIVED A COPY OF THESE OPACITY OBSERVATIONS

SIGNATURE:

TITLE: | DATE:

OBSERVER'S SIGNATURE: Michael Tackman | DATE: 10-19-87

VERIFIED BY:

APPENDIX A

Calibration Data

SUMMARY OF SAMPLING EQUIPMENT CALIBRATION

Equipment Calibration	Date of Calibration	Place of Calibration	Method of Calibration	Calibration Date
Nozzle	9/16/87	On Site	Vernier Caliper Ave.	See Following
Pitot Tube	1/87	Interscience	FDER Alt. Method	C_p = 0.84
Dry Gas Meter and Orifice	10/19/87	PACE	Wet Test Meter JU	MCF = 1.043
Barometer	----	Tampa Airport	----------	@ 12 noon
Thermocouples	1/87	Interscience	Calibrated at ambient and boiling water temperatures against ASTM mercury bulb thermometer	± 5°F
Nomograph Accuracy	1/87	Interscience	EPA Pub. "Adjustments in the EPA Nomograph for different Pitot Tube Coeff. and Dry Molecular Weights	± 10%

NOZZLE DIAMETER CALIBRATION DATA

Client: Johnson Controls, Inc.
Source I.D.: Central Vacuum System #2 (S/N 1588)
Test Date: September 16, 1987
Computed By: Michael C. Jackman

	Nozzle Diameter						
DATE	1	2	3	4	5	6	Average
9/16/87	0.224	0.223	0.224	0.225	0.224	0.224	0.224

pace laboratories, inc.

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa

REPORT OF LABORATORY ANALYSIS

DRY GAS METER AND ORIFICE CALIBRATION

Calibration Date: September 9, 1987
Calibrated by: Michael Jackman

Barometric Pressure: 29.995 in Hg
Calibration Time: 15 min

WET TEST METER					DRY GAS METER							CALIBRATION	
Initial Vol	Final Vol	Vw	dW	Tw °F	Initial Vol	Final Vol	Vm	dH	T in	T out	Tm ave	MCF	dH@
0.000	6.294	6.294	0.30	74.6	525.514	531.526	6.012	0.50	102	78	90.0	1.065	1.594
0.000	7.681	7.681	0.30	75.0	531.526	539.001	7.475	0.75	107	80	93.5	1.051	1.602
0.000	8.479	8.479	0.30	75.0	539.001	547.398	8.397	1.00	109	81	95.0	1.035	1.750
0.000	10.595	10.595	0.35	75.0	547.398	558.093	10.695	1.50	111	83	97.0	1.016	1.675
0.000	12.129	12.129	0.40	75.0	570.848	582.788	11.940	2.00	111	85	98.0	1.040	1.698
0.000	13.336	13.336	0.40	75.0	582.788	596.182	13.394	2.50	112	86	99.0	1.020	1.752
0.000	14.500	14.500	0.40	75.0	596.182	610.671	14.489	3.00	112	87	99.5	1.025	1.775
											AVERAGE	1.036	1.692

dH = Orifice Pressure — inches water
dW = Pressure (-) at Wet Test Meter — inches Hg
Vm = Gas Volume, Dry Gas Meter — cubic feet
Vw = Gas Volume, Wet Test Meter — cubic feet
Tw = Temperature, Wet Test Meter — °F
Tm = Temperature, Dry Gas Meter — °F
t = Calibration Time — minutes
MCF = Meter Correction Factor
dH@ = Standard Orifice Pressure Differential
0.75 CFM dry air @70°F, 29.92 inches Hg

$$MCF = [Vw*(Tm+460)*(Pb-dW)]/[Vm*(Tw+460)*(Pb+dH/13.6)]$$

$$dH@ = [(0.0317*dH/(Pb*(Tmout+460))][(Tw+460)*t/Vw]^2$$

STACK\DGM7CAL.MAS

pace laboratories, inc.

Offices:
Minneapolis, Minnesota
Tampa, Florida
Coralville, Iowa

REPORT OF LABORATORY ANALYSIS

DRY GAS METER AND ORIFICE CALIBRATION

Calibration Date: October 19, 1987
Calibrated by: Michael Jackman

Barometric Pressure: 30.02 in Hg
Calibration Time: 15 min

WET TEST METER					DRY GAS METER							CALIBRATION	
Initial Vol	Final Vol	Vw	dW	Tw °F	Initial Vol	Final Vol	Vm	dH	T in	T out	Tm ave	MCF	dH@
0.000	6.332	6.332	0.30	75.0	888.062	894.109	6.047	0.50	102	77	89.5	1.063	1.579
0.000	7.625	7.625	0.30	75.0	894.109	901.449	7.340	0.75	106	80	93.0	1.061	1.625
0.000	8.691	8.691	0.30	75.0	901.449	909.895	8.446	1.00	108	81	94.5	1.053	1.664
0.000	10.444	10.444	0.35	74.5	909.895	920.160	10.265	1.50	109	82	95.5	1.041	1.722
0.000	11.801	11.801	0.40	74.5	920.160	931.837	11.677	2.00	111	84	97.5	1.035	1.792
0.000	13.289	13.289	0.50	74.3	931.837	944.974	13.137	2.50	112	84	98.0	1.033	1.765
0.000	14.387	14.387	0.60	74.0	944.974	959.371	14.397	3.00	113	85	99.0	1.018	1.802
											AVERAGE	1.043	1.707

dH = Orifice Pressure — inches water
dW = Pressure (-) at Wet Test Meter — inches Hg
Vm = Gas Volume, Dry Gas Meter — cubic feet
Vw = Gas Volume, Wet Test Meter — cubic feet
Tw = Temperature, Wet Test Meter — °F
Tm = Temperature, Dry Gas Meter — °F
t = Calibration Time — minutes
MCF = Meter Correction Factor
dH@ = Standard Orifice Pressure Differential
0.75 CFM dry air @70°F, 29.92 inches Hg

$$MCF = [Vw*(Tm+460)*(Pb-dW)]/[Vm*(Tw+460)*(Pb+dH/13.6)]$$

$$dH@ = [(0.0317*dH/(Pb*(Tmout+460))][(Tw+460)*t/Vw]^{-2}$$

SOURCE SAMPLING PITOT TUBE CALIBRATION

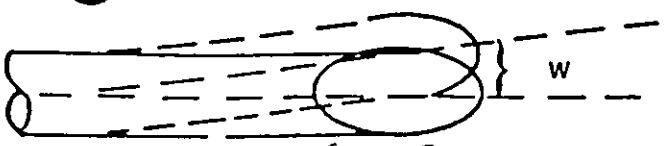
ALIGNMENT MEASUREMENT OF FACE-OPENINGS

DATE: 11/8/87

S/N: Tim Oswald

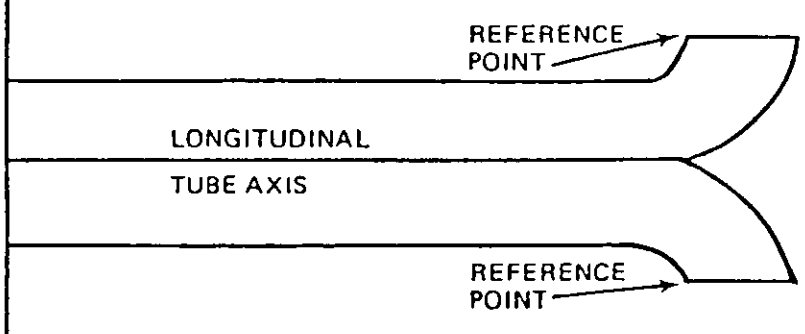
SIDE "A"

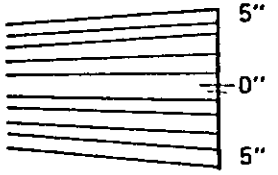
SIDE "B"



W = < 0.05 cm

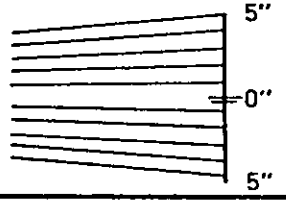
W < 0.08cm





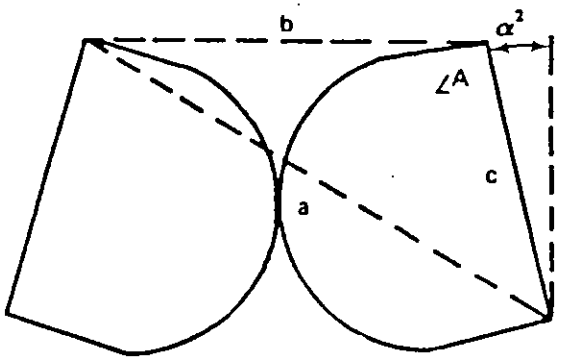
β^2 0.5 °

$\beta^2 < 5"$



β^1 0.3 °

SIDE "A"



a = 3.245 cm

b = 3.100 cm

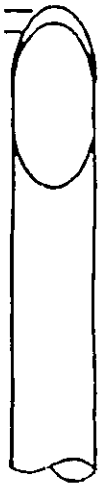
c = 0.950 cm

∠A = 89.8 °

$\alpha^2 = 180° - ((180° - \angle A) + 90°)$

α^2 = −0.20 °

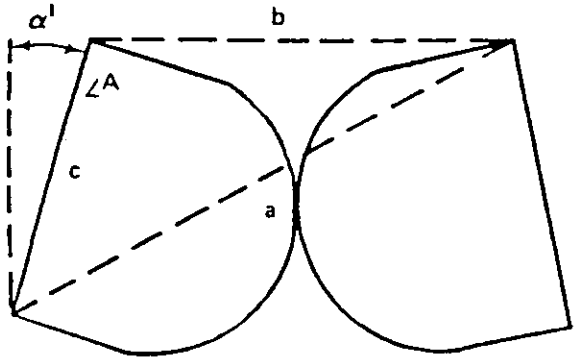
$\alpha^2 < 10°$



Z = 0 cm

Z < 0.32cm

SIDE "B"



a = 3.230 cm

b = 3.100 cm

c = 0.940 cm

∠A = 89.4 °

$\alpha^1 = 180° - ((180° - \angle A) + 90°)$

α^1 = −0.6 °

$\alpha^1 < 10°$

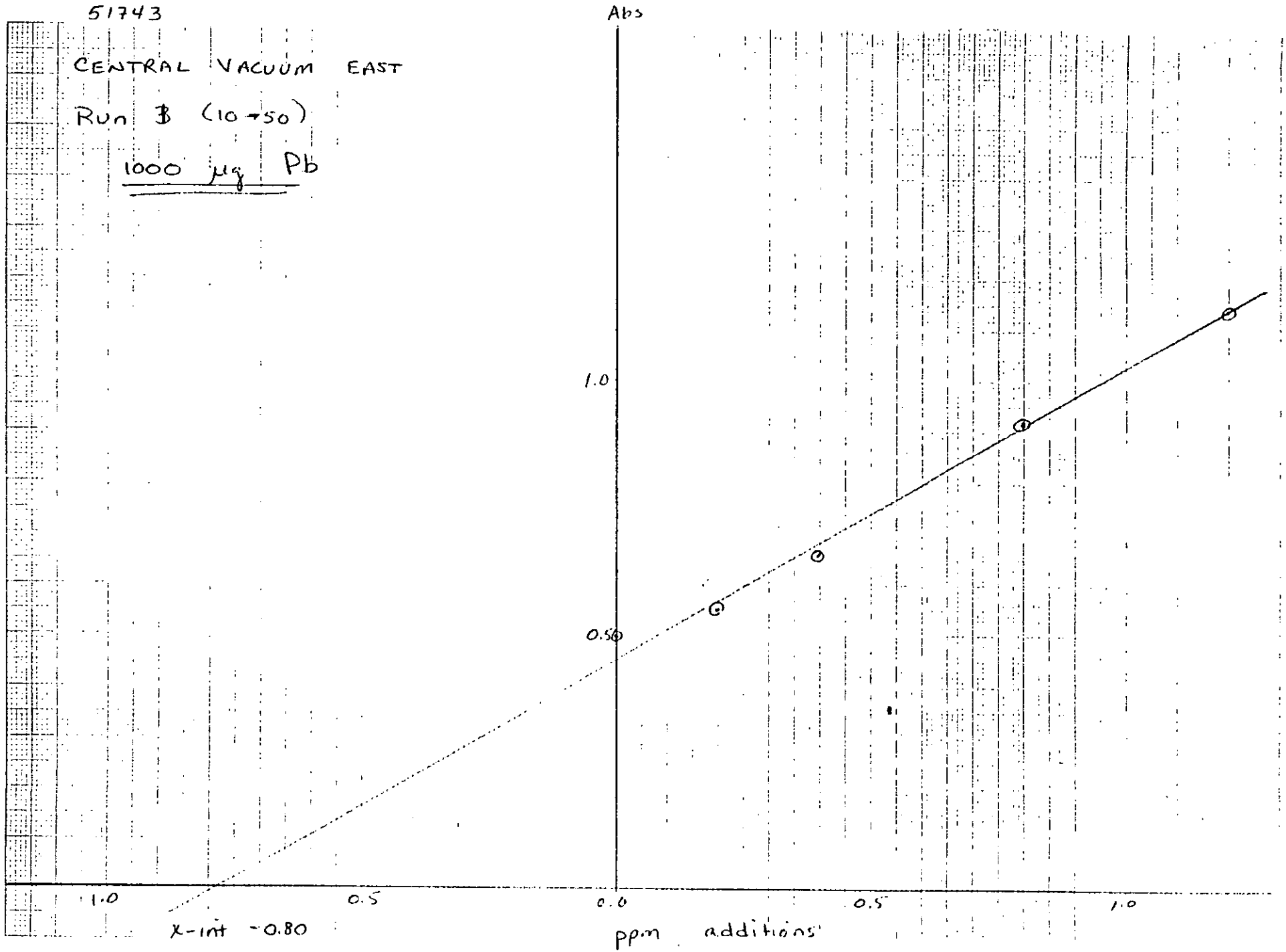
10 Millimeters to the Centimeter

51743

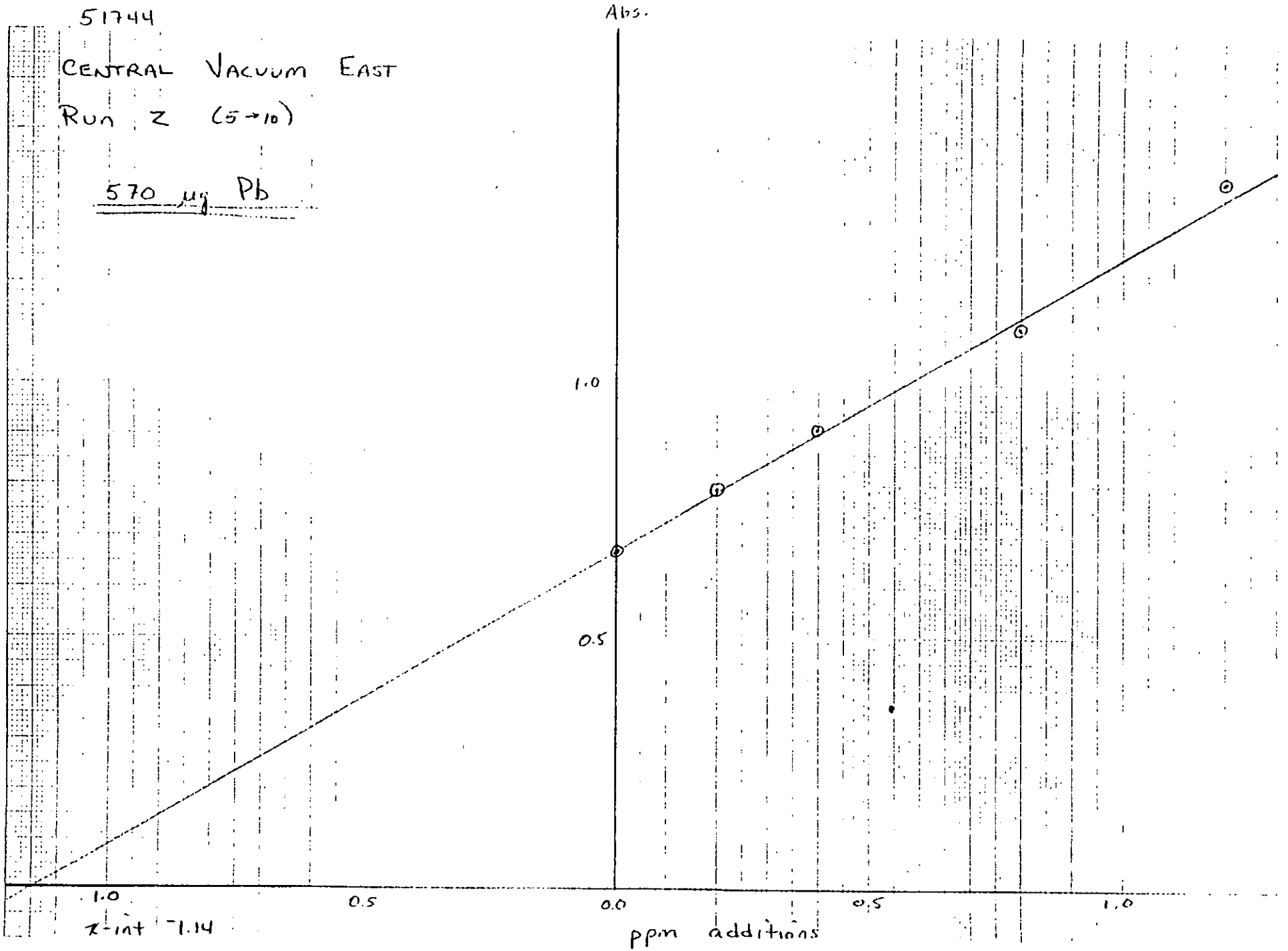
CENTRAL VACUUM EAST

Run 3 (10→50)

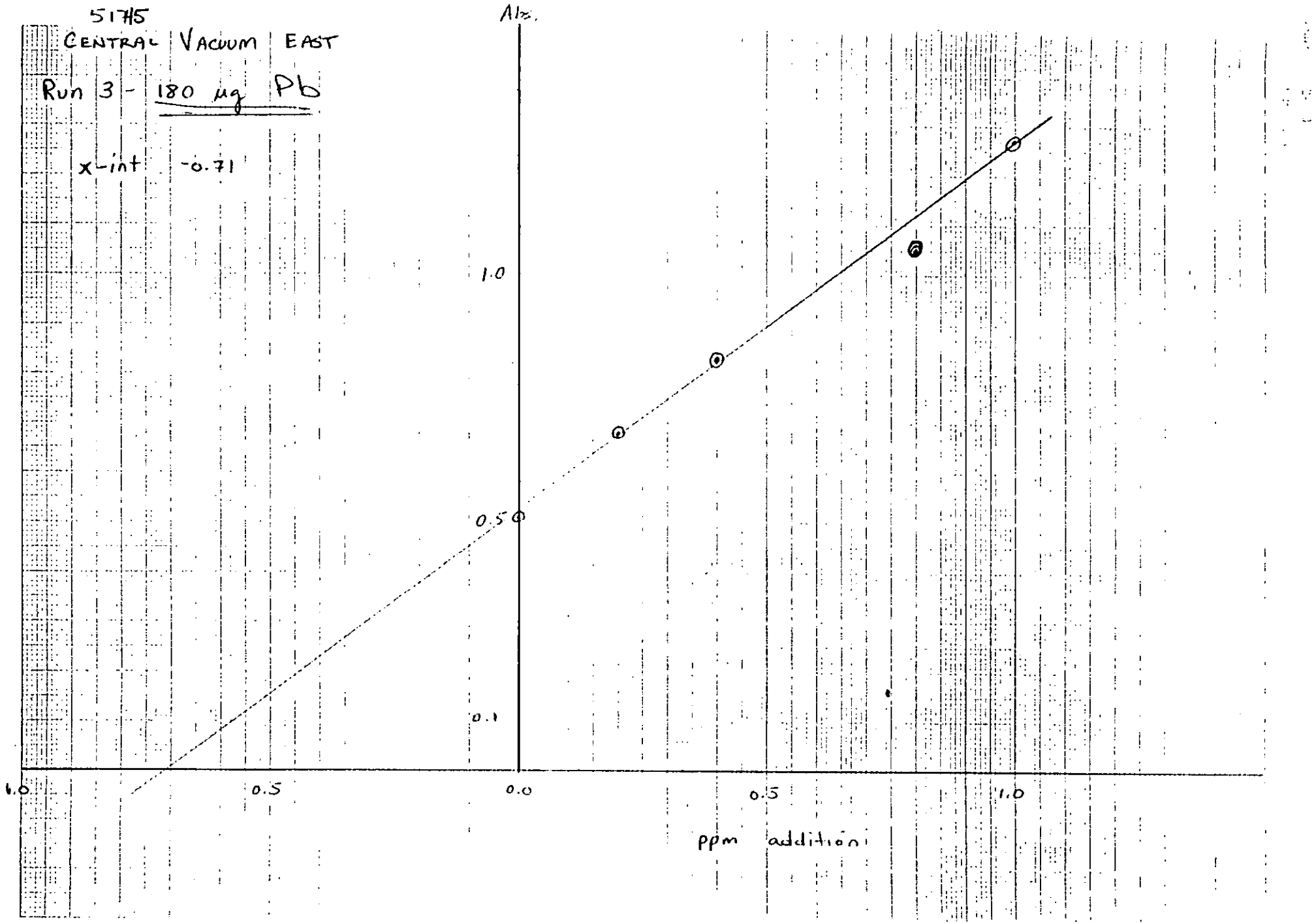
1000 µg Pb



10 Millimeters to the Centimeter



10 Millimeters to the Centimeter



APPENDIX B

Process Weight Statement

pace laboratories, inc.
PROFESSIONAL ANALYTICAL CHEMISTRY ● ENGINEERING

Offices:
Minneapolis, Minnesota
Tampa, Florida

5460 Beaumont Center Blvd. ☐ Tampa, Florida 33634 ☐ (813) 884-8268

STATEMENT OF PROCESS WEIGHT

COMPANY NAME Johnson Controls, Inc., Globe Battery Division

ADDRESS P. O. Box 16068, Tampa, Florida 33687

SOURCE IDENTIFICATION Central Vacuum System # 2 (S/N 158B)

SOURCE LOCATION 10215 North 30th Street, Tampa, Florida

DATE 09/16/87 SAMPLING TIME: 1000 TO: 1645

DATA ON OPERATING CYCLE TIME;

START OF OPERATION, TIME _____

END OF OPERATION, TIME _____

ELAPSED TIME _____

IDLE TIME DURING CYCLE _____

DESIGN PROCESS RATING;

PROCESS WEIGHT RATE (INPUT) _____ PRODUCT (OUTPUT) _____

DATA ON ACTUAL PROCESS RATE DURING OPERATION CYCLE;

MATERIAL Lead Bearing Dust RATE 15.5 lbs/hr

MATERIAL _____ RATE _____

MATERIAL _____ RATE _____

TOTAL PROCESS WEIGHT RATE;

PRODUCT Lead Bearing Dust RATE 15.5 lbs/hr

I certify that the above statement is true to the best of my knowledge and belief.

Signature William Scott

Title Managing Engineer