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Background Report Reference

AP-42 Section Number: 12.15

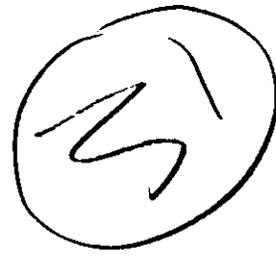
Background Chapter: 4

Reference Number: 24

Title: Source Sampling Report for Johnson
Controls, Inc., Tampa, FL, Main Grid
Caster

Environmental Testing, Inc.

1988



SOURCE SAMPLING REPORT
FOR
JOHNSON CONTROLS, INC.
Tampa, Florida
MAIN GRID CASTER
6 THREE HOUR RUNS - TAMPA

*Does not
appear to be
for USPS -
just test
repeatability
or length
comparisons*

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

Paul R Jenkins

Paul R. Jenkins, Jr.
September 1988

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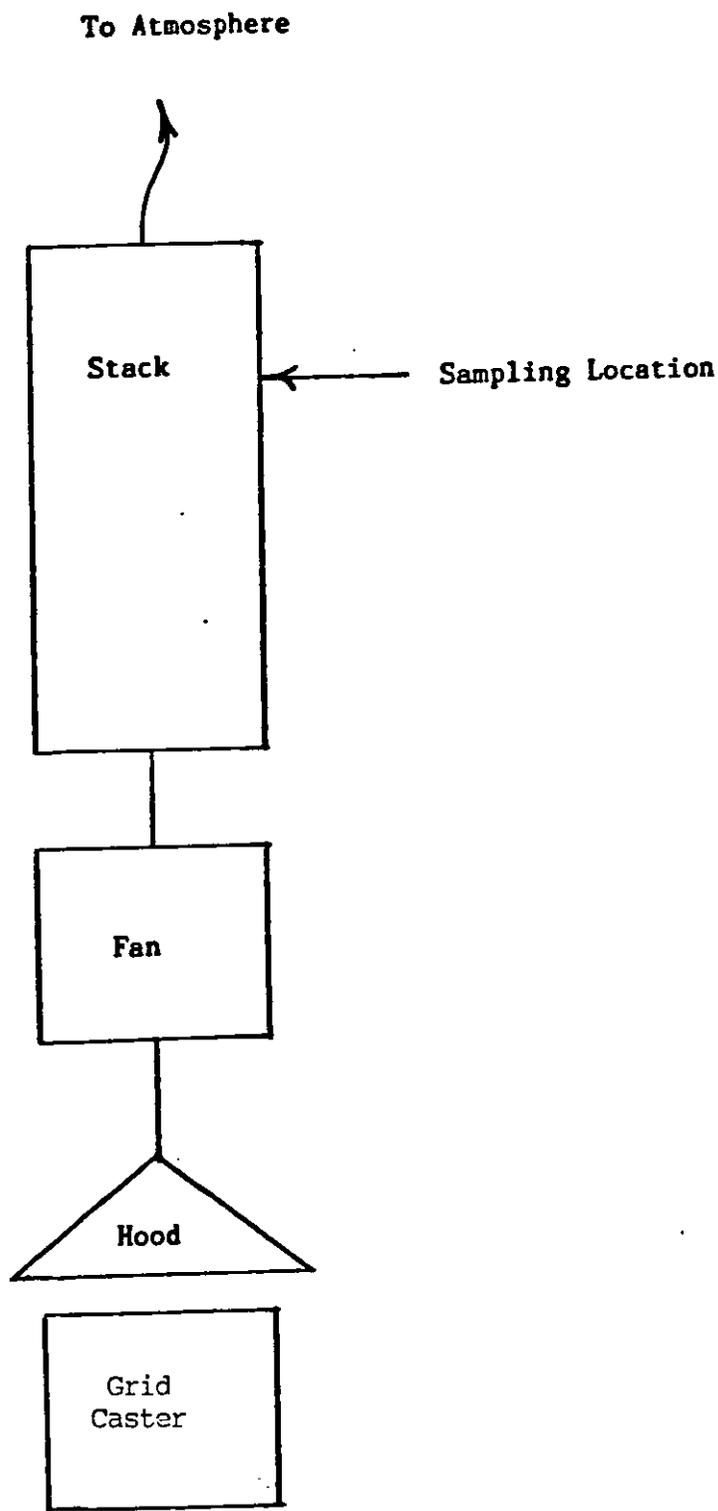
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INTRODUCTION

Source sampling was performed for the Johnson Controls, Inc. Tampa, Florida, plant to determine lead emissions and particulate from the Main Grid Caster Stack. Six sampling runs (three sampling hours per run) were made on September 6, 7, and 8, 1988. A typical sampling location is shown in Figure 1.

The measurements of stack gas flow rate and pollutant concentrations were made according to U.S. Environmental Protection Agency and the Florida Department of Environmental Regulation (FDER) recommendations.

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.



FLOW DIAGRAM

MAIN GRID CASTER (typical)

Figure 1

SUMMARY OF RESULTS

Table Number 1 presents the summary of results from the Method 12 lead sampling and for the Method 5 particulate sampling.

The mean lead concentration from the Main Grid Caster Stack was 0.104×10^{-3} grains per dry standard cubic foot. The mean lead emission rate was 0.01058 pounds per hour.

The mean particulate concentration from the Main Grid Caster Stack was 0.00123 grains per dry standard cubic foot. The mean particulate emission rate was 0.127 pounds per hour.

TABLE 1
SUMMARY OF RESULTS, LEAD AND PARTICULATE SAMPLING
MAIN GRID CASTER STACK

Run Number	Runs 1 - 3		
	1	2	3
Date	09/06/88	09/07/88	09/07/88
% Isokinetic	103.75	103.21	104.03
Volume of Gas Sampled, SCF * Dry	131.608	131.327	127.957
Stack Gas Flow Rate, SCFM * Dry	12034.4	12071.8	11668.6
Stack Gas Flow Rate, ACFM	14111.0	14044.9	13672.0
Lead:			
Catch, mgrams	0.8865	1.0070	0.8635
Concentration, grains/ SCF * Dry	0.000104	0.000118	0.000104
Emission Rate, lbs/hr	0.0107	0.0122	0.0104
Particulate:			
Catch, mgrams	8.02	10.43	9.29
Concentration, grains/ SCF * Dry	0.0009	0.0012	0.0011
Emission Rate, lbs/hr	0.097	0.127	0.112

*68°F, 29.92 in. Hg

**Nozzle, probe, filter, impingers

TABLE 1
SUMMARY OF RESULTS, LEAD AND PARTICULATE SAMPLING
MAIN GRID CASTER STACK

	Runs 4 - 6		
Run Number	4	5	6
Date	09/07/88	09/08/88	09/08/88
% Isokinetic	104.22	103.14	102.64
Volume of Gas Sampled, SCF * Dry	129.606	129.787	128.587
Stack Gas Flow Rate, SCFM * Dry	11798.1	11937.6	11885.2
Stack Gas Flow Rate, ACFM	13862.0	13805.4	13806.7
Lead:			
Catch, mgrams	0.7935	0.6690	1.0303
Concentration, grains/ SCF * Dry	0.0000943	0.0000794	0.000123
Emission Rate, lbs/hr	0.0095	0.0081	0.0126
Particulate:			
Catch, mgrams	12.42	9.29	13.55
Concentration, grains/ SCF * Dry	0.0015	0.0011	0.0016
Emission Rate, lbs/hr	0.149	0.113	0.165

*68°F, 29.92 in. Hg

**Nozzle, probe, filter, impingers

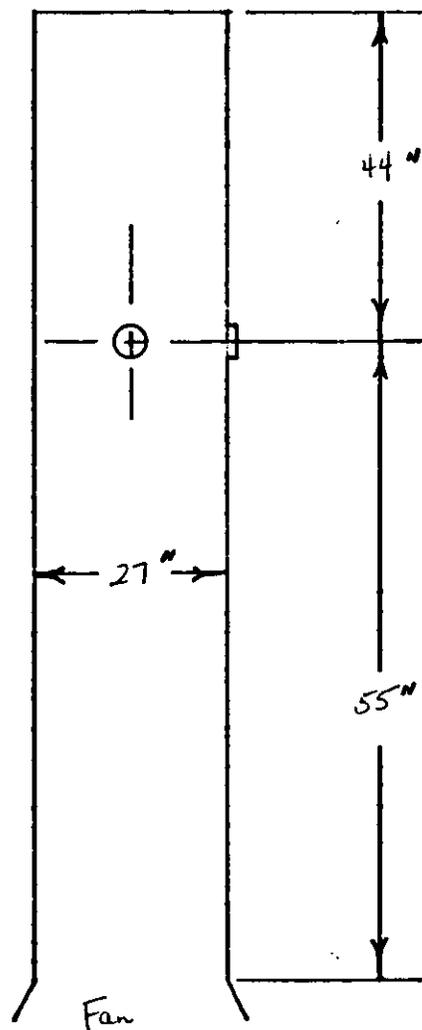
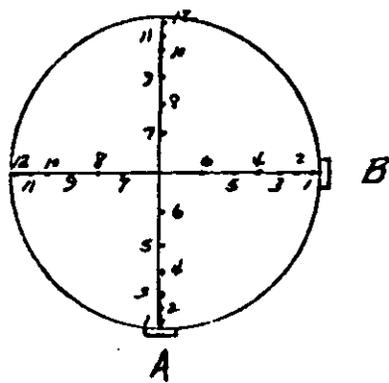
PROCESS DESCRIPTION AND OPERATION

The Johnson Controls, Inc. Tampa, Florida, plant has a grid casting operation that is typical. For the Main Grid Caster lead is melted in a pot and flows down runners to the grid casting operation. The combustion gases are exhausted to the atmosphere as shown in Figure 1. No control devices are employed in this process.

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

LOCATION OF SAMPLING POINTS

The dimensions of the stack and the location of the sampling points are shown in Figure 2. The stack cross section was divided into 24 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 180 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.



LOCATION OF SAMPLING POINTS

Figure 2

SAMPLING AND ANALYTICAL PROCEDURES

All sampling and analytical procedures used were those recommended by the U.S. Environmental Protection Agency and the FDER. Complete details are found in Appendix 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 - 5), and the Federal Register, Volume 47, Number 74, 16 April 1982 (Method 12).

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 5 was used for the particulate determination. Method 12 was used for the lead concentration determination.

APPENDICES

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Summary of Method 12 Lead Results

Johnson Controls Tampa Florida Main Grid Caster Runs 1 - 3

Run Number		1	2	3
Date		9/ 6/88	9/ 7/88	9/ 7/88
DN	Sample nozzle dia., in.	0.207	0.207	0.207
TT	Net time of test	180	180	180
PB	Barometric pressure, in. Hg.	29.80	29.76	29.76
PM	Average orifice pressure drop, in. H ₂ O	1.943	1.950	1.838
VM	Volume of dry gas sampled, cu. ft. at meter conditions	138.21	137.50	135.02
TM	Average gas meter temp. in degrees F.	94.69	92.29	96.46
VMSTD	Volume of dry gas sampled at standard conditions ² , SCF	131.608	131.327	127.957
VW	Total water collected in impingers + silica gel, ML.	58.0	52.0	56.0
VMV	Volume of water vapor at standard conditions ² , SCF	2.731	2.449	2.637
PMV	Percent moisture by volume	2.033	1.830	2.019
MD	Mole fraction dry gas	0.9797	0.9817	0.9798
PCO ₂	Percent CO ₂ by volume, dry	0.10	0.00	0.00
PO ₂	Percent O ₂ by volume, dry	20.70	20.90	20.90
PCO	Percent CO by volume, dry	0.00	0.00	0.00
PN ₂	Percent N ₂ by volume, dry	79.20	79.10	79.10
MWD	Molecular weight-dry stack gas	28.844	28.836	28.836
MW	Molecular weight-stack gas	28.624	28.638	28.617
CP	Pitot tube coefficient	0.84	0.84	0.84
DPS	Average velocity head of stack gas, inches water	0.9750	0.9734	0.9448
TS	Average stack temperature, F	142.88	138.63	141.71

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PSI	Static pressure of stack gas, inches Hg.	-0.048	-0.048	-0.048
PS	Stack pressure, absolute	29.752	29.712	29.712
VS	Average stack velocity, FPM	3534.6	3518.0	3424.6
AS	Stack area, inches sqrd.	572.5	572.5	572.5
QS	Stack flow rate, dry, standard conditions, DSCFM	12034.4	12071.8	11668.6
QSW	Stack flow rate, wet, standard conditions, WSCFM	12284.1	12296.9	11909.0
QA	Actual stack flow rate, ACFM	14111.0	14044.9	13672.0
PERI	Percent isokinetic	103.75	103.21	104.03
FMF	Lead, Mg.	0.8865	1.0070	0.8635
CAN	Lead, GR/DSCF	0.104E-03	0.118E-03	0.104E-03
CAM	Lead, GR/WSCF	0.106E-03	0.120E-03	0.106E-03
CAT	Lead, GR/ACF	0.885E-04	0.101E-03	0.887E-04
CAW	Lead, LB/HR	0.0107	0.0122	0.0104
FNP	Net sampling points	24	24	24
RW	Process weight, lbs/hr	5700.0	5700.0	5700.0

*68 Degrees F. 29.92 Inches Hg.

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Summary of Method 12 Lead Results

Johnson Controls Tampa Florida Main Grid Caster Runs 4 - 6

Run Number		1	2	3
Date		9/ 7/88	9/ 8/88	9/ 8/88
DN	Sample nozzle dia., in.	0.207	0.207	0.207
TT	Net time of test	180	180	180
PB	Barometric pressure, in. Hg.	29.76	29.79	29.79
PM	Average orifice pressure drop, in. H2O	1.882	1.892	1.889
VM	Volume of dry gas sampled, cu. ft. at meter conditions	137.58	136.80	136.83
TM	Average gas meter temp. in degrees F.	99.85	96.48	101.79
VMSTD	Volume of dry gas sampled at standard conditions*, SCF	129.606	129.787	128.587
VW	Total water collected in impingers + silica gel, ML.	60.0	53.0	58.0
VMV	Volume of water vapor at standard conditions*, SCF	2.825	2.496	2.731
PMV	Percent moisture by volume	2.133	1.887	2.080
MD	Mole fraction dry gas	0.9787	0.9811	0.9792
PCO2	Percent CO2 by volume, dry	0.00	0.10	0.00
PO2	Percent O2 by volume, dry	20.90	20.70	20.90
PCO	Percent CO by volume, dry	0.00	0.00	0.00
PN2	Percent N2 by volume, dry	79.10	79.20	79.10
MWD	Molecular weight-dry stack gas	28.836	28.844	28.836
MW	Molecular weight-stack gas	28.605	28.639	28.611
CP	Pitot tube coefficient	0.84	0.84	0.84
DPS	Average velocity head of stack gas, inches water	0.9570	0.9600	0.9584
TS	Average stack temperature, F	142.67	135.29	136.79

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PSI	Static pressure of stack gas, inches Hg.	-0.048	-0.048	-0.048
PS	Stack pressure, absolute	29.712	29.742	29.742
VS	Average stack velocity, FPM	3472.2	3458.0	3458.4
AS	Stack area, inches sqrd.	572.5	572.5	572.5
QS	Stack flow rate, dry, standard conditions, DSCFM	11798.1	11937.6	11885.2
QSW	Stack flow rate, wet, standard conditions, WSCFM	12055.3	12167.1	12137.7
QA	Actual stack flow rate, ACFM	13862.0	13805.4	13806.7
PERI	Percent isokinetic	104.22	103.14	102.64
FMF	Lead, Mg.	0.7935	0.6690	1.0303
CAN	Lead, GR/DSCF	0.943E-04	0.794E-04	0.123E-03
CAM	Lead, GR/WSCF	0.963E-04	0.809E-04	0.126E-03
CAT	Lead, GR/ACF	0.802E-04	0.686E-04	0.106E-03
CAW	Lead, LB/HR	0.0095	0.0081	0.0126
FNP	Net sampling points	24	24	24
RW	Process weight, lbs/hr	5700.0	5700.0	5700.0

*68 Degrees F. 29.92 Inches Hg.

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Method 12 Lead Calculations Test Number 1

Johnson Controls Tampa Florida Main Grid Caster Runs 1 - 3

Volume of Dry Gas Sampled at Standard Conditions

$$VMSTD = \frac{17.64 \times VM \times (PB + PM / 13.6)}{TM + 460} = 131.608$$

Volume of Water Vapor at Standard Conditions

$$VMV = 0.04709 \times VW = 2.731$$

Percent Moisture in Stack Gas

$$PMV = \frac{100 \times VMV}{VMSTD + VMV} = 2.033$$

Mole Fraction of Dry Gas

$$MD = \frac{100 - PMV}{100} = 0.9797$$

Average Molecular Weight of Dry Stack Gas

$$MWD = 0.44 \times PCO2 + 0.32 \times PO2 + 0.28 \times (PN2 + PCO) = 28.844$$

Molecular Weight of Stack Gas

$$MW = MWD \times MD + 18 \times (1 - MD) = 28.624$$

Stack Gas Velocity at Stack Conditions

$$VS = 5129.4 \times CP \times DPS \times \sqrt{(TS + 460)} / (PS \times MW) = 3534.6$$

Stack Gas Volumetric Flow at Standard Conditions, Dry

$$QS = \frac{0.123 \times VS \times AS \times PS \times MD}{TS + 460} = 12034.4$$

Stack Gas Volumetric Flow at Stack Conditions

$$QA = \frac{QS \times (TS + 460)}{17.64 \times PS \times MD} = 14111.0$$

Percent Isokinetic

$$PERI = \frac{1039 \times (TS + 460) \times VMSTD}{VS \times TT \times PS \times MD \times DN \times DN} = 103.75$$

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

$$\text{CAN} = 0.0154 * \text{FMF} / \text{VMSTD} =$$

0.104E-03

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

$$17.64 * \text{CAN} * \text{PS} * \text{MD}$$

$$\text{CAT} = \frac{\text{-----}}{\text{TS} + 460} =$$

0.885E-04

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

$$\text{CAW} = 0.00857 * \text{CAN} * \text{QS} =$$

0.0107

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Method 12 Lead Calculations Test Number 1

Johnson Controls Tampa Florida Main Grid Caster Runs 4 - 6

Volume of Dry Gas Sampled at Standard Conditions

$$VMSTD = \frac{17.64 \times VM \times (PB + PM / 13.6)}{TM + 460} = 129.606$$

Volume of Water Vapor at Standard Conditions

$$VMV = 0.04709 \times VW = 2.825$$

Percent Moisture in Stack Gas

$$PMV = \frac{100 \times VMV}{VMSTD + VMV} = 2.133$$

Mole Fraction of Dry Gas

$$MD = \frac{100 - PMV}{100} = 0.9787$$

Average Molecular Weight of Dry Stack Gas

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

Molecular Weight of Stack Gas

$$MW = MWD \times MD + 18 \times (1 - MD) = 28.605$$

Stack Gas Velocity at Stack Conditions

$$VS = 5129.4 \times CP \times DPS \times \text{SQRT}(TS + 460) / (PS \times MW) = 3472.2$$

Stack Gas Volumetric Flow at Standard Conditions, Dry

$$QS = \frac{0.123 \times VS \times AS \times PS \times MD}{TS + 460} = 11798.1$$

Stack Gas Volumetric Flow at Stack Conditions

$$QA = \frac{QS \times (TS + 460)}{17.64 \times PS \times MD} = 13862.0$$

Percent Isokinetic

$$PERI = \frac{1039 \times (TS + 460) \times VMSTD}{VS \times TT \times PS \times MD \times DN \times DN} = 104.22$$

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

$$\text{CAN} = 0.0154 * \text{FMF} / \text{VMSTD} =$$

0.943E-04

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

$$17.64 * \text{CAN} * \text{PS} * \text{MD}$$

$$\text{CAT} = \frac{\text{-----}}{\text{TS} + 460} =$$

0.802E-04

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

$$\text{CAW} = 0.00857 * \text{CAN} * \text{QS} =$$

0.0095

Summary of Method 5 Particulate Results

Johnson Controls Inc. Tampa Florida Main Grid Caster Runs 1 - 3

Run Number		1	2	3
Date		9/ 6/88	9/ 7/88	9/ 7/88
DN	Sample nozzle dia., in.	0.207	0.207	0.207
TT	Net time of test	180	180	180
PB	Barometric pressure, in. Hg.	29.80	29.76	29.76
PM	Average orifice pressure drop, in. H ₂ O	1.943	1.950	1.838
VM	Volume of dry gas sampled, cu. ft. at meter conditions	138.21	137.50	135.02
TM	Average gas meter temp. in degrees F.	94.69	92.29	96.46
VMSTD	Volume of dry gas sampled at standard conditions ² , SCF	131.608	131.327	127.957
VW	Total water collected in impingers + silica gel, ML.	58.0	52.0	56.0
VMV	Volume of water vapor at standard conditions ² , SCF	2.731	2.449	2.637
PMV	Percent moisture by volume	2.033	1.830	2.019
MD	Mole fraction dry gas	0.9797	0.9817	0.9798
PCO ₂	Percent CO ₂ by volume, dry	0.10	0.00	0.00
PO ₂	Percent O ₂ by volume, dry	20.70	20.90	20.90
PCO	Percent CO by volume, dry	0.00	0.00	0.00
PN ₂	Percent N ₂ by volume, dry	79.20	79.10	79.10
MWD	Molecular weight-dry stack gas	28.844	28.836	28.836
MW	Molecular weight-stack gas	28.624	28.638	28.617
CP	Pitot tube coefficient	0.84	0.84	0.84
DPS	Average velocity head of stack gas, inches water	0.9750	0.9734	0.9448
TS	Average stack temperature, F	142.88	138.63	141.71

PSI	Static pressure of stack gas, inches Hg.	-0.048	-0.048	-0.048
PS	Stack pressure, absolute	29.752	29.712	29.712
VS	Average stack velocity, FPM	3534.6	3518.0	3424.6
AS	Stack area, inches sqrd.	572.5	572.5	572.5
QS	Stack flow rate, dry, standard conditions, DSCFM	12034.4	12071.8	11668.6
QSW	Stack flow rate, wet, standard conditions, WSCFM	12284.1	12296.9	11909.0
QA	Actual stack flow rate, ACFM	14111.0	14044.9	13672.0
PERI	Percent isokinetic	103.75	103.21	104.03
FMF	Particulate, Mg., front	8.02	10.43	9.29
CAN	Particulate, GR/DSCF front	0.0009	0.0012	0.0011
CAM	Particulate, GR/WSCF front	0.0010	0.0012	0.0011
CAT	Particulate, GR/ACF front	0.0008	0.0011	0.0010
CAW	Particulate, LB/HR front	0.097	0.127	0.112
FNP	Net sampling points	24	24	24
RW	Process weight, lbs/hr	5700.0	5700.0	5700.0

*68 Degrees F. 29.92 Inches Hg.

Summary of Method 5 Particulate Results

Johnson Controls Inc. Tampa Florida Main Grid Caster Runs 4 - 6

Run Number		4	5	6
Date		9/ 7/88	9/ 8/88	9/ 8/88
DN	Sample nozzle dia., in.	0.207	0.207	0.207
TT	Net time of test	180	180	180
PB	Barometric pressure, in. Hg.	29.76	29.79	29.79
PM	Average orifice pressure drop, in. H2O	1.882	1.892	1.889
VM	Volume of dry gas sampled, cu. ft. at meter conditions	137.58	136.80	136.83
TM	Average gas meter temp. in degrees F.	99.85	96.48	101.79
VMSTD	Volume of dry gas sampled at standard conditions*, SCF	129.606	129.787	128.587
VW	Total water collected in impingers + silica gel, ML.	60.0	53.0	58.0
VMV	Volume of water vapor at standard conditions*, SCF	2.825	2.496	2.731
PMV	Percent moisture by volume	2.133	1.887	2.080
MD	Mole fraction dry gas	0.9787	0.9811	0.9792
PCO2	Percent CO2 by volume, dry	0.00	0.10	0.00
PO2	Percent O2 by volume, dry	20.90	20.70	20.90
PCO	Percent CO by volume, dry	0.00	0.00	0.00
PN2	Percent N2 by volume, dry	79.10	79.20	79.10
MWD	Molecular weight-dry stack gas	28.836	28.844	28.836
MW	Molecular weight-stack gas	28.605	28.639	28.611
CP	Pitot tube coefficient	0.84	0.84	0.84
DPS	Average velocity head of stack gas, inches water	0.9570	0.9600	0.9584
TS	Average stack temperature, F	142.67	135.29	136.79

PSI	Static pressure of stack gas, inches Hg.	-0.048	-0.048	-0.048
PS	Stack pressure, absolute	29.712	29.742	29.742
VS	Average stack velocity, FPM	3472.2	3458.0	3458.4
AS	Stack area, inches sqrd.	572.5	572.5	572.5
QS	Stack flow rate, dry, standard conditions, DSCFM	11798.1	11937.6	11885.2
QSW	Stack flow rate, wet, standard conditions, WSCFM	12055.3	12167.1	12137.7
QA	Actual stack flow rate, ACFM	13862.0	13805.4	13806.7
PERI	Percent isokinetic	104.22	103.14	102.64
FMF	Particulate, Mg., front	12.42	9.29	13.55
CAN	Particulate, GR/DSCF front	0.0015	0.0011	0.0016
CAM	Particulate, GR/WSCF front	0.0015	0.0011	0.0017
CAT	Particulate, GR/ACF front	0.0013	0.0010	0.0014
CAW	Particulate, LB/HR front	0.149	0.113	0.165
FNP	Net sampling points	24	24	24
RW	Process weight, lbs/hr	5700.0	5700.0	5700.0

*68 Degrees F. 29.92 Inches Hg.

Method 5 Particulate Calculations Test Number 1

Johnson Controls Inc. Tampa Florida Main Grid Caster Runs 1 - 3

Volume of Dry Gas Sampled at Standard Conditions
 $17.64 \times VM \times (PB + PM / 13.6)$

$$VMSTD = \frac{\text{-----}}{TM + 460} = 131.608$$

Volume of Water Vapor at Standard Conditions

$$VMV = 0.04709 \times VW = 2.731$$

Percent Moisture in Stack Gas

$$PMV = \frac{100 \times VMV}{VMSTD + VMV} = 2.033$$

Mole Fraction of Dry Gas

$$MD = \frac{100 - PMV}{100} = 0.9797$$

Average Molecular Weight of Dry Stack Gas

$$MWD = 0.44 \times PCO2 + 0.32 \times PO2 + 0.28 \times (PN2 + PCO) = 28.844$$

Molecular Weight of Stack Gas

$$MW = MWD \times MD + 18 \times (1 - MD) = 28.624$$

Stack Gas Velocity at Stack Conditions

$$VS = 5129.4 \times CP \times DPS \times \text{SQRT}(TS + 460) / (PS \times MW) = 3534.6$$

Stack Gas Volumetric Flow at Standard Conditions, Dry
 $0.123 \times VS \times AS \times PS \times MD$

$$QS = \frac{\text{-----}}{TS + 460} = 12034.4$$

Stack Gas Volumetric Flow at Stack Conditions

$$QA = \frac{QS \times (TS + 460)}{17.64 \times PS \times MD} = 14111.0$$

Percent Isokinetic

$$PERI = \frac{1039 \times (TS + 460) \times VMSTD}{VS \times TT \times PS \times MD \times DN \times DN} = 103.75$$

Particulate Loading -- Probe, Cyclone, Filter
(At Standard Conditions)

$$\text{CAN} = 0.0154 * \text{FMF} / \text{VMSTD} = 0.0009$$

Particulate Loading -- Probe, Cyclone, Filter
(At Stack Conditions)

$$\text{CAT} = \frac{17.64 * \text{CAN} * \text{PS} * \text{MD}}{\text{TS} + 460} = 0.0008$$

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

$$\text{CAW} = 0.00857 * \text{CAN} * \text{QS} = 0.097$$

Method 5 Particulate Calculations Test Number 1

Johnson Controls Inc. Tampa Florida Main Grid Caster Runs 4 - 6

Volume of Dry Gas Sampled at Standard Conditions $17.64 \times VM \times (PB + PM / 13.6)$	
VMSTD = $\frac{\text{-----}}{TM + 460} =$	129.606
Volume of Water Vapor at Standard Conditions VMV = $0.04709 \times VW =$	2.825
Percent Moisture in Stack Gas $100 \times VMV$	
PMV = $\frac{\text{-----}}{VMSTD + VMV} =$	2.133
Mole Fraction of Dry Gas $100 - PMV$	
MD = $\frac{\text{-----}}{100} =$	0.9787
Average Molecular Weight of Dry Stack Gas $MWD = 0.44 \times PCO_2 + 0.32 \times PO_2 + 0.28 \times (PN_2 + PCO) =$	28.836
Molecular Weight of Stack Gas $MW = MWD \times MD + 18 \times (1 - MD) =$	28.605
Stack Gas Velocity at Stack Conditions $VS = 5129.4 \times CP \times DPS \times \text{SQRT}(TS + 460) / (PS \times MW) =$	3472.2
Stack Gas Volumetric Flow at Standard Conditions, Dry $0.123 \times VS \times AS \times PS \times MD$	
QS = $\frac{\text{-----}}{TS + 460} =$	11798.1
Stack Gas Volumetric Flow at Stack Conditions $QS \times (TS + 460)$	
QA = $\frac{\text{-----}}{17.64 \times PS \times MD} =$	13862.0
Percent Isokinetic $1039 \times (TS + 460) \times VMSTD$	
PERI = $\frac{\text{-----}}{VS \times TT \times PS \times MD \times DN \times DN} =$	104.22

Particulate Loading -- Probe, Cyclone, Filter
(At Standard Conditions)

$$\text{CAN} = 0.0154 * \text{FMF} / \text{VMSTD} =$$

0.0015

Particulate Loading -- Probe, Cyclone, Filter
(At Stack Conditions)

$$17.64 * \text{CAN} * \text{PS} * \text{MD}$$

$$\text{CAT} = \frac{\text{-----}}{\text{TS} + 460} =$$

0.0013

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

$$\text{CAW} = 0.00857 * \text{CAN} * \text{QS} =$$

0.149

METHOD 3 - ORSAT AND DRY MOLECULAR WEIGHT DETERMINATION

Plant Johnson Controls - Tampa, FLA Sample Location Main Stack
 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 09-06-88 Ambient Temp. °F 75
 Sampling Time (24 - hr clock) 1415-1720 Analysis By PRJ

Gas	Run 1		Run 2		Run 3		Avg. %	Mult.	Molecular Wt. Dry lb/lb mole
	Actual	Net	Actual	Net	Actual	Net			
CO ₂	0.1	0.1	0.1	0.1	0.1	0.1	0.10	.44	0.044
O ₂	20.8	20.7	20.8	20.7	20.8	20.7	20.70	.32	6.624
CO	20.8	0.0	20.8	0.0	20.8	0.0	0.00	.28	0.000
N ₂	100	79.2	100	79.2	100	79.2	79.20	.28	22.176
$F_s = \frac{20.9 - \%O_2}{\%CO_2} = NA$									Total 28,844

Run No. 2 Sample Date 09-07-88 Ambient Temp. °F 76
 Sampling Time (24 - hr clock) 0705-1008 Analysis By PRJ

Gas	Run 1		Run 2		Run 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
$F_s = \frac{20.9 - \%O_2}{\%CO_2} = NA$									Total 28,836

Run No. 3 Sample Date 09-07-88 Ambient Temp. °F 75
 Sampling Time (24 - hr clock) 1035-1339 Analysis By PRJ

Gas	Run 1		Run 2		Run 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
$F_s = \frac{20.9 - \%O_2}{\%CO_2} = NA$									Total 28,836

Fuel type	F _s range
Coal: Anthracite and lignite.....	1.016-1.130
Bituminous.....	1.063-1.230
Wood.....	1.000-1.120
Wood bark.....	1.003-1.130

METHOD 3 - ORSAT AND DRY MOLECULAR WEIGHT DETERMINATION

Plant Johnson Controls Tampa, FLA Sample Location Main Stack
 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 09-07-85 Ambient Temp. °F 79
 Sampling Time (24 - hr clock) 1350-1654 Analysis By PRJ

Gas	Run 1		Run 2		Run 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
$F_o = \frac{20.9 - \%O_2}{\%CO_2} = NA$									Total 28.536

Run No. 5 Sample Date 09-08-85 Ambient Temp. °F 76
 Sampling Time (24 - hr clock) 0705-1010 Analysis By PRJ

Gas	Run 1		Run 2		Run 3		Avg. %	Mult.	Molecular Wt. Dry lb/lb mole
	Actual	Net	Actual	Net	Actual	Net			
CO ₂	0.1	0.1	0.1	0.1	0.1	0.1	0.10	.44	0.044
O ₂	20.8	20.7	20.8	20.7	20.8	20.7	20.70	.32	6.624
CO	20.8	0.0	20.8	0.0	20.8	0.0	0.00	.28	0.000
N ₂	100	79.2	100	79.2	100	79.2	79.20	.28	22.176
$F_o = \frac{20.9 - \%O_2}{\%CO_2} = NA$									Total 28.844

Run No. 6 Sample Date 09-08-85 Ambient Temp. °F 78
 Sampling Time (24 - hr clock) 1015-1318 Analysis By PRJ

Gas	Run 1		Run 2		Run 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
$F_o = \frac{20.9 - \%O_2}{\%CO_2} = NA$									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

METHOD 12 SAMPLE RECOVERY AND INTEGRITY SHEET

Plant Johnson Controls, Tampa FL Recovered By RBM/PRS/JAF
 Sample Location Main Grid Stack Recovery Date 9/9/88

Run Number	<u>1</u>	<u>2</u>	<u>3</u>
Sample Date	<u>9/6/88</u>	<u>9/7/88</u>	<u>9/7/88</u>
Sample Box Number	<u>1</u>	<u>2</u>	<u>3</u>
Probe Number	<u>1</u>	<u>2</u>	<u>3</u>

MOISTURE DETERMINATION AND SAMPLE RECOVERY - IMPINGERS

Impingers Cont. Number	<u>M12 28</u>	<u>M12 29</u>	<u>M12 30</u>
Description of Water	<u>clear</u>	<u>clear</u>	<u>clear</u>
Liquid Level Marked	<u>✓</u>	<u>✓</u>	<u>✓</u>
Final Volume (wt.), ml	<u>258</u>	<u>252</u>	<u>256</u>
Initial Volume (wt.), ml	<u>200</u>	<u>200</u>	<u>200</u>
Net Volume (wt.), ml (g)	<u>58</u>	<u>52</u>	<u>56</u>

Silica Gel Cont. Number	<u>M12 28</u>	<u>M12 29</u>	<u>M12 30</u>
Silica Gel % Spent	<u>85%</u>	<u>90%</u>	<u>90%</u>
Final Weight, g	<u>231.3</u>	<u>230.3</u>	<u>230.6</u>
Initial Weight, g	<u>200.0</u>	<u>200.0</u>	<u>200.0</u>
Net Weight, g	<u>31.3</u>	<u>30.3</u>	<u>30.6</u>

Total Moisture, g	<u>89.3</u>	<u>82.3</u>	<u>86.6</u>
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SAMPLE RECOVERY - FILTER

Filter Cont. Number	<u>M12 28</u>	<u>M12 29</u>	<u>M12 30</u>
Particulate Description	<u>light grey</u>	<u>light grey</u>	<u>light grey</u>
Filter Cont. Sealed	<u>✓</u>	<u>✓</u>	<u>✓</u>

Probe Rinse Cont. Number	<u>M12 28</u>	<u>M12 29</u>	<u>M12 30</u>
Liquid Level Marked	<u>✓</u>	<u>✓</u>	<u>✓</u>

SAMPLE WEIGHT CALCULATION

Run #	Conc., mg/l	x	Vol., l	-	Blank, mg	=	Total mg Lead
1	3.586	x	0.250	-	<0.010	=	0.8865
2	4.068	x	0.250	-	<0.010	=	1.0070
3	3.494	x	0.250	-	<0.010	=	0.8635

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: PRS-RBM-JAF Date Received: 9/9/88
 Stored and Locked: ✓ Remarks: NA

METHOD 12 SAMPLE RECOVERY AND INTEGRITY SHEET

Plant Johnson Controls, Tampa Fl Recovered By RBM/PLJ/JMF
 Sample Location Main Grid Caster Stack Recovery Date 9/8/88

Run Number	<u>4</u>	<u>5</u>	<u>6</u>
Sample Date	<u>9/7/88</u>	<u>9/8/88</u>	<u>9/8/88</u>
Sample Box Number	<u>4</u>	<u>5</u>	<u>6</u>
Probe Number	<u>4</u>	<u>5</u>	<u>6</u>

MOISTURE DETERMINATION AND SAMPLE RECOVERY - IMPINGERS

Impingers Cont. Number	<u>M12 31</u>	<u>M12 32</u>	<u>M12 33</u>
Description of Water	<u>clear</u>	<u>clear</u>	<u>clear</u>
Liquid Level Marked	<u>✓</u>	<u>✓</u>	<u>✓</u>
Final Volume (wt.), ml	<u>260</u>	<u>253</u>	<u>258</u>
Initial Volume (wt.), ml	<u>200</u>	<u>200</u>	<u>200</u>
Net Volume (wt.), ml (g)	<u>60</u>	<u>53</u>	<u>58</u>

Silica Gel Cont. Number	<u>M12 31</u>	<u>M12 32</u>	<u>M12 33</u>
Silica Gel % Spent	<u>85%</u>	<u>85%</u>	<u>85%</u>
Final Weight, g	<u>226.7</u>	<u>231.0</u>	<u>230.9</u>
Initial Weight, g	<u>200.0</u>	<u>200.0</u>	<u>200.0</u>
Net Weight, g	<u>26.7</u>	<u>31.0</u>	<u>30.9</u>

Total Moisture, g	<u>86.7</u>	<u>84.0</u>	<u>88.9</u>
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SAMPLE RECOVERY - FILTER

Filter Cont. Number	<u>M12 31</u>	<u>M12 32</u>	<u>M12 33</u>
Particulate Description	<u>light grey</u>	<u>light grey</u>	<u>light grey</u>
Filter Cont. Sealed	<u>✓</u>	<u>✓</u>	<u>✓</u>

Probe Rinse Cont. Number	<u>M12 31</u>	<u>M12 32</u>	<u>M12 33</u>
Liquid Level Marked	<u>✓</u>	<u>✓</u>	<u>✓</u>

SAMPLE WEIGHT CALCULATION

Run #	Conc., mg/l	x	Vol., l	-	Blank, mg	=	Total mg Lead
1	3.214	x	0.250	-	< 0.010	=	0.7935
2	2.716	x	0.250	-	< 0.010	=	0.6690
3	4.161	x	0.250	-	< 0.010	=	1.0303

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: PLJ-RBM-JMF Date Received: 9/9/88
 Stored and Locked: ✓ Remarks: NA

METHOD 12 ATOMIC ABSORPTION DATA

MAIN GRID CASTER

RUNS 1 - 6

CALIBRATION DATA

Standard No. 1	=	<u>0.500</u>	mg/l	Absorbance	=	<u>0.031</u>
Standard No. 2	=	<u>0.250</u>	mg/l	Absorbance	=	<u>0.014</u>
Standard No. 3	=	<u>0.050</u>	mg/l	Absorbance	=	<u>0.002</u>
Standard No. 4	=	<u>1.000</u>	mg/l	Absorbance	=	<u>0.056</u>
Standard No. 5	=	<u>2.500</u>	mg/l	Absorbance	=	<u>0.141</u>
Standard No. 6	=	<u>5.000</u>	mg/l	Absorbance	=	<u>0.266</u>

SAMPLE CONCENTRATION DATA

Mean Concentration Run No. 1	=	<u>3.586</u>	mg/l
Mean Concentration Run No. 2	=	<u>4.068</u>	mg/l
Mean Concentration Run No. 3	=	<u>3.494</u>	mg/l
Mean Concentration Run No. 4	=	<u>3.214</u>	mg/l
Mean Concentration Run No. 5	=	<u>2.716</u>	mg/l
Mean Concentration Run No. 6	=	<u>4.161</u>	mg/l
Mean Concentration Run No. 1 Dup.	=	<u>3.559</u>	mg/l
Mean Concentration Filter Blk. A	=	<u><0.050</u>	mg/l
Mean Concentration Filter Blk. B	=	<u><0.050</u>	mg/l
Mean Concentration 0.10N HNO ₃	=	<u><0.050</u>	mg/l

Analyzed by PRJ Date September 16, 1988

Remarks Matrix checked with 1.000 mg/l spike

Spike recovery: 99.4%

EPA QC 386 used for calibration check: true = 0.250
obtained = 0.264

Calibration recovery: 105.6%

Duplicate Precision Check: 0.76%

METHOD 5 SAMPLE RECOVERY AND INTEGRITY SHEET

Plant Johnson Controls, Tampa FL Recovered By PRJ-JAF
 Sample Location Main Grid Caster Stack Recovery Date 9/7/88

Run Number	1	2	3
Sample Date	9/6/88	9/7/88	9/7/88
Sample Box Number	1	2	3
Probe Number	1	2	3
Filter Number	77	76	75

MOISTURE RECOVERY

Impingers Cont. Number	M12 28	M12 29	M12 30
Description of Water	clear	clear	clear
Liquid Level Marked	✓	✓	✓
Final Volume (wt.), ml	258	252	256
Initial Volume (wt.), ml	200	200	200
Net Volume (wt.), ml (g)	58	52	56
Silica Gel Cont. Number	M12 28	M12 29	M12 30
Silica Gel % Spent	85%	90%	90%
Final Weight, g	231.3	230.3	230.6
Initial Weight, g	200.0	200.0	200.0
Net Weight, g	31.3	30.3	30.6
Total Moisture, g	89.3	82.3	86.6

PARTICULATE RECOVERY

Filter Cont. Number	M12 28	M12 29	M12 30
Particulate Description	light grey	light grey	light grey
Filter Cont. Sealed	✓	✓	✓
Final Weight, mg	491.14	489.70	486.30
Final Weight Audit, mg	491.13	489.66	486.31
Initial Weight, mg	486.49	483.32	480.98
Initial Weight Audit, mg	486.55	483.38	481.05
Filter Catch, mg	4.62	6.33	5.29
Probe Rinse Cont. Number <th>M12 28</th> <th>M12 29</th> <th>M12 30</th>	M12 28	M12 29	M12 30
Liquid Level Marked	✓	✓	✓
Final Weight, mg	105319.5	105761.2	103819.3
Final Weight Audit, mg	105319.7	105761.4	103819.5
Initial Weight, mg	105316.3	105757.3	103815.6
Initial Weight Audit, mg	105316.5	105757.4	103815.6
Less Acetone Blank, mg	+0.2	+0.2	+0.2
Acetone Rinse Catch, mg	3.4	4.1	4.0
Total Particulate, mg	8.02	10.43	9.29

Acetone Blank Number	A
Final Weight, mg	106458.7
Final Weight Audit, mg	106458.6
Initial Weight, mg	106458.8
Initial Weight Audit, mg	106458.9
Acetone Residue, mg	0.2
Acetone Volume, ml	150
Concentration, mg/mg	

LABORATORY CUSTODY	
Received By:	PRJ
Date Received:	9/9/88
Stored & Locked:	✓
Remarks:	NA

METHOD 5 SAMPLE RECOVERY AND INTEGRITY SHEET

Plant Johnson Controls, Tampa Fl Recovered By ROM/PRT/JAF
 Sample Location Main Grid Cluster Stack Recovery Date 9/8/88

Run Number	<u>4</u>	<u>5</u>	<u>6</u>
Sample Date	<u>9/7/88</u>	<u>9/8/88</u>	<u>9/8/88</u>
Sample Box Number	<u>4</u>	<u>5</u>	<u>6</u>
Probe Number	<u>4</u>	<u>5</u>	<u>6</u>
Filter Number	<u>74</u>	<u>73</u>	<u>62</u>

MOISTURE RECOVERY

Impingers Cont. Number	<u>M12 31</u>	<u>M12 32</u>	<u>M12 33</u>
Description of Water	<u>clear</u>	<u>clear</u>	<u>clear</u>
Liquid Level Marked	<u>✓</u>	<u>✓</u>	<u>✓</u>
Final Volume (wt.), ml	<u>260</u>	<u>253</u>	<u>258</u>
Initial Volume (wt.), ml	<u>200</u>	<u>200</u>	<u>200</u>
Net Volume (wt.), ml (g)	<u>60</u>	<u>53</u>	<u>58</u>
Silica Gel Cont. Number	<u>M12 31</u>	<u>M12 32</u>	<u>M12 33</u>
Silica Gel % Spent	<u>85%</u>	<u>85%</u>	<u>85%</u>
Final Weight, g	<u>226.7</u>	<u>231.0</u>	<u>230.9</u>
Initial Weight, g	<u>200.0</u>	<u>200.0</u>	<u>200.0</u>
Net Weight, g	<u>26.7</u>	<u>31.0</u>	<u>30.9</u>
Total Moisture, g	<u>86.7</u>	<u>84.0</u>	<u>88.9</u>

PARTICULATE RECOVERY

Filter Cont. Number	<u>M12 31</u>	<u>M12 32</u>	<u>M12 33</u>
Particulate Description	<u>light grey</u>	<u>light grey</u>	<u>light grey</u>
Filter Cont. Sealed	<u>✓</u>	<u>✓</u>	<u>✓</u>
Final Weight, mg	<u>495.21</u>	<u>488.13</u>	<u>488.21</u>
Final Weight Audit, mg	<u>495.27</u>	<u>488.06</u>	<u>488.27</u>
Initial Weight, mg	<u>487.05</u>	<u>479.85</u>	<u>482.11</u>
Initial Weight Audit, mg	<u>487.18</u>	<u>479.84</u>	<u>482.26</u>
Filter Catch, mg	<u>8.12</u>	<u>6.19</u>	<u>6.05</u>
Probe Rinse Cont. Number	<u>M12 31</u>	<u>M12 32</u>	<u>M12 33</u>
Liquid Level Marked	<u>✓</u>	<u>✓</u>	<u>✓</u>
Final Weight, mg	<u>98077.5</u>	<u>104712.2</u>	<u>100128.6</u>
Final Weight Audit, mg	<u>98077.6</u>	<u>104712.3</u>	<u>100128.7</u>
Initial Weight, mg	<u>98073.6</u>	<u>104709.4</u>	<u>100121.3</u>
Initial Weight Audit, mg	<u>98073.4</u>	<u>104709.3</u>	<u>100121.5</u>
Less Acetone Blank, mg	<u>+0.2</u>	<u>+0.2</u>	<u>+0.2</u>
Acetone Rinse Catch, mg	<u>4.3</u>	<u>3.1</u>	<u>7.5</u>
Total Particulate, mg	<u>12.42</u>	<u>9.29</u>	<u>13.55</u>

Acetone Blank Number	<u>A</u>
Final Weight, mg	<u>106458.7</u>
Final Weight Audit, mg	<u>106458.6</u>
Initial Weight, mg	<u>106458.8</u>
Initial Weight Audit, mg	<u>106458.9</u>
Acetone Residue, mg	<u>+0.2</u>
Acetone Volume, ml	<u>150</u>
Concentration, mg/mg	

LABORATORY CUSTODY

Received By: PRT
 Date Received: 9/9/88
 Stored & Locked: ✓
 Remarks: NA

APPENDIX C

PROCESS DATA

The average input for the Main Grid Caster during the six sampling runs was 5700 pounds per hour. This data was submitted by Johnson Controls, Inc. personnel.

STATEMENT OF PROCESS WEIGHT

COMPANY NAME Johnson Controls, Inc., Globe Battery Division

ADDRESS P. O. Box 16068, Tampa, Florida 33687

SOURCE IDENTIFICATION GRID CASTING - MAIN EXHAUST STACK

SOURCE LOCATION 10215 North 30th Street, Tampa, Florida

DATE 9/1/83 SAMPLING TIME: 7:00 AM TO: 7:00 PM

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) 6000 #/hr PRODUCT (OUTPUT) 3600 #/hr

DATA ON ACTUAL PROCESS RATE DURING OPERATION CYCLE:

MATERIAL _____ RATE _____

MATERIAL _____ RATE _____

MATERIAL _____ RATE _____

TOTAL PROCESS WEIGHT RATE:

PRODUCT CAST LEAD GRIDS RATE 5700 #/hr

I certify that the above statement is true to the best of my knowledge and belief.

Signature Will Scott

Title MANAGER ENGINEERING

environmental testing inc.

APPENDIX E

THURSDAY, AUGUST 18, 1977
PART II



**ENVIRONMENTAL
PROTECTION
AGENCY**

■

**STANDARDS OF
PERFORMANCE FOR NEW
STATIONARY SOURCES**

Revision to Reference Method 1-8

**Environmental
Protection
Agency
Standards of
Performance for
New Stationary
Sources**

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 608 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 TESTS 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.

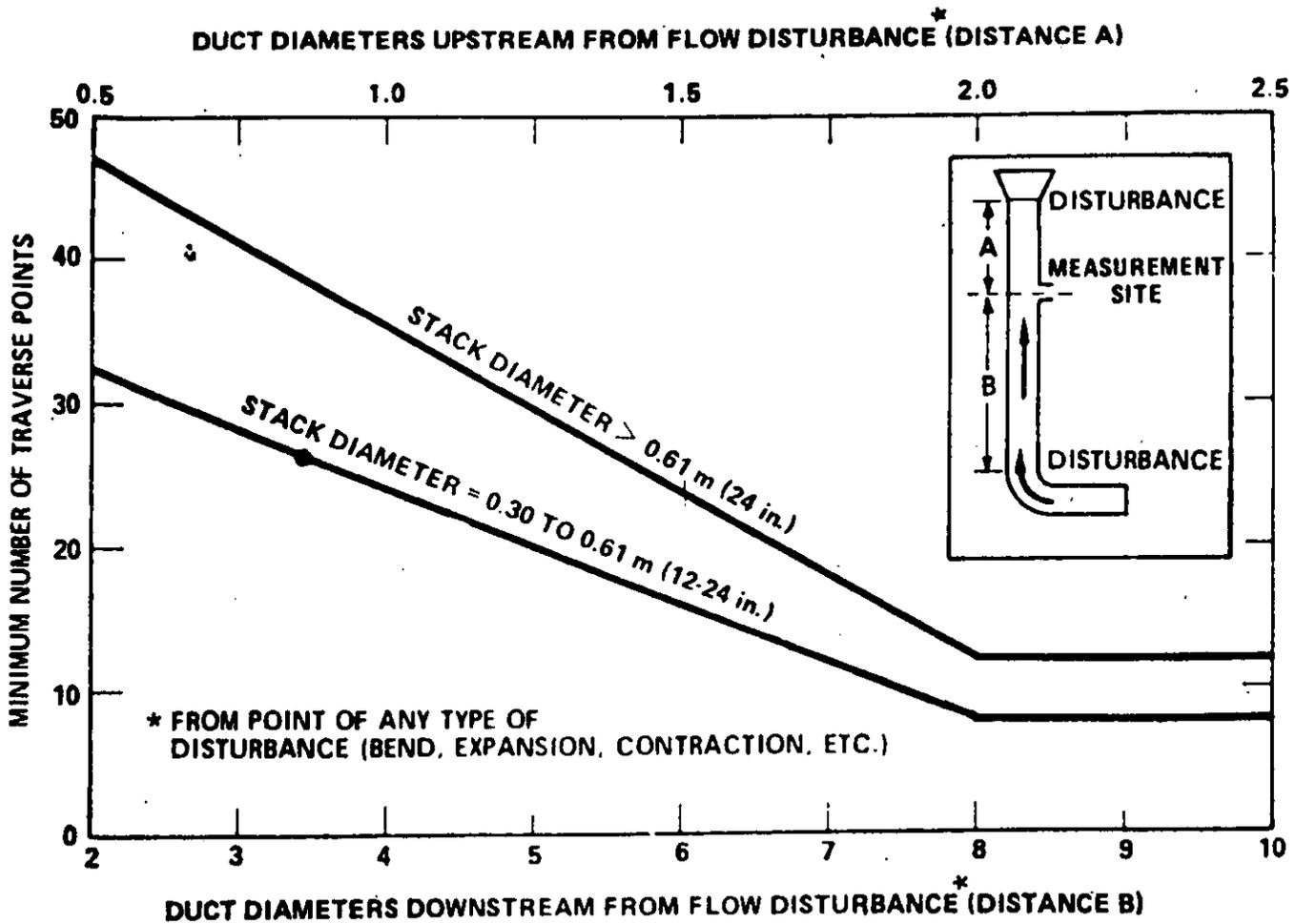
1.2 Applicability. This method is applicable to flowing gas streams in ducts, stacks, and flues. The method cannot be used when: (1) flow is cyclonic or swirling (see Section 2.4); (2) a stack is smaller than about 0.30 meter (12 in.) in diameter, or 0.071 m² (113 in.²) in cross-sectional area, or (3) 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:

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



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	Max- imum lay- out
8	3x3
12	4x3
16	4x4
20	5x4
25	5x5
36	6x6
42	7x6
48	7x7

DUCT DIAMETERS UPSTREAM FROM FLOW DISTURBANCE (DISTANCE A)

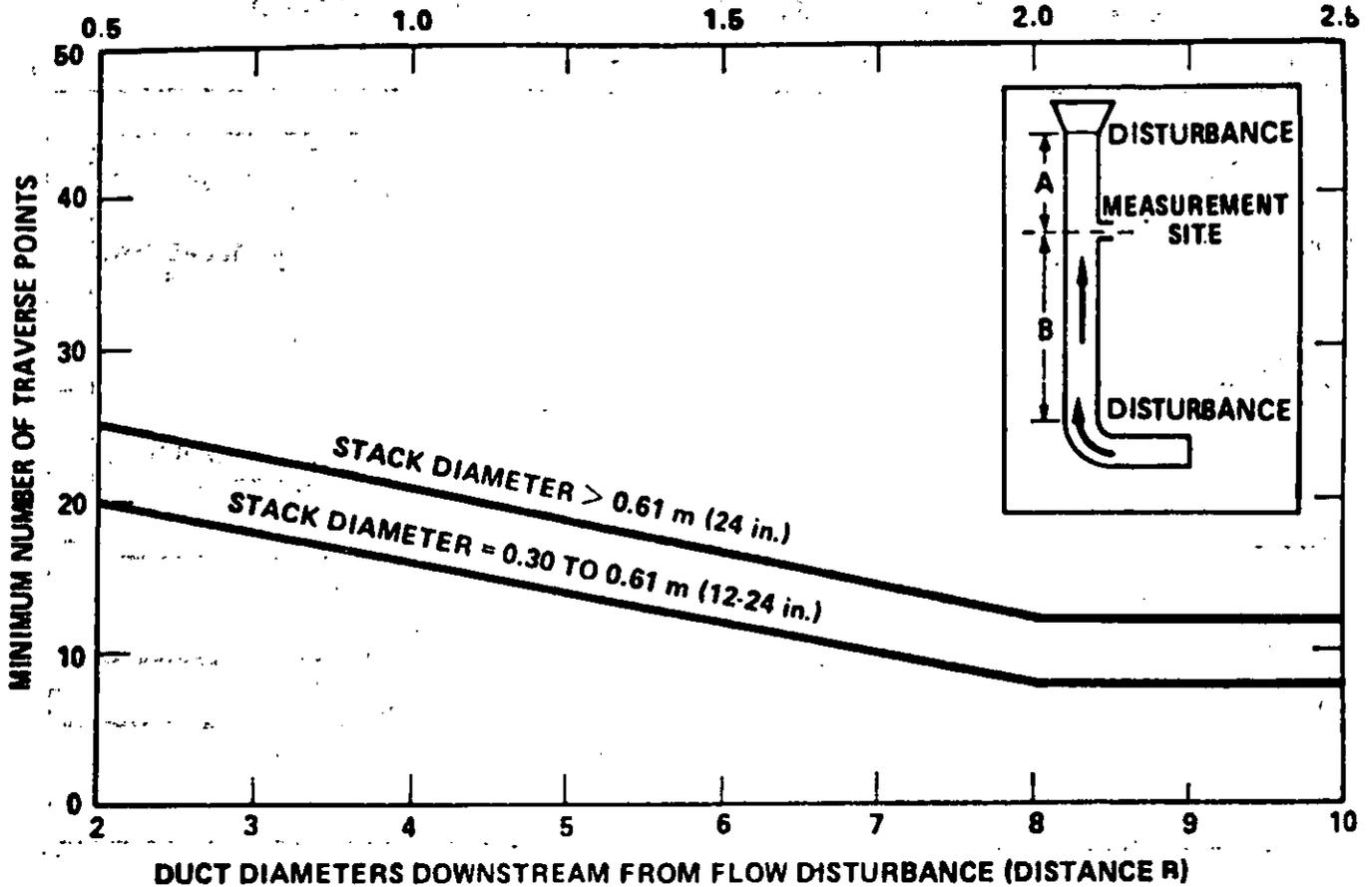


Figure 1-2. Minimum number of traverse points for velocity (nonparticulate) traverses.

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

2.3 Cross-Sectional Layout and Location of Traverse Points.

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

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

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

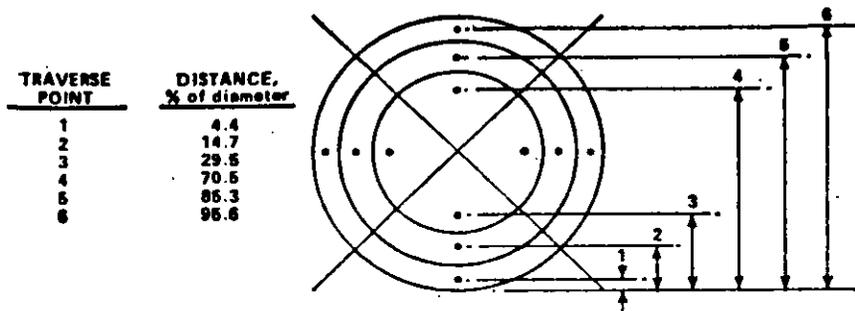


Figure 1-3. Example showing circular stack cross section divided into 12 equal areas, with location of traverse points indicated.

(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.

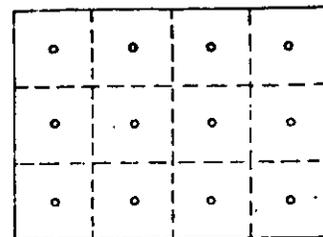


Figure 1-4. Example showing rectangular stack cross section divided into 12 equal areas, with a traverse point at centroid of each area.

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	89.4	83.9
19										96.1	91.3	86.8
20										99.7	94.0	89.5
21											96.5	92.1
22											98.9	94.5
23												96.8
24												99.9

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

2.4 Verification of Absence of Cyclonic Flow In most stationary sources, the direction of stack gas flow is essentially parallel to the stack walls. However, cyclonic flow may exist (1) after such devices as cyclones and inertial demisters following venturi scrubbers, or

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 a 40° 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

1. Determining Dust Concentration in a Gas Stream. ASME, Performance Test Code No. 27, New York, 1977.
2. Devorkin, Howard, et al. Air Pollution Source Testing Manual. Air Pollution Control District, Los Angeles, CA, November 1963.
3. Methods for Determination of Velocity, Volume, Moist and Moist Content of Gases, Western Precipitation Division of Joy Manufacturing Co., Los Angeles, CA, Bulletin WP-50, 1968.
4. Standard Method for Sampling Stacks for Particulate Matter. In: 1971 Book of ASTM Standards, Part 23, ASTM Designation D-2228-71, Philadelphia, Pa., 1971.
5. Hanson, H. A., et al. Particulate Sampling Strategies for Large Power Plants Including Nonuniform Flow. USEPA, ORL, ESRL, Research Triangle Park, N.C., EPA-600/2-76-170, June 1976.
6. Entropy Environmentalists, Inc. Determination of the Optimum Number of Sampling Points: An Analysis of Method 1 Criteria. Environmental Protection Agency, Research Triangle Park, N.C., EPA Contract No. 68-01-3172, Task 7.

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

1. Principle and Applicability

1.1 Principle. The average gas velocity in a stack is determined from the gas density and from measurement of the average velocity head with a Type S (unshielded 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.

3.6 Determine the stack gas dry molecular weight. For combustion processes or processes that emit essentially CO_2 , O_2 , CO , and N_2 , use Method 2. For processes emitting essentially air, an analysis need not be conducted; use a dry molecular weight of 28.8. For other processes, other methods, subject to the approval of the Administrator, must be used.

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

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

4. Calibration

4.1 Type 8 Pitot Tube. Before its initial use, carefully examine the Type 8 pitot tube in top, side, and end views to verify that the face openings of the tube are aligned within the specifications illustrated in Figures 2-6 or 2-7. 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 distance (dimension P_1 and P_2 , Figure 2-2b). If D_t is between 0.48 and 0.95 cm ($3/16$ and $3/8$ in.) and if P_1 and P_2 are equal and between 1.08 and 1.50 cm, 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_1 , and P_2 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 8 Pitot Tube Assemblies. During sample and velocity traverses, the isolated Type 8 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 8 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 8 pitot tubes having external tubing diameters between 0.48 and 0.95 cm ($3/16$ and $3/8$ in.). Type 8 pitot tube assemblies that fail to meet any or all of the specifications of Figures 2-4 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 inter-component spacings (pitot-nozzle, pitot-thermocouple, pitot-probe sheath) shall be measured and recorded.

Note.—Do not use any Type 8 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 8 pitot tube is to be calibrated, one leg of the tube shall be permanently marked A, and the other, J. Calibration shall be done in a flow system having the following essential design features:

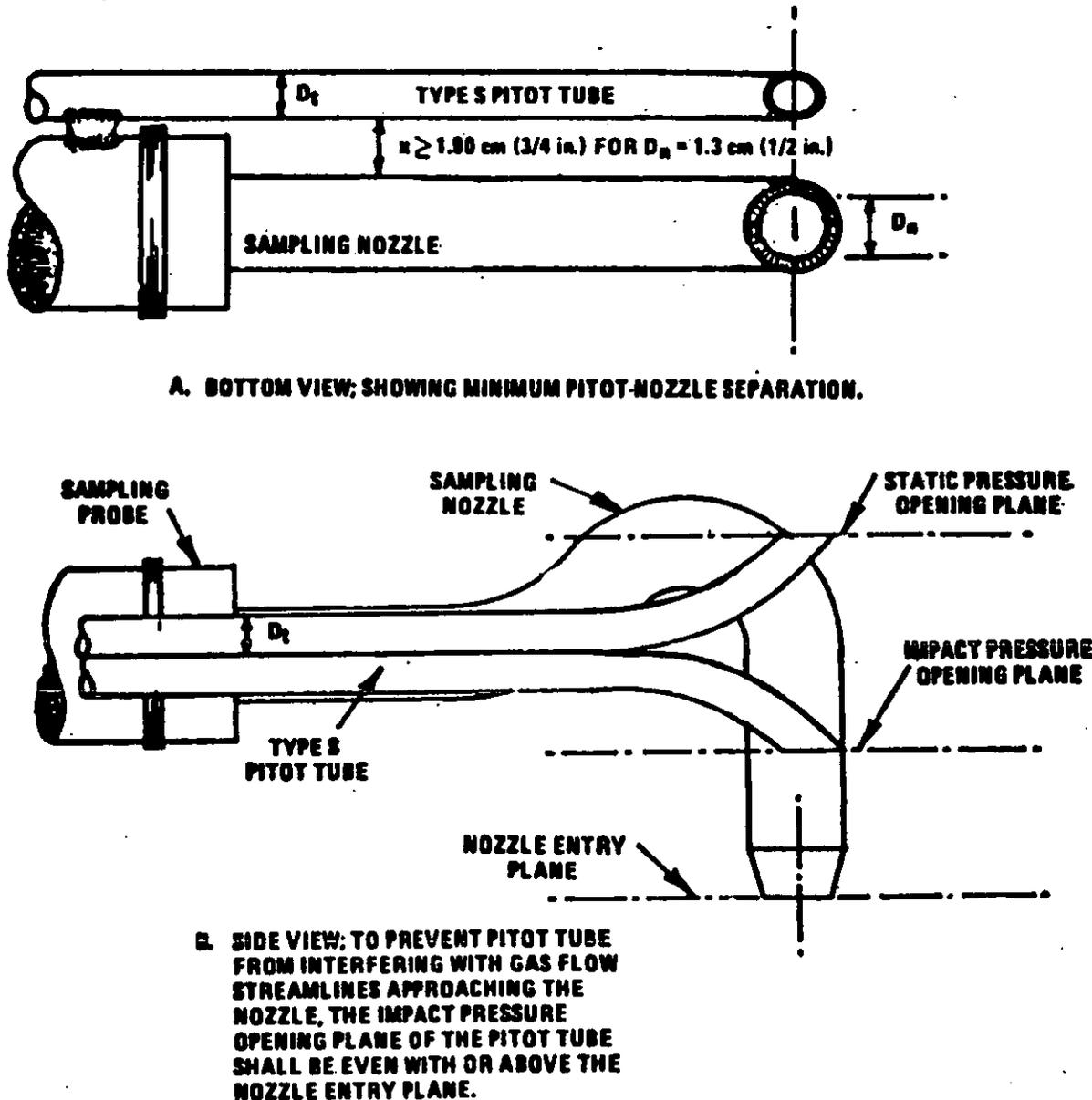


Figure 2-6. Proper pitot tube - sampling nozzle configuration to prevent aerodynamic interference; buttonhook - type nozzle; centers of nozzle and pitot opening aligned; D_t between 0.48 and 0.95 cm ($3/16$ and $3/8$ in.).

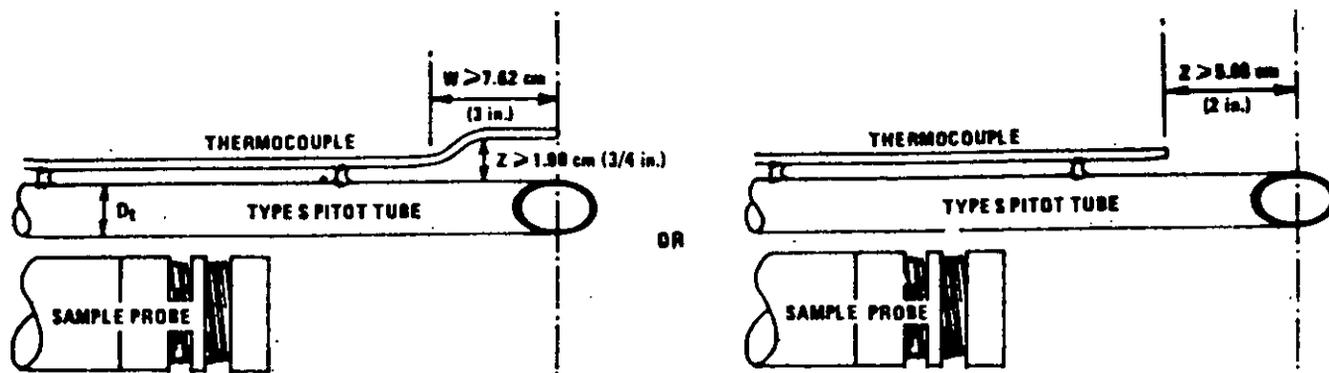


Figure 2-7. Proper thermocouple placement to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

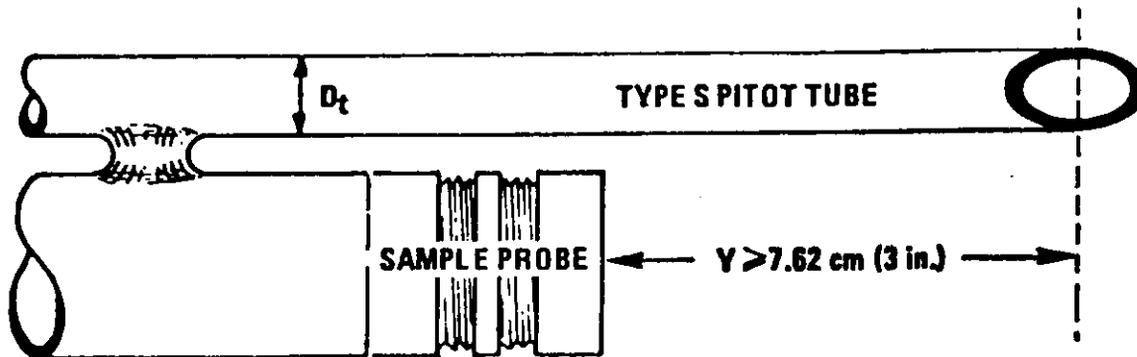


Figure 2-8. Minimum pitot-sample probe separation needed to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

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

f/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 f/min) will generally be valid to within ± 3 percent for the measurement of velocities above 305 m/min (1,000 f/min) and to within ± 6 to 8 percent for the measurement of velocities between 180 and 305 m/min (600 and 1,000 f/min). If a more precise correlation between C_p and velocity is desired, the flow system shall have the capacity to generate at least four distinct, time-invariant test-section velocities covering the velocity range from 180 to 1,525 m/min (600 to 5,000 f/min), and calibration data shall be taken at regular velocity intervals over this range (see Citations 9 and 14 in Section 6 for details).

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

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

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

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

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

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

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

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

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

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

4.1.3.9 Perform calculations, as described in Section 4.1.4 below.

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

PITOT TUBE IDENTIFICATION NUMBER: _____ DATE: _____
 CALIBRATED BY: _____

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

$$\text{AVERAGE DEVIATION} = \sigma \text{ (A OR B)} = \frac{1}{3} \sum |C_{p(s)} - \bar{C}_p \text{ (A OR B)}| \leftarrow \text{MUST BE } < 0.01$$

$$|\bar{C}_p \text{ (SIDE A)} - \bar{C}_p \text{ (SIDE B)}| \leftarrow \text{MUST BE } < 0.01$$

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 8 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 H₂O (in. H₂O)

Δp_s = Velocity head measured by the Type 8 pitot tube, cm H₂O (in. H₂O)

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:

$$\sigma \text{ (Side A or B)} = \frac{\sum |C_{p(s)} - \bar{C}_p \text{ (A or B)}|}{3}$$

Equation 2-4

4.1.4.5 Use the Type 8 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.

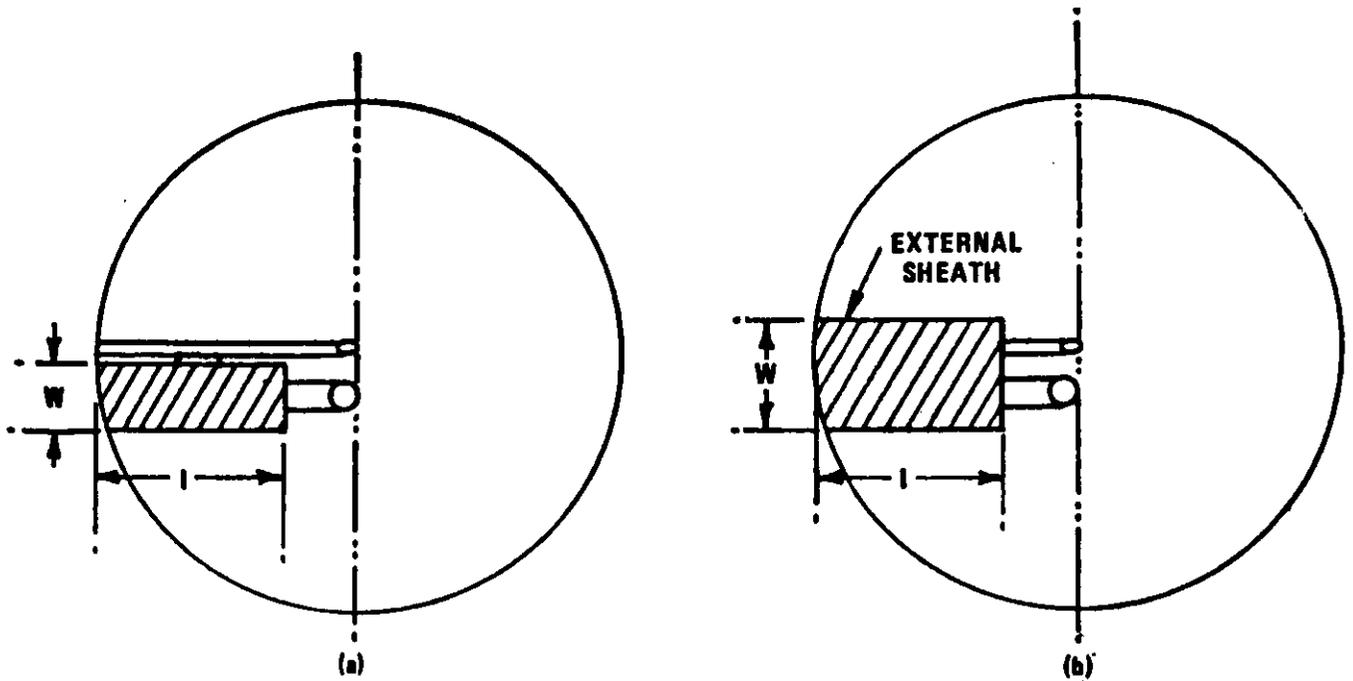
4.1.5.1.1 When an isolated Type 8 pitot tube is calibrated, select a calibration point at or near the center of the duct, and follow the procedures outlined in Sections 4.1.3 and 4.1.4 above. The Type 8 pitot coefficients so obtained, i.e., \bar{C}_p (side A) and \bar{C}_p (side B), will be valid, so 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 2-8 through 2-8).

4.1.5.1.2 For Type 8 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 2-6).

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 1/4 in.) are not ordinarily used for isokinetic sampling at velocities around 915 m/min (3,000 ft/min), which is the calibration velocity; note also that it is not necessary to draw an isokinetic sample during calibration (see Citation 19 in Section 6).

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



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

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

4.1.6 Field Use and Recalibration.
4.1.6.1 Field Use.

4.1.6.1.1 When a Type 8 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 8 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 C_p . Consult Citation 9 in Section 6 for details. Conventional pitot-sampling probe assemblies are not recommended for use in ducts having inside diameters smaller than 12 inches (Citation 16 in Section 6).

4.1.6.2 Recalibration.

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

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

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

the tube shall be in an interference-free arrangement (subject to the approval of the Administrator).

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

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

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

5. Calculations

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

5.1 Nomenclature.

- A = Cross-sectional area of stack, m² (ft²).
- B_w = Water vapor in the gas stream (from Method 5 or Reference Method 4), proportion by volume.
- C_p = Pitot tube coefficient, dimensionless.
- K_p = Pitot tube constant.

$$34.97 \frac{\text{m}}{\text{sec}} \left[\frac{(\rho/\text{mol}) (\text{mm Hg})}{(^{\circ}\text{K}) (\text{mm H}_2\text{O})} \right]^{1/2}$$

for the metric system and

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

for the English system.

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

$$= M_d (1 - B_w) + 18.0 B_w \quad \text{Equation 2-5}$$

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

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

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

$$= P_{bar} + P_s \quad \text{Equation 2-6}$$

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 (dacf/hr).

t = Stack temperature, °C (°F).

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

$$= 273 + t, \text{ for metric} \quad \text{Equation 2-7}$$

$$= 460 + t, \text{ for English} \quad \text{Equation 2-8}$$

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

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

Δp = Velocity head of stack gas, mm H₂O (in. H₂O).

3,600 = Conversion factor, sec/hr.

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

5.2 Average stack gas velocity.

$$v_s = K_p C_p (\sqrt{\Delta p})_{ave} \sqrt{\frac{T_s(ave)}{P_s M_s}}$$

$$\text{Equation 2-9}$$

5.3 Average stack gas dry volumetric flow rate.

$$Q_{sd} = 3,600 (1 - B_w) v_s A \left(\frac{T_{std}}{T_s(ave)} \right) \left(\frac{P_s}{P_{std}} \right) \quad \text{Equation 2-10}$$

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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 analysed for percent carbon dioxide (CO₂), percent oxygen (O₂), and, if necessary, percent carbon monoxide (CO). If a dry molecular weight determination is to be made, either an Orsat or a Fyrite¹ 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 CO₂ and O₂ 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 CO₂, O₂, CO, and nitrogen (N₂) 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 analyse individual grab samples obtained at each point; (2) a method using CO₂ or O₂ and stoichiometric calculations to determine dry molecular weight and excess air; (3) assigning a value of 28.0 for dry molecular weight, in lieu of actual measurements, for processes burning natural gas, coal, or oil. These methods and modifications may be used, but are subject to the approval of the Administrator.

2. Apparatus

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

2.1 Grab Sampling (Figure 3-1).

2.1.1 Probe. The probe should be made of stainless steel or borosilicate glass tubing and should be equipped with an in-stack or out-stack filter to remove particulate matter (a plug of glass wool is satisfactory for this purpose). Any other material inert to O₂, CO₂, CO, and N₂ 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 O₂, CO₂, CO, and N₂ 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 85 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 H₂O (2 to 4 in. H₂O). 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 H₂O (2 to 4 in. H₂O) 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 CO₂ (less than 4.0 percent) or high O₂ (greater than 15.0 percent) concentrations, the measuring burette of the Orsat must have at least 0.1 percent subdivisions.

3. Dry Molecular Weight Determination

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

3.1 Single-Point, Grab Sampling and Analytical Procedure.

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

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

3.1.3 Place the probe in the stack, with the tip of the probe positioned at the sampling point; purge the sampling line. Draw a sample into the analyzer and immediately analyze it for percent CO₂ and percent O₂. Determine the percentage of the gas that is N₂ and CO by subtracting the sum of the percent CO₂ and percent O₂ 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 fine gas sample during each pollutant emission rate determination. Within 8 hours after the sample is taken, analyze it for percent CO₂ and percent O₂ 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 N₂ and CO by subtracting the sum of the percent CO₂ and percent O₂

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 3-2.

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 CO₂ and percent O₂ are measured, the analytical results of any of the three procedures given below may also be used for calculating the dry molecular weight.

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

4.1 Single-Point, Grab Sampling and Analytical Procedure.

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

4.1.2 Set up the equipment as shown in Figure 3-1, making sure all connections ahead of the analyzer are tight and leak-free. Leak-check the Orsat analyzer according to the procedure described in Section 5. This leak-check is mandatory.

TIME	TRAVERSE PT.	Q lpm	% DEV. ^a
AVERAGE			

$$^a \% DEV = \left(\frac{Q - Q_{avg}}{Q_{avg}} \right) 100 \quad (\text{MUST BE } \leq 10\%)$$

Figure 3-3. Sampling rate data.

4.1.3 Place the probe in the stack, with the tip of the probe positioned at the sampling point; purge the sampling line. Draw a sample into the analyzer. For emission rate correction factor determination, immediately analyze the sample, as outlined in Sections 4.1.4 and 4.1.5, for percent CO₂ or percent O₂. 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 CO₂, O₂, and CO; (2) determine the percentage of the gas that is N₂ by subtracting the sum of the percent CO₂, percent O₂, 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 CO₂, O₂, 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 CO₂ or O₂ is required, it is recommended that both CO₂ and O₂ 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 fine 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 CO₂ or percent O₂ (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 CO₂, O₂, and CO; (2) determine the percentage of the gas that is N₂ by subtracting the sum of the percent CO₂, percent O₂, and percent CO from 100 percent; (3) calculate percent excess air, as outlined in Section 6.2.

4.2.5 To ensure complete absorption of the CO₂, O₂, 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 CO₂, repeat the analytical procedure until the results of any three analyses differ by no more than (a) 0.3 percent by volume when CO₂ is greater than 4.0 percent or (b) 0.2 percent by volume when CO₂ is less than or equal to 4.0 percent. Average the three acceptable values of percent CO₂ and report the results to the nearest 0.1 percent.

4.2.6.2 For percent O₂, repeat the analytical procedure until the results of any three analyses differ by no more

than (a) 0.1 percent by volume when O₂ is less than 15.0 percent or (b) 0.2 percent by volume when O₂ is greater than 15.0 percent. Average the three acceptable values of percent O₂ 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 CO₂ or O₂ is required, it is recommended that both CO₂ and O₂ 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 fine gas sample is introduced into it. The procedure on 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.

%CO₂ = Percent CO₂ by volume (dry basis).

%O₂ = Percent O₂ by volume (dry basis).

%CO = Percent CO by volume (dry basis).

%N₂ = Percent N₂ by volume (dry basis).

0.284 = Ratio of O₂ to N₂ in air, v/v.

0.280 = Molecular weight of N₂ or CO, divided by 100.

0.320 = Molecular weight of O₂ divided by 100.

0.440 = Molecular weight of CO₂ divided by 100.

6.2 Percent Excess Air. Calculate the percent excess air (if applicable), by substituting the appropriate values of percent O₂, CO, and N₂ (obtained from Section 4.1.3 or 4.2.4) into Equation 3-1.

$$\%EA = \left[\frac{\%O_2 - 0.5\%CO}{0.264\%N_2 - \frac{0.5\%CO}{0.284} + 0.5\%CO} \right] 100$$

Equation 3-1

Note.—The equation above assumes that ambient air is used as the source of O₂ and that the fuel does not contain appreciable amounts of N₂ (as do coke oven or blast furnace gases). For those cases when appreciable amounts of N₂ are present (coal, oil, and natural gas do not contain appreciable amounts of N₂) 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

$$M_D = 0.150(\%CO) + 0.320(\%O_2) + 0.280(\%N_2 + \%CO)$$

Equation 3-2

Note.—The above equation does not consider argon in air (about 0.9 percent, molecular weight of 39.7). 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. This 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 H₂O 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.

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.

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.

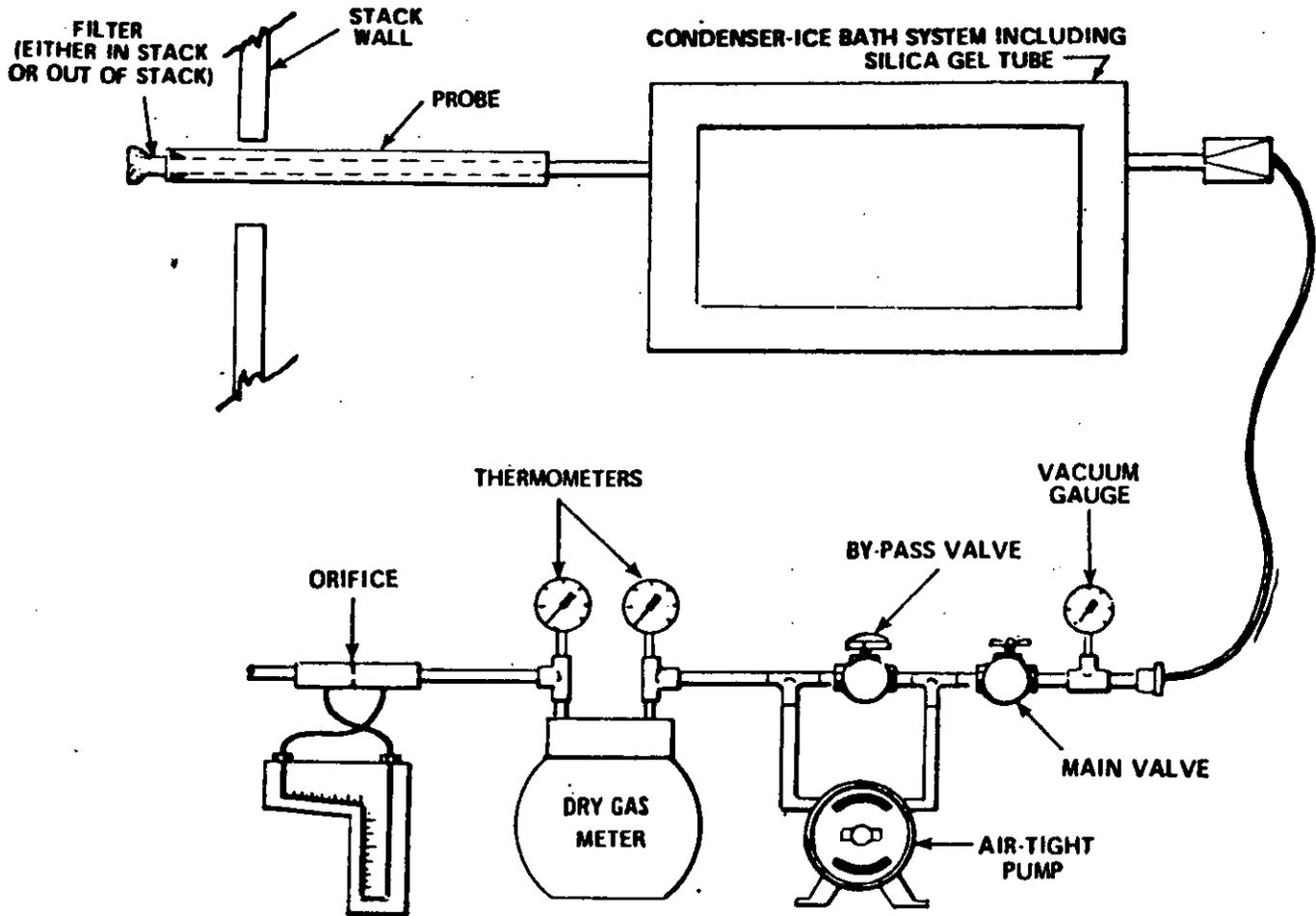


Figure 4-1. Moisture sampling train-reference method.

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 ($\frac{1}{2}$ inch) ID glass tube extending to about 1.3 cm ($\frac{1}{2}$ inch) 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 Balances.** 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 de-

scribed 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 $0.021\text{ m}^3/\text{min}$ (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

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

Figure 4-3. Analytical data - reference method.

2.3.1 Nomenclature.

- B_{sat} - 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, 0.08206 (mm Hg) (m³)/ (g-mole) (°K) for metric units and 21.85 (in. Hg) (ft³/lb-mole) (°K) for English units.
- T_m - Absolute temperature of meter, °K (°R).
- T_{std} - Standard absolute temperature, 293° K (528° R).
- V_m - Dry gas volume measured by dry gas meter, dem (scf).
- ΔV_m - Incremental dry gas volume measured by dry gas meter at each traverse point, dem (scf).
- $V_{m(tot)}$ - Dry gas volume measured by the dry gas meter, corrected to standard conditions, dem (scf).
- $V_{w(tot)}$ - Volume of water vapor condensed corrected to standard conditions, scm (scd).
- $V_{s(tot)}$ - Volume of water vapor collected in silica gel corrected to standard conditions, scm (scd).
- V_c - 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 (0.07220 lb/ml).

2.3.2 Volume of water vapor condensed.

$$V_{w(tot)} = \frac{(V_f - V_i) \rho_w R T_{std}}{P_{std} M_w} = K_1 (V_f - V_i) \quad \text{Equation 4-1}$$

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

2.3.3 Volume of water vapor collected in silica gel.

$$V_{s(tot)} = \frac{(W_f - W_i) R T_{std}}{P_{std} M_w} = K_2 (W_f - W_i) \quad \text{Equation 4-2}$$

where:
 $K_2 = 0.001333$ m³/g for metric units
 $= 0.04718$ ft³/g for English units

2.3.4 Sample gas volume.

$$V_m(tot) = V_m Y \frac{(P_m)(T_{std})}{(P_{std})(T_m)} = K_3 Y \frac{V_m P_m}{T_m} \quad \text{Equation 4-3}$$

where:
 $K_3 = 0.386$ °K/mm Hg for metric units
 $= 17.64$ °R/in. Hg for English units

NOTE - If the post-test leak rate (Section 2.2.0) 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.

$$B_{sat} = \frac{V_{w(tot)} + V_{s(tot)}}{V_{m(tot)} + V_{w(tot)} + V_{s(tot)}} \quad \text{Equation 4-4}$$

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_{sat} 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 rate from 0 to 3 lpm (0 to 0.11 cfm).

3.1.9 Graduated Cylinder, 25 ml.

3.1.10 Barometer. Mercury, aneroid, or other barometer, as described in Section 2.1.5 above.

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

3.2 Procedure.

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

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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 4-3.

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.

- $H_{w,v}$ = Approximate proportion, by volume, of water vapor in the gas stream leaving the second impinger, 0.025.
- $H_{w,l}$ = 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, 0.10236 (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, dscf.
- $V_{m(std)}$ = 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, acm (scf).
- ρ_w = Density of water, 0.002201 g/ml (0.002201 lb/ml).

3.3.2 Volume of water vapor collected.

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

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/min Hg for metric units
= 17.64 °R/in. Hg for English units

3.3.4 Approximate moisture content.

$$B_{w,v} = \frac{V_{w,v}}{V_{w,v} + V_{m(std)}} + B_{w,m} = \frac{V_{w,v}}{V_{w,v} + V_m} + (0.025)$$

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.

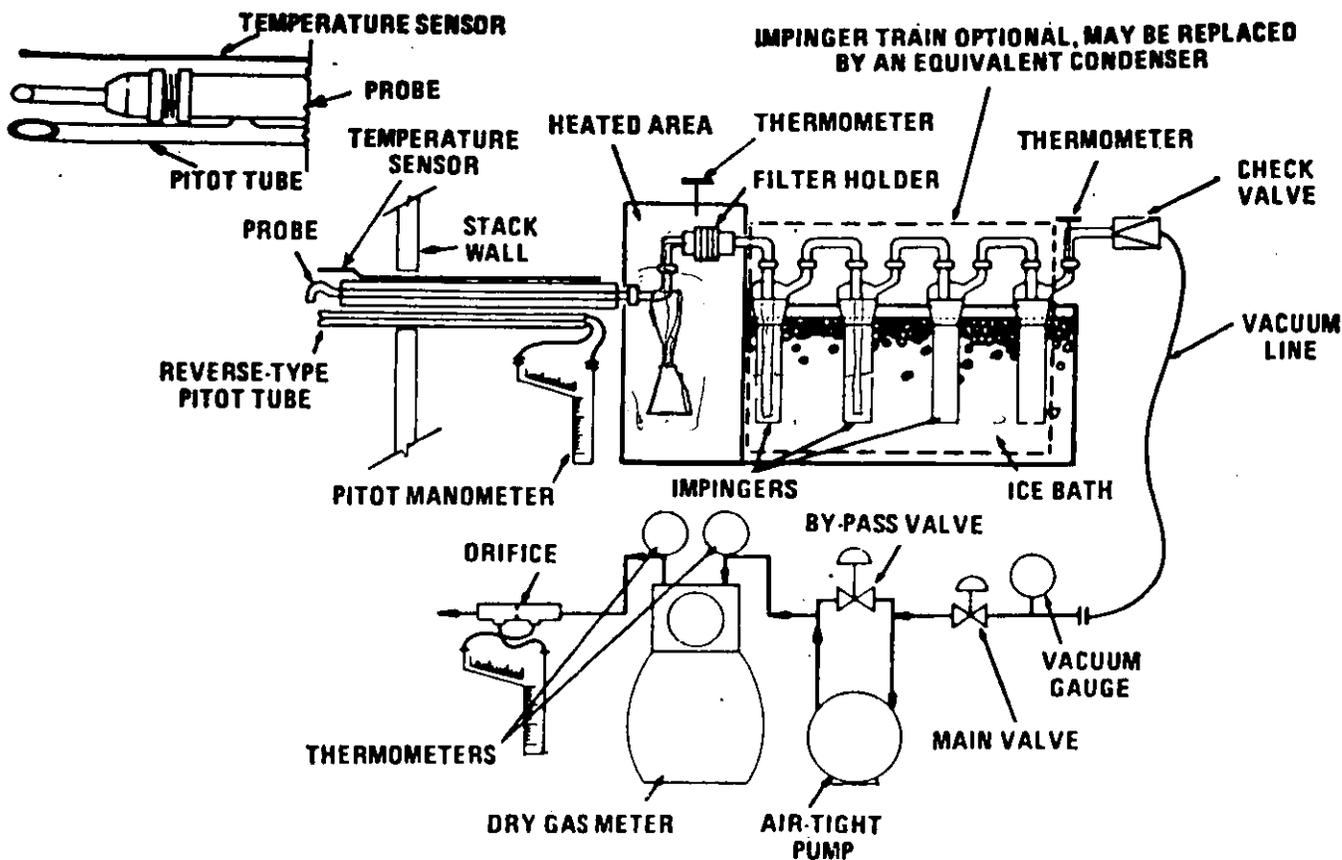


Figure 5-1. Particulate-sampling train.

2.1.1 Probe Nozzle. Stainless steel (316) or glass with sharp, tapered leading edge. The angle of taper shall be $\leq 60^\circ$ 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 ($\frac{1}{8}$ to $\frac{1}{2}$ in.)—or larger if higher volume sampling trains are used—inside diameter (ID) nozzles in increments of 0.16 cm ($\frac{1}{16}$ 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 $120 \pm 14^\circ\text{C}$ ($248 \pm 25^\circ\text{F}$), 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 $1,650^\circ\text{F}$). 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 ($1,508^\circ\text{F}$), and for quartz it is $1,500^\circ\text{C}$ ($2,732^\circ\text{F}$).

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, or other corrosion resistant metals) made of seamless tubing may be used, subject to the approval of the Administrator.

2.1.3 Pitot Tubes. Type B, 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 B 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 $120 \pm 14^\circ\text{C}$ ($248 \pm 25^\circ\text{F}$), 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 ($\frac{1}{2}$ in.) ID glass tube extending to about 1.3 cm ($\frac{1}{2}$ 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 measur-

ing 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

* 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 difference 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 B 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 in 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 polyethylene, 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 2960-71. 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 (345°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 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 tweezers 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 200°C (500°F) and an asbestos string gasket when temperatures are higher. See APTD-0576 for

details. Other connecting systems using either 316 stain less 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 temperature. Allow time for the temperature 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 procedure 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 change in flow rates are made, before and after each leak check, and when sampling is halted.

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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:

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

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

3. Rinse the probe liner with acetone by filling 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 4.1.

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

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

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

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

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

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

Plant _____
 Date _____
 Run No. _____
 Filter No. _____
 Amount liquid lost during transport _____
 Acetone blank volume, ml _____
 Acetone wash volume, ml _____
 Acetone blank concentration, mg/mg (equation 5-4) _____
 Acetone wash blank, mg (equation 5-5) _____

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

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

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

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

Figure 5-3. Analytical data.

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

Container No. 2. Note the level of liquid in the container and confirm on the analysis sheet whether or not leakage occurred during transport. If a noticeable amount of leakage has occurred, either void the sample or use methods, subject to the approval of the Administrator, to correct the final results. Measure the liquid in this container either volumetrically to ±1 ml or gravimetrically to ±0.5 g. Transfer the contents to a tared 250-ml beaker and evaporate to dryness at ambient temperature and pressure. Desiccate for 24 hours and weigh to a constant weight. Report the results to the nearest 0.1 mg.

Container No. 3. Weigh the spent silica gel (or silica gel plus impinger) to the nearest 0.5 g using a balance. This step may be conducted in the field.

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

Note.—At the option of the tester, the contents of Container No. 2 as well as the acetone blank container may be evaporated at temperatures higher than ambient. If evaporation is done at an elevated temperature, the temperature must be below the boiling point of the solvent; also, to prevent "bumping," the evaporation process must be closely supervised, and the contents of the beaker must be stirred 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 B 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-4176. 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-0578 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.

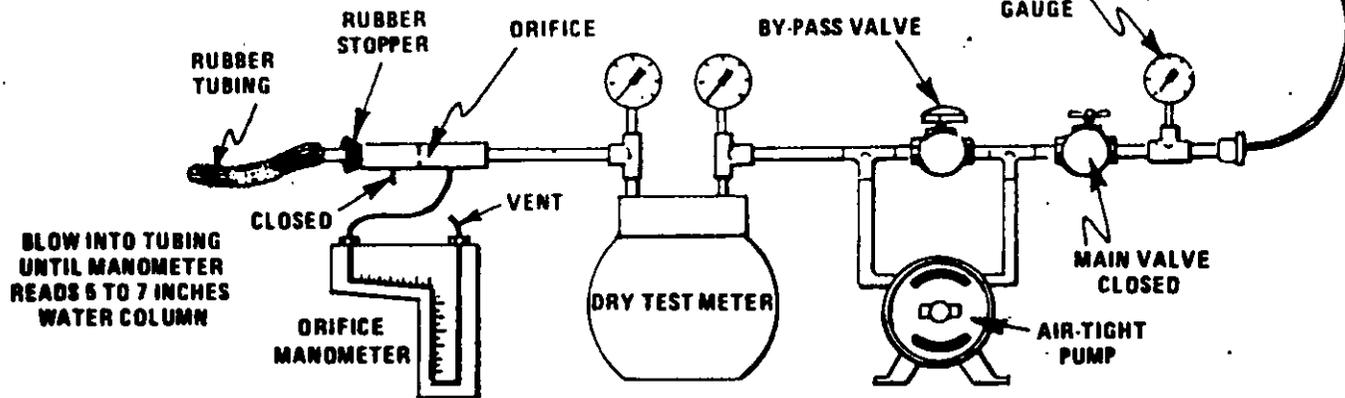


Figure 5-4. Leak check of meter box.

6.1 Nomenclature

- A_c = Cross-sectional area of nozzle, m² (ft²).
- B_w = Water vapor in the gas stream, proportion by volume.
- C_a = Acetone blank residue concentrations, mg/g.
- C_p = 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" 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_p = 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_{wa} = Volume of acetone used in wash, ml.
- V_l = 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 3, 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 H₂O (in. H₂O).
- 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.

- θ₁ = Sampling time interval, from the beginning of a run until the first component change, min.
- θ₂ = Sampling time interval, between two successive component changes, beginning with the interval between the first and second changes, min.
- θ_n = Sampling time interval, from the final (nth) 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:
 $m = 0.0024 \text{ }^\circ\text{K/mm Hg}$ for metric units
 $= 17.64 \text{ }^\circ\text{R/in. Hg}$ 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_0 . If L_1 or L_2 exceeds L_0 , 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:

$$V_m = (L_1 - L_0)\theta$$

(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:

$$\left[V_m - (L_1 - L_0)\theta_1 - \sum_{i=2}^n (L_i - L_0)\theta_i - (L_p - L_0)\theta_p \right]$$

and substitute only for those leakage rates (L_i or L_p) which exceed L_0 .

6.4 Volume of water vapor.

Equation 5-2

$$V_{w(\text{std})} = V_{10} \left(\frac{p_w}{M_w} \right) \left(\frac{RT_{\text{std}}}{P_{\text{std}}} \right) = K_2 V_{10}$$

where:
 $K_2 = 0.001333 \text{ m}^3/\text{ml}$ for metric units
 $= 0.04707 \text{ ft}^3/\text{ml}$ for English units.

6.5 Moisture Content.

$$B_{w,s} = \frac{V_{w(\text{std})}}{V_{m(\text{std})} + V_{w(\text{std})}}$$

Equation 5-3

$$I = \frac{100 T_s [K_1 V_{10} + (V_m/T_m) (P_{\text{bar}} + \Delta H/13.6)]}{60 \theta v_s P_s A_s}$$

Equation 5-7

where:
 $K_1 = 0.00344 \text{ mm Hg} \cdot \text{m}^3/\text{ml} \cdot \text{ }^\circ\text{K}$ for metric units
 $= 0.002659 \text{ in. Hg} \cdot \text{ft}^3/\text{ml} \cdot \text{ }^\circ\text{R}$ for English units.

6.11.2 Calculation From Intermediate Values.

$$I = \frac{T_s V_m (v_w) P_{\text{std}} 100}{T_{\text{std}} v_s \theta A_s P_s 60 (1 - B_{w,s})}$$

$$= K_3 \frac{T_s V_m (v_w)}{P_s V_s A_s \theta (1 - B_{w,s})}$$

Equation 5-8

where:
 $K_3 = 4.320$ for metric units
 $= 0.09450$ for English units.

6.12 Acceptable Results. If 90 percent $< I < 110$ 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

1. Addendum to Specifications for Incinerator Testing at Federal Facilities. PHS, NCAFC, Dec. 6, 1967.
2. Martin, Robert M. Construction Details of Isokinetic Source-Sampling Equipment. Environmental Protection Agency, Research Triangle Park, N.C. APTD-0581, April, 1971.
3. Rom, Jerome J. Maintenance, Calibration, and Operation of Isokinetic Source Sampling Equipment. Environmental Protection Agency, Research Triangle Park, N.C. APTD-0576, March, 1972.
4. Smith, W. S., R. T. Shigehara, and W. F. Todd. A Method of Interpreting Stack Sampling Data. Paper Presented at the 63d Annual Meeting of the Air Pollution Control Association, St. Louis, Mo. June 14-19, 1970.
5. Smith, W. S., et al. Stack Gas Sampling Improved and Simplified With New Equipment. AFCA Paper No. 67-119, 1967.
6. Specifications for Incinerator Testing at Federal Facilities. PHS, NCAFC, 1967.
7. Shigehara, R. T. Adjustments in the EPA Nomenclature for Different Pitot Tube Coefficients and Dry Molecular Weights. Stack Sampling News #4-11, October, 1974.

Note.—In saturated or water droplet-laden gas streams, two calculations of the moisture content of the stack gas shall be made, one from the impinger analysis (Equation 5-3), and a second from the assumption of saturated conditions. The lower of the two values of $B_{w,s}$ shall be considered correct. The procedure for determining the moisture content based upon assumption of saturated conditions is given in the Note of Section 1.3 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 $\pm 1^\circ\text{C}$ (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.

$$c_p = (0.001 \text{ g/mg}) (m_p/V_{m(\text{std})})$$

Equation 5-6

6.10 Conversion Factors:

From	To	Multiply by
ml	m ³	0.02832
g/l ³	gr/ft ³	15.43
g/l ³	lb/ft ³	2.206 × 10 ⁻³
g/l ³	g/m ³	35.31

6.11 Isokinetic Variation.

6.11.1 Calculation From Raw Data.

8. Vollaro, R. F. A Survey of Commercially Available Instrumentation For the Measurement of Low-Range Gas Velocities. U.S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, N.C. November, 1976 (unpublished paper).

9. Annual Book of ASTM Standards, Part 26, Gaseous Fuels; Coal and Coke; Atmospheric Analysis. American Society for Testing and Materials, Philadelphia, Pa. 1974, pp. 617-622.

METHOD 5—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 SO₂/m³ (2.12 × 10⁻⁷ lb/ft³). Although no upper limit has been established, tests have shown that concentrations as high as 80,000 mg/m³ of SO₂ can be collected efficiently in two midjet 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 65,300 mg/m³.

Possible interferences 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 SO₂ analysis. When samples are being taken from a gas stream with high concentrations of very fine metallic fumes (such as 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 interferences.

Free ammonia interferences by reacting with SO₂ to form particulate sulfate 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

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:

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 1978. 350 p.

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

9. Entropy Environmentalists, Inc. Traverse Point Study. EPA Contract No. 68-02-3172. June 1977. 19 p.

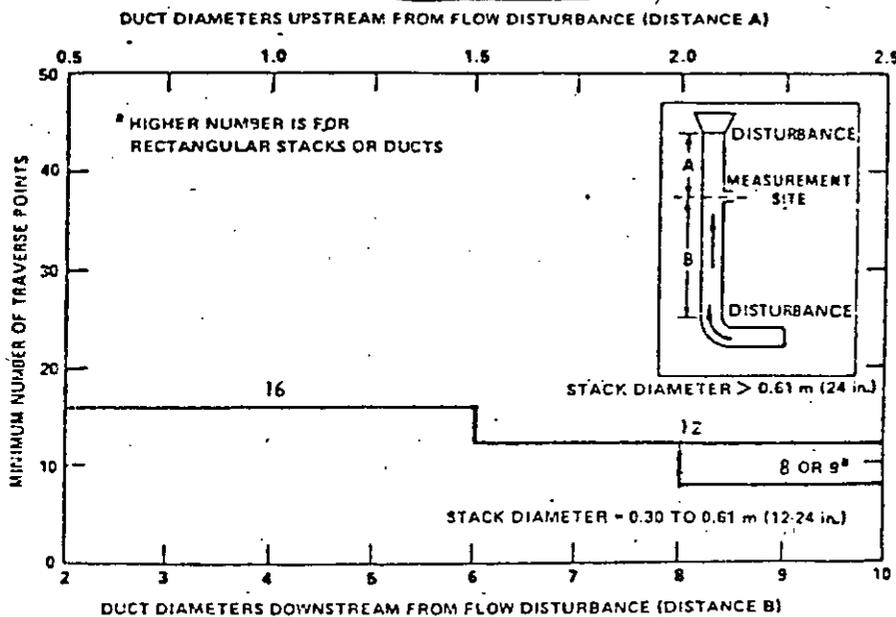
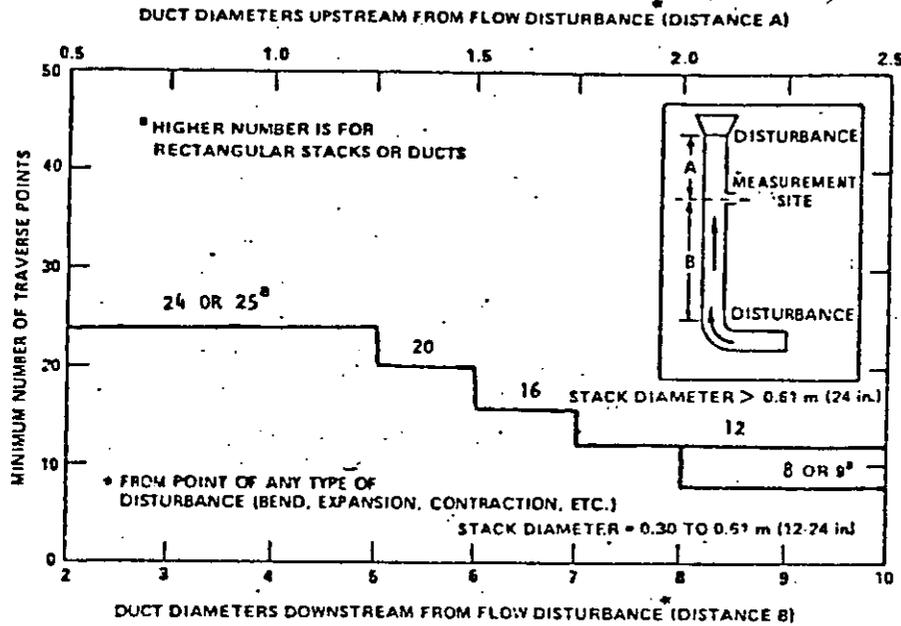
10. Brown, J. and K. Yu. Test Report: Particulate Sampling Strategy in Circular Ducts. Emission Measurement Branch, Emission Standards and Engineering Division. U.S. Environmental Protection Agency, Research Triangle Park, N.C. 27711. July 31, 1980. 12 p.

11. Hawksley, P.G.W., S. Badzioch, and J.H. Blackett. Measurement of Solids in Flue Gases. Leatherhead, England. The British Coal Utilisation Research Association, 1961. p. 129-133.

12. Knapp, K.T. The Number of Sampling Points Needed for Representative Source Sampling. In: Proceedings of the Fourth National Conference on Energy and the Environment, Theodore, L., et al. (ed.). Dayton, Dayton Section of the American Institute of Chemical Engineers, October 3-7, 1976. p. 563-568.

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

[FR Doc. 83-26377 Filed 9-29-83; 8:45 am]
 BILLING CODE 6560-50-M



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.

60.370 Applicability and designation of affected facility.

60.371 Definitions.

60.372 Standards for lead.

60.373 Monitoring of emissions and operations.

60.374 Test methods and procedures.

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:

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

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

Q_{e_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:

$$C_{mT} = \sum_{a=1}^N (C_{m_a} Q_{e_a} / Q_{e_T})$$

Where:

C_{mT} = 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_{m_a} = is the emission concentration from each control device.

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

Q_{e_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:

$$E_m = C_m Q_m / F$$

Where:

E_m = is the lead emission rate from the facility in milligrams per kilogram of lead charged.

C_m = 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_m = 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 $\mu\text{g Pb/ml}$ 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 ($\frac{1}{2}$ in.) ID glass tube extending to about 1.3 cm ($\frac{1}{2}$ 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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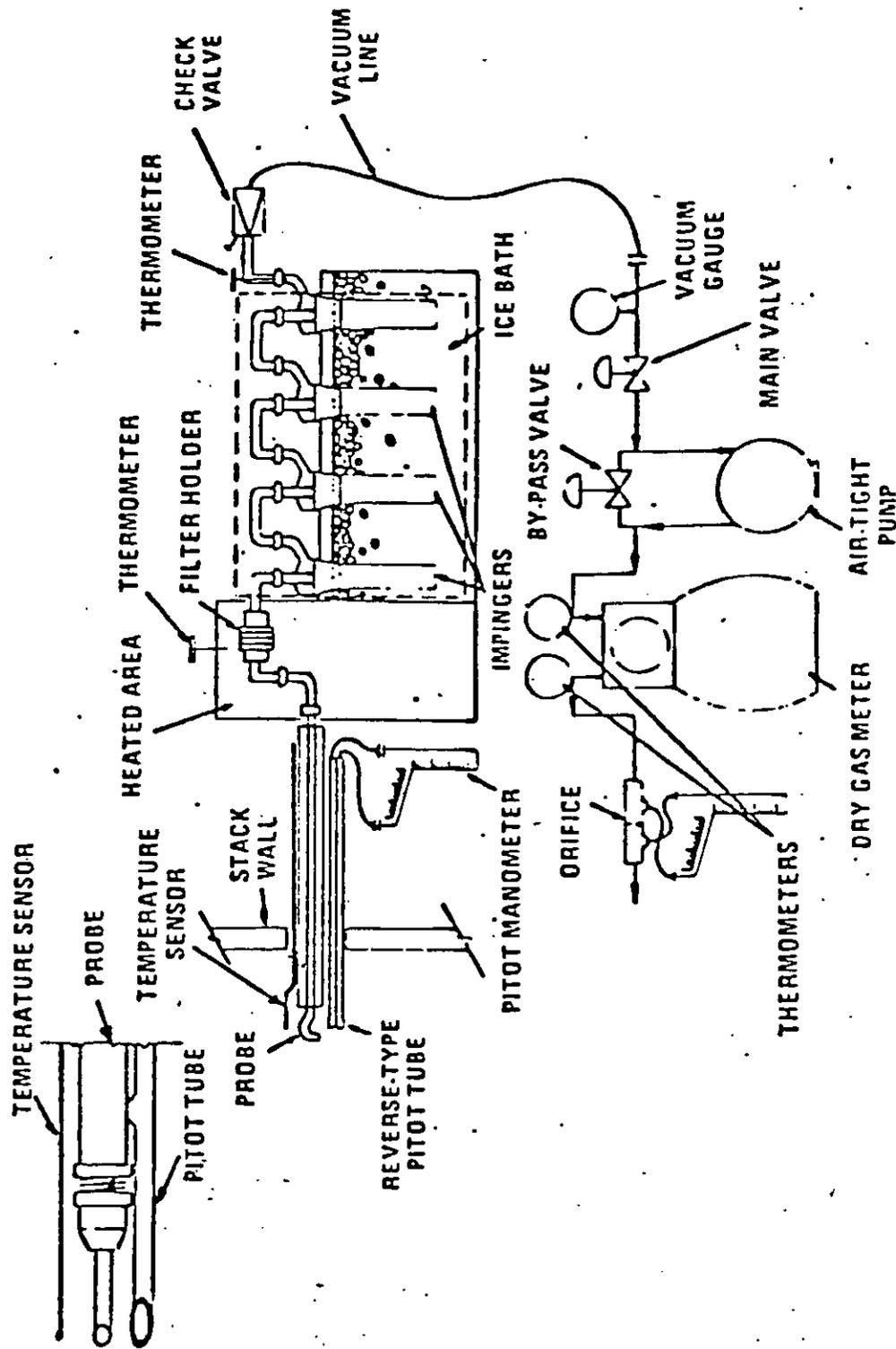


Figure 12-1. Inorganic lead sampling train.

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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 (HNO₃) 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 HNO₃. (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 SCWPO 4700 or equivalent.

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

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

4. Reagents.

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

4.1.1 Filter. Gelman Spectro Grade, Reeve Angel 934 AH, MSA 1106 BH, all with lot assay for Pb, or other high-purity glass fiber filters, without organic binder, exhibiting at least 99.95 percent efficiency (<0.05 percent penetration) on 0.3 micron dioctyl phthalate smoke particles. Conduct the filter efficiency test using ASTM Standard Method 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 HNO₃ 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 HNO₃ is needed. Dilute 390 ml of concentrated HNO₃ 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 HNO₃ (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 HNO₃ 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(NO₃)₂] in about 60 ml of deionized distilled water, add 2 ml concentrated HNO₃ 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 HNO₃ 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 H₂O₂ to 100 ml with deionized distilled water.

5. Procedure.

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

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

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

5.1.3 Preparation of Collection Train. Follow the same general procedure given in Method 5, Section 4.1.3, except place 100 ml of 0.1 N HNO₃ in each of the first two impingers, leave the third impinger empty, and transfer approximately 200 to 300 g of preweighed silica gel from its container to the fourth impinger. Set up the train as shown in Figure 12-1.

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

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

5.1.6 Calculation of Percentokinetic. Same as Method 5, Section 4.1.6.

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

Allow the probe to cool. When it can be safely handled, wipe off all external particulate matter near the tip of the probe nozzle and place a cap over it. Do not cap off the probe tip tightly while the sampling train

is cooling down as this would create a vacuum in the filter holder, thus drawing liquid from the impingers into the filter.

Before moving the sampling train to the cleanup site, remove the probe from the sampling train, wipe off the silicone grease, and cap the open outlet of the probe. Be careful not to lose any condensate that might be present. Wipe off the silicone grease from the glassware inlet where the probe was fastened and cap the inlet. Remove the umbilical cord from the last impinger and cap the impinger. The tester may use ground-glass stoppers, plastic caps, or serum caps to close these openings.

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

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

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

5.2.2 Container No. 2 (Probe). Taking care that dust on the outside of the probe or other exterior surfaces does not get into the sample, quantitatively recover sample matter or any condensate from the probe nozzle, probe fitting, probe liner, and front half of the filter holder by washing these components with 0.1 N HNO₃ 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 HNO₃ used for each rinse. Perform the 0.1 N HNO₃ rinses as follows:

Carefully remove the probe nozzle and rinse the inside surfaces with 0.1 N HNO₃ from a wash bottle while brushing with a stainless steel, Nylon-bristle brush. Brush until the 0.1 N HNO₃ rinse shows no visible particles, then make a final rinse of the inside surface.

● Brush and rinse with 0.1 N HNO₃ the inside parts of the Swagelok fitting in a similar way until no visible particles remain.

Rinse the probe liner with 0.1 N HNO₃. While rotating the probe so that all inside surfaces will be rinsed with 0.1 N HNO₃, tilt the probe and squirt 0.1 N HNO₃ into its upper end. Let the 0.1 N HNO₃ 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 HNO₃ 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 HNO₃ 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 HNO₃ 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 HNO₃ 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 HNO₃ the inside of the front half of the filter holder. Brush and rinse each surface three times or more. If needed, to remove visible sample matter. Make a final rinse of the brush and filter holder. After all 0.1 N HNO₃ 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 HNO₃ used for rinsing. Pour approximately 30 ml of 0.1 N HNO₃ into each of the first three

impingers and agitate the impingers. Drain the 0.1 N HNO₃ 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 HNO₃; 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 HNO₃ 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 HNO₃ 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 HNO₃ 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 HNO₃ for every 100 mg of sample collected in the train or a minimum of 30 ml of 50 percent HNO₃, 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 HNO₃. Add 10 ml of 3 percent H₂O₂ and continue heating for 10 min. Add 50 ml of hot (60°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 HNO₃ and treat as described in Section 5.3.3 using 10 ml of 3 percent H₂O₂ and 50 ml of hot, deionized distilled water. Filter and dilute to a total volume of 100 ml using deionized distilled water.

5.3.5 0.1 N HNO₃ Blank. Take the entire 200 ml of 0.1 N HNO₃ to dryness on a steam

bath, add 15 ml of 50 percent HNO₃ and treat as described in Section 5.3.3 using 10 ml of 3 percent H₂O₂ 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 HNO₃ 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 composition 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 $\mu\text{g Pb/ml}$ (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_{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_{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 $V_{w(vap)}$ and the moisture content B_w 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 HNO₃ 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_{Tm} (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_m in mg/dscm as follows:

$$C_m = K \frac{C_{Tm}}{V_{std}}$$

Where:

$K = 0.001 \text{ mg}/\mu\text{g}$ for metric units;
 $= 2.205 \text{ lb}/\mu\text{g}$ for English units.

7.5 Isokinetic Variation and Acceptable Results. Same as Method 5, Sections 6.11 and 6.12, respectively. To calculate v_a , 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 HNO₃ 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 HNO₃, after the in-stack filter and (2) he recovers and analyzes the probe and impinger contents for Pb. Recover sample from the nozzle with acetone if a particulate analysis is to be made.

9. Bibliography

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

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

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

9.4 Mitchell, W.J. and M.R. Midgett. Determining Inorganic and Alkyl Lead Emissions from Stationary Sources. U.S. Environmental Protection Agency, Emission Monitoring and Support Laboratory, Research Triangle Park, 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.

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

(FR Doc. 82-10481 Filed 4-15-82; 8:45 am)
 BILLING CODE 6560-50-M

CALIBRATION INFORMATIONNOZZLES

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.

METHOD 5 PRETEST - POSTEST CALIBRATION CHECKS

Plant Johnson Controls - Tampa Calibrated by JSM
 Meter box number 1348 Date 9/10/88

Dry Gas Meter

Pretest meter calibration factor, Y = 1.00 (within ± 2%)
 Posttest meter calibration factor, Y = 1.02 (within ± 5% of pretest)
 Recalibration required? Circle one: yes or no If yes new Y = _____
 Lower cal. factor, Y = _____ for calculations (pretest or posttest)

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)
 Posttest 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, (122°F) 582 °R
 Temperature of ref. thermometer for recalibration #1 532 #2 532 °R
 (within ± 10% of the average stack temperature)
 Temperature of stack thermometer for recalibration #1 531 #2 532 °R
 Diff. between ref. and stack thermometer temps. #1 1 #2 0 °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
 Posttest comparison? ±0.001 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	Posttest
Hg in glass	29.204	29.149
Field	29.200	29.150
Difference	0.004	0.001

Nozzle

Was the nozzle calibrated to the nearest .001 in.? Circle one: yes or no
 Nozzle #1: .207 .207 .207 .207 .206 : Average .207
 Nozzle #2: " " " " " : Average "
 Nozzle #3: " " " " " : Average "

Same Nozzle Used For All Runs

Impinger Thermometer

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

PRETEST - POSTEST THERMOMETER CALIBRATION

Client Johnson Controls Date 8/25/88
 Location Tampa, FL Ref. Thermometer #5

Thermometer	Pretest		Posttest	
	Temp., °F	Ref. Temp., °F	Temp., °F	Ref. Temp., °F
DGM # 1348	72/72	72	73/72	73
DGM # 1965	71/72	72	73/73	73
DGM # 1401	72/72	72	73/73	73
DGM # —	—	—	—	—
Impinger #1	71	72	73	73
Impinger #2	72	72	73	73
Impinger #3	72	72	73	73
Impinger #4	73	72	74	73
Impinger #5	72	72	72	73
WB #	72	72	72	73
DB #	72	72	73	73
Box #1	73	72	73	73
Box #2	72	72	73	73
Box #3	73	72	73	73
Box #4	72	72	74	73
Box #5	72	72	73	73
Box #6	72	72	73	73
WB Omega 873	72	72	73	73
DB Omega 873	72	72	73	73
WB Omega #	73	72	73	73
DB Omega #	73	72	73	73
Probe 4' #1	72	72	73	73
Probe 4' #2	72	72	73	73
Probe 5' #1	72	72	73	73
Probe 5' #2	72	72	73	73
—	—	—	—	—

POSTEST DRY GAS METER CALIBRATION DATA FORM (English Units)
 Test Number 1 Date 9/10/88 Meter Box No. 1348 Plant Johnson Controls - Tampa
 Barometric Pressure, $P_b = 29.321$ in. Hg Dry Gas Meter No. 1 Pretest $Y = 1.00$
Wet Test

Orifice manometer setting, inches H ₂ O	Gas Volume		Temperature				Time min. θ	Vacuum setting in. Hg	Y_1	$Y_c = 1.02$
	Wet test meter, ft, V_w	Dry gas meter, ft, V_d	Wet test meter, °F t_w	Dry Gas Meter		Average °F t_d				
				Inlet °F t_{d1}	Outlet °F t_{d0}					
1.8	10	$\frac{785.39}{714.83}$ 10.46	70 70	$\frac{124}{122}$ 123	$\frac{100}{99.5}$	111.25	8.0	$\frac{10(29.321)(111.25+460)}{10.46(29.321+13.6)(70+460)}$		
1.8	10	$\frac{795.97}{725.39}$ 10.58	70 70	$\frac{124}{124}$	$\frac{100}{100}$	112.0	8.0	$\frac{10(29.321)(112+460)}{10.58(29.321+13.6)(70+460)}$		
1.8	10	$\frac{807.61}{797.03}$	70	$\frac{124}{125}$ 124.5	$\frac{100}{101}$	112.75	8.0	$\frac{10(29.321)(112.75+460)}{10.58(29.321+13.6)(70+460)}$		

- V_w = Gas volume passing through the wet test meter, ft.³
- V_d = Gas volume passing through the dry gas meter, ft.³
- t_w = Temperature of the gas in the wet test meter, °F
- t_{d1} = Temperature of the inlet gas of the dry gas meter, °F
- t_{d0} = 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_{d1} and t_{d0} , °F
- ΔH = Pressure differential across orifice, in. H₂O
- Y_1 = 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 $Y \pm 0.05Y$
- P_b = Barometric pressure, in. Hg
- θ = Time of calibration run, min.

RAC STAKSAMPLER CALIBRATION SHEET

Meter Box Serial Number: 1348 Barometric Pressure (P_b): 29.763

Leak Check @ 6.8 in. H₂O: OK Date: 01-29-88 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 avg.	Time t
0.5	5	5.33	68.3	108.0	96.0	102.00	12.70
1.0	5	5.34	68.4	115.0	97.5	106.25	9.32
1.5	10	10.73	68.5	119.5	99.5	109.50	15.46
2.0	10	10.76	68.5	124.0	101.5	112.75	13.45
3.0	10	10.75	68.5	126.0	103.0	114.50	11.14
4.0	10	10.71	68.5	126.0	103.0	114.50	9.68

Calculate Y and -H₀ as follows:

$$Y = \frac{CF_m P_b (T_d \text{ avg.} + 460)}{CF_d (P_b + -H/13.6)(T_m + 460)} = 1.00 \quad -H_0 = \frac{0.0317 \quad -H}{P_b (T_d + 460)} \left(\frac{(T_m + 460) t^2}{CF_m} \right) = 1.86$$

Tolerances: Y = 0.90 - 1.00 - 1.10 Y +/- 0.02Y -H₀ = 1.6 - 1.84 - 2.1 -H₀₁ +/- 0.15 in.

CALIBRATION CALCULATIONS PUMP AND ORIFICE METER

Manometer Delta H 0.5 in. H₂O

$$Y = \frac{5 \times 29.763 (102.00 + 460)}{5.33 (29.763 + 0.0368)(68.3 + 460)} = 0.997 \quad -H_0 = \frac{0.01585}{29.763 (102.00 + 460)} \left(\frac{(68.3 + 460) 12.70^2}{5} \right) = 1.706$$

Manometer Delta H 1.0 in. H₂O

$$Y = \frac{5 \times 29.763 (106.25 + 460)}{5.34 (29.763 + 0.0737)(68.4 + 460)} = 1.001 \quad -H_0 = \frac{0.03170}{29.763 (106.25 + 460)} \left(\frac{(68.4 + 460) 9.32^2}{5} \right) = 1.825$$

Manometer Delta H 1.5 in. H₂O

$$Y = \frac{10 \times 29.763 (109.50 + 460)}{10.73 (29.763 + 0.1103)(68.5 + 460)} = 1.001 \quad -H_0 = \frac{0.04755}{29.763 (109.50 + 460)} \left(\frac{(68.5 + 460) 15.46^2}{10} \right) = 1.873$$

Manometer Delta H 2.0 in. H₂O

$$Y = \frac{10 \times 29.763 (112.75 + 460)}{10.76 (29.763 + 0.1471)(68.5 + 460)} = 1.002 \quad -H_0 = \frac{0.06340}{29.763 (112.75 + 460)} \left(\frac{(68.5 + 460) 13.45^2}{10} \right) = 1.879$$

Manometer Delta H 3.0 in. H₂O

$$Y = \frac{10 \times 29.763 (114.50 + 460)}{10.75 (29.763 + 0.2206)(68.5 + 460)} = 1.004 \quad -H_0 = \frac{0.09510}{29.763 (114.50 + 460)} \left(\frac{(68.5 + 460) 11.14^2}{10} \right) = 1.928$$

Manometer Delta H 4.0 in. H₂O

$$Y = \frac{10 \times 29.763 (114.50 + 460)}{10.71 (29.763 + 0.2941)(68.5 + 460)} = 1.005 \quad -H_0 = \frac{0.12680}{29.763 (114.50 + 460)} \left(\frac{(68.5 + 460) 9.68^2}{10} \right) = 1.941$$

NOZZLE CALIBRATION

Fused Silica Probes

Date: 07-07-88

By: PRJ

Nozzle I.D.	D ₁ , in.	D ₂ , in.	D ₃ , in.	D ₄ , in.	D ₅ , in.	D, in.	D _{avg.}
48" -1	0.274	0.273	0.272	0.272	0.273	0.002	0.273
48" -2	0.346	0.347	0.346	0.347	0.347	0.001	0.347
48" -3	0.347	0.347	0.346	0.348	0.347	0.002	0.347
48" -4	0.397	0.396	0.396	0.396	0.396	0.001	0.396
72"							
.450-1	0.453	0.452	0.452	0.452	0.452	0.001	0.452
.450-2	0.451	0.451	0.450	0.452	0.451	0.002	0.451
.450-3	0.441	0.442	0.442	0.443	0.442	0.002	0.442
.600-1	0.587	0.586	0.587	0.586	0.586	0.001	0.586
.600-2	0.587	0.588	0.587	0.587	0.587	0.001	0.587
.600-3	0.585	0.586	0.586	0.585	0.586	0.001	0.586
.750-1	0.775	0.774	0.774	0.774	0.774	0.001	0.774
.750-2	0.778	0.780	0.780	0.780	0.780	0.002	0.780
.750-3	0.779	0.778	0.779	0.779	0.779	0.001	0.779

Anderson Particle Size

Nozzle I.D.	D ₁ , in.	D ₂ , in.	D ₃ , in.	D ₄ , in.	D ₅ , in.	D, in.	D _{avg.}
.125-1	0.124	0.123	0.124	0.125	0.124	0.002	0.124
.187-1	0.185	0.185	0.184	0.185	0.185	0.001	0.185
.250-1	0.251	0.251	0.250	0.251	0.251	0.001	0.251
.300-1	0.314	0.315	0.316	0.315	0.315	0.002	0.315
.375-1	0.370	0.370	0.370	0.379	0.369	0.001	0.370
.500-1	0.496	0.494	0.495	0.495	0.495	0.002	0.495

Where:

D_{1,2,3,4,5} = nozzle diameter measured on a different diameter, in.
Tolerance = measure within 0.001 in.

D = maximum difference in any two measurements, in.
Tolerance = 0.004 in.

D_{avg.} = average of D₁, D₂, D₃, D₄, and D₅.

TYPE S PITOT TUBE INSPECTION DATA FORM

Date: 03-15-88
 Calibrator: RBMc

Specifications:

- 1.) Pitot tube assembly must be level.
- 2.) If pitot tube is damaged explain under comments section.
- 3.) $z = A \sin \tau$ (<0.125) and $w = A \sin \theta$ (<0.03125)
- 4.) $\alpha < 10^\circ$ and $\beta < 5^\circ$

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	1.0	1.0	1.0	2.0	0.5	0.778	0.027	0.00679	0.389	0.389	0.376
36"-2	2.0	0.5	1.0	2.0	0.0	0.5	1.151	0.000	0.01004	0.575	0.576	0.377
40"-1	1.0	1.0	1.0	1.0	0.0	0.5	1.100	0.000	0.00960	0.550	0.550	0.388
54"-1	3.0	3.0	1.0	1.0	1.0	1.5	1.006	0.018	0.02633	0.503	0.503	0.380
66"-1	1.0	0.0	4.0	0.0	0.0	1.5	1.040	0.000	0.02722	0.520	0.520	0.386
96"-1	2.0	0.5	3.0	2.0	2.0	0.5	0.910	0.032	0.00794	0.455	0.455	0.376
4'-1	1.0	3.0	1.0	4.0	0.0	0.5	0.966	0.000	0.00843	0.483	0.483	0.378
4'-2	2.0	1.0	1.0	1.0	0.0	1.0	0.891	0.000	0.01555	0.445	0.446	0.371
4'-3	4.0	2.0	2.0	3.0	0.0	1.0	0.878	0.000	0.01532	0.439	0.439	0.375
4'-4	1.0	4.0	4.0	1.0	0.5	0.0	0.839	0.007	0.00000	0.419	0.420	0.375
4'-5	0.0	2.0	2.0	1.0	0.5	0.0	0.866	0.007	0.00000	0.433	0.433	0.372
4'-6	2.0	1.0	1.0	0.0	1.0	0.5	0.955	0.017	0.00833	0.477	0.478	0.376
5'-1	2.0	1.0	0.0	1.0	1.0	1.0	1.001	0.017	0.01747	0.500	0.501	0.375
5'-2	1.0	3.0	0.0	0.0	0.0	1.5	1.045	0.000	0.02735	0.522	0.523	0.377
5'-3	1.0	1.0	1.0	1.0	2.0	0.5	1.048	0.037	0.00915	0.524	0.524	0.376
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	1.0	0.5	0.0	1.0	0.995	0.000	0.01737	0.498	0.497	0.380
6'-2	1.0	1.0	0.0	0.0	2.0	1.5	1.004	0.035	0.02628	0.502	0.502	0.378
6'-3	1.0	1.0	0.5	1.0	1.0	0.5	1.009	0.018	0.00881	0.504	0.505	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.

NOZZLE CALIBRATION

Date: 06-27-88

Set Number 1 Brown Box

By: RBMc

Nozzle I.D.	D ₁ , in.	D ₂ , in.	D ₃ , in.	D ₄ , in.	D ₅ , in.	D, in.	D _{avg.}
.187-1	0.187	0.188	0.188	0.186	0.187	0.002	0.187
.187-2	0.189	0.189	0.189	0.190	0.189	0.001	0.189
.187-3	0.186	0.186	0.185	0.186	0.186	0.001	0.186
.203-1	0.207	0.208	0.207	0.207	0.207	0.001	0.207
.250-1	0.252	0.252	0.252	0.252	0.252	0.000	0.252
.250-2	0.254	0.253	0.253	0.254	0.253	0.001	0.253
.250-3	0.251	0.250	0.249	0.249	0.250	0.002	0.250
.300-1	0.304	0.304	0.305	0.305	0.304	0.001	0.304
.300-2	0.302	0.303	0.304	0.303	0.303	0.002	0.303
.300-3	0.300	0.301	0.300	0.300	0.300	0.001	0.300
.335-1	0.336	0.336	0.336	0.336	0.336	0.000	0.336
.375-1	0.375	0.375	0.376	0.376	0.375	0.001	0.375
.375-2	0.375	0.374	0.375	0.375	0.374	0.001	0.375
.375-3	0.374	0.375	0.375	0.376	0.375	0.002	0.375
.400-1	0.404	0.405	0.404	0.405	0.405	0.001	0.405
.500-1	0.505	0.504	0.504	0.504	0.504	0.001	0.504
.500-2	0.504	0.502	0.503	0.503	0.503	0.002	0.503
.500-3	0.502	0.503	0.503	0.502	0.502	0.001	0.502
.625-1	0.619	0.618	0.619	0.619	0.619	0.001	0.619
.775-1	0.770	0.778	0.780	0.780	0.780	0.002	0.779
1.00-1	1.000	1.000	0.999	1.000	1.000	0.001	1.000

Set Number 2 Blue Box

Nozzle I.D.	D ₁ , in.	D ₂ , in.	D ₃ , in.	D ₄ , in.	D ₅ , in.	D, in.	D _{avg.}
.187-1	0.185	0.185	0.186	0.185	0.184	0.002	0.185
.187-2	0.184	0.185	0.185	0.185	0.185	0.001	0.185
.187-3	0.186	0.186	0.186	0.186	0.186	0.000	0.186
.203-1	0.207	0.207	0.206	0.207	0.207	0.001	0.207
.250-1	0.250	0.250	0.250	0.249	0.249	0.001	0.250
.250-2	0.251	0.252	0.252	0.251	0.252	0.001	0.252
.250-3	0.249	0.250	0.249	0.250	0.250	0.001	0.250
.300-1	0.301	0.302	0.302	0.302	0.301	0.001	0.302
.300-2	0.301	0.303	0.303	0.302	0.302	0.002	0.302
.300-3	0.301	0.300	0.302	0.302	0.302	0.002	0.302
.335-1	0.340	0.339	0.339	0.339	0.338	0.002	0.339
.375-1	0.378	0.378	0.378	0.378	0.378	0.000	0.378
.375-2	0.376	0.377	0.376	0.376	0.377	0.001	0.376
.375-3	0.376	0.376	0.376	0.375	0.376	0.001	0.376
.500-1	0.496	0.495	0.497	0.496	0.496	0.002	0.496
.500-2	0.497	0.499	0.499	0.499	0.499	0.002	0.499
.500-3	0.497	0.498	0.498	0.497	0.498	0.001	0.498

Where:

D_{1,2,3,4,5} = nozzle diameter measured on a different diameter, in.

Tolerance = measure within 0.001 in.

D = maximum difference in any two measurements, in.

Tolerance = 0.004 in.

D_{avg.} = average of D₁, D₂, D₃, D₄, and D₅.

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

DATE: 07/07/88
 AMBIENT TEMPERATURE, F : 71
 CALIBRATOR: PRJ

BAROMETRIC PRESSURE: 29.44
 REFERENCE THERMOMETER # 22

REFERENCE POINT #	SOURCE	REFERENCE THERMOMETER TEMPERATURE, F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, F	TEMPERATURE DIFFERENCE, %	
Impinger					
#1	A.	ice bath	35	35	0.00
	B.	water bath	71	71	0.00
	C.	oil bath	111	112	-0.18
#2	A.	ice bath	35	36	-0.20
	B.	water bath	71	72	-0.19
	C.	oil bath	111	111	0.00
#3	A.	ice bath	35	35	0.00
	B.	water bath	71	72	-0.19
	C.	oil bath	111	111	0.00
#4	A.	ice bath	35	34	0.20
	B.	water bath	71	71	0.00
	C.	oil bath	112	112	0.00
#5	A.	ice bath	35	36	-0.20
	B.	water bath	71	71	0.00
	C.	oil bath	112	113	-0.17

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

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

DATE: 07/07/88
AMBIENT TEMPERATURE, F : 71
CALIBRATOR: PRJ

BAROMETRIC PRESSURE: 29.44
REFERENCE THERMOMETER # 22

REFERENCE POINT #	SOURCE	REFERENCE THERMOMETER TEMPERATURE, F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, F	TEMPERATURE DIFFERENCE, %	
Bimetallic					
Wb1	A.	water bath	71	71	0.00
	B.	oil bath	125	125	0.00
	C.	oil bath	187	188	-.15
	D.	oil bath	224	225	-.15
	E.	oil bath	275	277	-.27
Wb1	A.	water bath	71	70	0.19
	B.	oil bath	125	125	0.00
	C.	oil bath	187	188	-.15
	D.	oil bath	226	226	0.00
	E.	oil bath	276	275	0.14
Db2	A.	water bath	71	71	0.00
	B.	oil bath	126	126	0.00
	C.	oil bath	187	189	-.31
	D.	oil bath	226	227	-.15
	E.	oil bath	278	279	-.14
Wb2	A.	water bath	71	72	-.19
	B.	oil bath	127	128	-.17
	C.	oil bath	188	190	-.31
	D.	oil bath	227	228	-.15
	E.	oil bath	278	279	-.14
Nox	A.	water bath	71	71	0.00
	B.	water bath	85	86	-.18
	C.	water bath	111	112	-.18
	D.	oil bath	126	127	-.17
	E.	oil bath	188	189	-.15
Hot Box	A.	water bath	71	70	0.19
	B.	oil bath	127	128	-.17
	C.	oil bath	188	190	-.31
	D.	oil bath	227	228	-.15
	E.	oil bath	289	290	-.13

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

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

DATE: 07/07/88
AMBIENT TEMPERATURE, F : 71
CALIBRATOR: PRJ

BAROMETRIC PRESSURE: 29.44
REFERENCE THERMOMETER # 22

REFERENCE POINT #	SOURCE	REFERENCE THERMOMETER TEMPERATURE, F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, F	TEMPERATURE DIFFERENCE, %	
Omega Temp HH-2 #1					
Db1	A.	water bath	71	71	0.00
	B.	oil bath	125	125	0.00
	C.	oil bath	186	187	-.15
	D.	oil bath	224	225	-.15
	E.	oil bath	277	277	0.00
Wb1	A.	water bath	71	71	0.00
	B.	oil bath	125	126	-.17
	C.	oil bath	185	187	-.31
	D.	oil bath	225	226	-.15
	E.	oil bath	277	277	0.00
Omega Temp HH-2 #2					
Db2	A.	water bath	71	72	-.19
	B.	oil bath	126	126	0.00
	C.	oil bath	187	187	0.00
	D.	oil bath	226	227	-.15
	E.	oil bath	278	278	0.00
Wb2	A.	water bath	71	70	0.19
	B.	oil bath	126	127	-.17
	C.	oil bath	187	188	-.15
	D.	oil bath	226	227	-.15
	E.	oil bath	278	279	-.14
Omega Temp 873-F					
Db1	A.	water bath	71	71	0.00
	B.	oil bath	126	127	-.17
	C.	oil bath	187	188	-.15
	D.	oil bath	226	227	-.15
	E.	oil bath	278	280	-.27
Wb1	A.	water bath	71	71	0.00
	B.	oil bath	127	127	0.00
	C.	oil bath	188	188	0.00
	D.	oil bath	227	229	-.29
	E.	oil bath	279	280	-.14
Omega Temp 873-F High Temp					
A.	oil bath	323	324	-.13	
	H. Furnace	455	457	-.22	
	H. Furnace	585	586	-.10	
	H. Furnace	845	847	-.15	
	H. Furnace	1150	1152	-.12	

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

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

DATE: 07/07/88
 AMBIENT TEMPERATURE, F : 71
 CALIBRATOR: PRJ

BAROMETRIC PRESSURE: 29.44
 REFERENCE THERMOMETER # 22 & #5

REFERENCE POINT #	SOURCE	REFERENCE THERMOMETER TEMPERATURE, F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, F	TEMPERATURE DIFFERENCE, %	
Probe - #					
4'-1	A.	oil bath	95	95	0.00
	B.	oil bath	265	266	-.14
	C.	oil bath	377	378	-.12
4'-2	A.	oil bath	95	96	-.18
	B.	oil bath	266	266	0.00
	C.	oil bath	377	378	-.12
5'-1	A.	oil bath	95	95	0.00
	B.	oil bath	266	265	0.14
	C.	oil bath	378	377	0.12
5'-2	A.	oil bath	96	96	0.00
	B.	oil bath	266	267	-.14
	C.	oil bath	378	379	-.12
6'-1	A.	oil bath	96	97	-.18
	B.	oil bath	267	267	0.00
	C.	oil bath	378	377	0.12
6'-2	A.	oil bath	97	97	0.00
	B.	oil bath	268	267	0.14
	C.	oil bath	378	379	-.12
8'-1	A.	oil bath	97	97	0.00
	B.	oil bath	268	267	0.14
	C.	oil bath	379	378	0.12
8'-2	A.	oil bath	97	98	-.18
	B.	oil bath	268	269	-.14
	C.	oil bath	379	380	-.12
8'-3	A.	oil bath	98	98	0.00
	B.	oil bath	269	268	0.14
	C.	oil bath	379	380	-.12
8' 9"	A.	oil bath	100	101	-.18
	B.	oil bath	270	269	0.14
	C.	oil bath	380	379	0.12
9' 7"	A.	oil bath	100	99	0.18
	B.	oil bath	270	270	0.00
	C.	oil bath	380	379	0.12

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

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

DATE: 07/07/88
 AMBIENT TEMPERATURE, F : 71
 CALIBRATOR: PRJ

BAROMETRIC PRESSURE: 29.44
 REFERENCE THERMOMETER # 22

REFERENCE POINT #	SOURCE	REFERENCE THERMOMETER TEMPERATURE, F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, F	TEMPERATURE DIFFERENCE, %
METER BOX				
1264A	A. ice bath	35	35	0.00
	B. water bath	71	72	-.19
	C. oil bath	125	126	-.17
	D. oil bath	149	149	0.00
1264B	A. ice bath	35	36	-.20
	B. water bath	71	70	0.19
	C. oil bath	125	126	-.17
	D. oil bath	149	150	-.16
1348A	A. ice bath	35	36	-.20
	B. water bath	71	72	-.19
	C. oil bath	126	126	0.00
	D. oil bath	150	151	-.16
1348B	A. ice bath	36	36	0.00
	B. water bath	71	72	-.19
	C. oil bath	126	126	0.00
	D. oil bath	150	151	-.16
1401A	A. ice bath	36	35	0.20
	B. water bath	71	72	-.19
	C. oil bath	126	126	0.00
	D. oil bath	150	150	0.00
1401B	A. ice bath	36	36	0.00
	B. water bath	71	72	-.19
	C. oil bath	126	127	-.17
	D. oil bath	150	149	0.16
1965A	A. ice bath	36	37	-.20
	B. water bath	71	72	-.19
	C. oil bath	127	127	0.00
	D. oil bath	151	150	0.16
1965B	A. ice bath	36	36	0.00
	B. water bath	71	70	0.19
	C. oil bath	127	128	-.17
	D. oil bath	151	151	0.00

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

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

DATE: 07/07/88
 AMBIENT TEMPERATURE, F : 71
 CALIBRATOR: PRJ

BAROMETRIC PRESSURE: 29.44
 REFERENCE THERMOMETER # 22

REFERENCE POINT #	SOURCE	REFERENCE THERMOMETER TEMPERATURE, F	THERMOCOUPLE POTENTIOMETER TEMPERATURE, F	TEMPERATURE DIFFERENCE, %	
SAMPLE BOX					
#1	A.	water bath	71	71	0.00
	B.	oil bath	125	124	0.17
	C.	oil bath	186	186	0.00
	D.	oil bath	223	224	-.15
	E.	oil bath	277	277	0.00
#2	A.	water bath	71	70	0.19
	B.	oil bath	125	126	-.17
	C.	oil bath	186	188	-.31
	D.	oil bath	186	188	-.31
	E.	oil bath	223	224	-.15
#3	A.	water bath	71	71	0.00
	B.	oil bath	126	126	0.00
	C.	oil bath	187	188	-.15
	D.	oil bath	223	225	-.29
	E.	oil bath	277	278	-.14
#4	A.	water bath	71	72	-.19
	B.	oil bath	126	126	0.00
	C.	oil bath	187	188	-.15
	D.	oil bath	224	226	-.29
	E.	oil bath	277	278	-.14
#5	A.	water bath	71	71	0.00
	B.	oil bath	126	126	0.00
	C.	oil bath	187	188	-.15
	D.	oil bath	225	225	0.00
	E.	oil bath	278	279	-.14
#6	A.	water bath	71	71	0.00
	B.	oil bath	127	127	0.00
	C.	oil bath	188	188	0.00
	D.	oil bath	227	228	-.15
	E.	oil bath	279	280	-.14
#7	A.	water bath	71	71	0.00
	B.	oil bath	127	127	0.00
	C.	oil bath	188	189	-.15
	D.	oil bath	227	229	-.29
	E.	oil bath	279	280	-.14
#8	A.	water bath	71	71	0.00
	B.	oil bath	129	130	-.17
	C.	oil bath	189	190	-.15
	D.	oil bath	229	230	-.15
	E.	oil bath	280	282	-.27

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



Whatman Inc.

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

February 1, 1979

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

Dear Mr. Jenkins:

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

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

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

Very truly yours,

John Zacharias
Vice President

Business Manager, Paper Division, N. A.

JZ/mpa

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:	<u>13</u>	_____
Mettler calibration date of test weights used:	<u>8-1-87</u>	_____
National Bureau of Standards test number:	<u>737/0670-49</u>	_____

Model and serial number of balances serviced:

AE163- C57742
H54AR- 677277

Kevin Z. Biff
Mettler Service Representative

1-17-88
Date of Issue

METTLER

Mettler Instrument Corporation
Box 71, Hightstown, NJ 08520
(609) 448-3000



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. Jenkins:

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

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

Respectfully,



Bob Husberg
Supervisor, Customer Service

BH/mg

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.

Sione Ciulla

the
OMEGA
Group

DATE: 12-10-85

CERTIFICATE OF CALIBRATION

CUSTOMER: ENVIRONMENTAL TESTING INC Customer Purchase Order: 2861RO

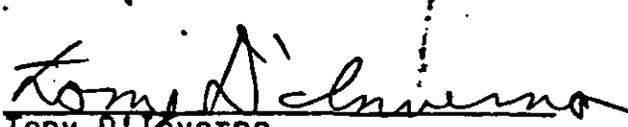
1700 UNIV COMMERCIAL PL OMEGA Work Order No: SO 511268760

CHARLOTTE NC 28213 MODEL: HH-2

SERIAL NO: 14403

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

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


Tony D'Inverno
Supervisor, Instrumentation

CAL-3

 OMEGA ENGINEERING, INC.

 OMEGA PRESS

 OMEGA INTERNATIONAL CORP.

 BIOMEGA

One Omega Drive, Box 4047, Stamford, CT 06907-0047 (203) 359-1680 Telex 996404 Cable OMEGA FAX (203) 359-7700

CORNING

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

• CORNING Laboratory Sciences Company

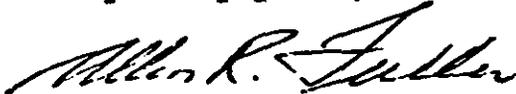
November 18, 1986

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

Dear Mr. Jenkins:

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

Very truly yours,



Allen R. Fuller
Product Engineering Supervisor

b10012



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.