AP42 Section:	11.7
Reference:	6
Title:	Particulate Emission Testing For Florida Tile Corporation, Lawrenceburg, Kentucky, March 7-8, 1989, Air Systems Testing, Inc., Marietta, GA, April 1989.

PARTICULATE EMISSION TESTING
FOR
FLORIDA TILE CORPORATION
LAWRENCEBURG, KENTUCKY
MARCH 7-8, 1989

Submitted By:

AIR SYSTEMS TESTING, INC.
P.O. Box 6278
Marietta, GA 30065
(404) 426-0447

BRUCE LAWRIE

TABLE OF CONTENTS

APPENDICIES

INTRODUCTION

On Tuesday and Wednesday, March 7 and 8, 1989, Air Systems Testing, Inc. *(AST)*, of Marietta, Georgia, performed compliance particulate and gaseous fluoride emission testing on the Forkiner kiln exhaust at the Florida Tile Corporation plant located in Lawrenceburg, Kentucky. The testing was performed to determine if the particulate and gaseous fluoride emission levels were within the allowable rate defined by the Kentucky Bureau of Environmental Protection. *AST* field test personnel were Bruce Lawrie and Jerry Freeman.

AST would like to thank Mr. Jim Jefferies and his associates at Florida Tile for their assistance and cooperation throughout the testing program. We would also like to thank Mr. Jim Neal, Mr. Patrick Springston, and Mr. Gerald Slucher, all with the Kentucky Bureau of Environemntal Protection, for their review of the test procedures and plant operation.

SUMMARY OF TEST RESULTS

The summary of the results of the testing can be found below and on the following pages. Below is shown the results of each of the three test repetitions and the average of the three (which is used to determine compliance with state standards). The results are shown in pounds per hour for particulate and fluoride emissions.

Test No.	Particulate Emission Rate (pounds/hour)	Allowable Emission Rate (pounds/hour)	Fluoride Emission Rate (pounds/hour)
1	0.02	2.34	0.01
2	0.02	2.34	0.01
3	0.02	2.34	<0.01
Average	0.02	2.34	0.01

Thus, from the above table, the Forniker kiln at Florida Tile, Lawrenceburg, Kentucky, is within allowable standards for particulate emissions.

SUMMARY OF TEST RESULTS
Forniker Kiln Exhaust

	Test #1	Test #2	Test #3
Volume @ Meter (Vm):	38.692	39.187	40.957
Sqrt Delta P:	0.445	0.433	0.454
Sampling Time (min):	60	60	60
Barometric Pressure (Pb):	29.50	29.50	29.50
Delta H (H):	1.54	1.53	1.69
Volume in Impingers (mls):	20.0	37.0	41.5
Stack Pressure (Ps):	29.50	29.50	29.50
Stack Temperature (Ts):	916	925	904
Meter Coefficient (Y):	1.031	1.031	1.031
Pitot Coefficient (Cp):	0.99	0.99	0.99
Meter Temperature (Tm):	538	539	536
Area Stack (As):	0.27	0.27	0.27
Area Nozzle (An):	0.000524	0.000524	0.000524
Percent CO2 (%):	0.0	1.0	1.0
Percent O2 (%):	21.0	20.0	20.0
Percent N2 (%):	79.0	79.0	79.0
Milligrams:	12.6	13.3	16.6
Molecular Weight Dry (Md):	28.84	28.96	28.96
Volume Water (Vwstd):	0.94	1.74	1.95
Volume Gas Sampled (Vmstd):	38.733	39.155	41.169
Wet Fraction (Bws):	0.024	0.043	0.045
Molecular Weight Wet (Ms):	28.58	28.49	28.46
Volume Gas Sampled (Vma):	69.809	72.666	74.882
Stack Gas Velocity, (Vs):	39.25	38.44	39.87
Volumetric Flowrate (Qs):	353	336	355
Volumetric Flowrate (Qa):	636	623	646
Grainloading, gr/dscf (cs):	0.0050	0.0052	0.0062
Grainloading, gr/ACF (csi):	0.0028	0.0028	0.0034
Emission Rate, #/Hour:	0.02	0.02	0.02
Percent Isokinetic Sampling:	94.3	100.3	99.6

SUMMARY OF TEST RESULTS
Forniker Kiln Exhaust
Fluoride Emissions

	Test #1	Test #2	Test #3
Volume @ Meter (Vm):	38.692	39.187	40.957
Sqrt Delta P:	0.445	0.433	0.454
Sampling Time (min):	60	60	60
Barometric Pressure (Pb):	29.50	29.50	29.50
Delta H (H):	1.54	1.53	1.69
Volume in Impingers (mls):	20.0	37.0	41.5
Stack Pressure (Ps):	29.50	29.50	29.50
Stack Temperature (Ts):	916	925	904
Meter Coefficient (Y):	1.031	1.031	1.031
Pitot Coefficient (Cp):	0.99	0.99	0.99
Meter Temperature (Tm):	538	539	536
Area Stack (As):	0.27	0.27	0.27
Area Nozzle (An):	0.000524	0.000524	0.000524
Percent CO2 (%):	0.0	1.0	1.0
Percent O2 (%):	21.0	20.0	20.0
Percent N2 (%):	79.0	79.0	79.0
Milligrams:	5.07	4.95	1.78
Molecular Weight Dry (Md):	28.84	28.96	28.96
Volume Water (Vwstd):	0.94	1.74	1.95
Volume Gas Sampled (Vmstd):	38.733	39.155	41.169
Wet Fraction (Bws):	0.024	0.043	0.045
Molecular Weight Wet (Ms):	28.58	28.49	28.46
Volume Gas Sampled (Vma):	69.809	72.666	74.882
Stack Gas Velocity, (Vs):	39.25	38.44	39.87
Volumetric Flowrate (Qs):	353	336	355
Volumetric Flowrate (Qa):	636	623	646
Grainloading, gr/dscf (cs):	0.0020	0.0020	0.0007
Grainloading, gr/ACF (csi):	0.0011	0.0011	0.0004
Emission Rate, #/Hour:	0.01	0.01	.00
Percent Isokinetic Sampling:	94.3	100.3	99.6

E.P.A. TEST PROCEDURES

The testing procedures followed were according to Methods 1, 2, 3, and 5, and Kentucky Method 130 for location of sampling points; measuring of stack gas velocity and volumetric flow rate; determination of CO_2, O_2, and dry molecular weight; determination of particulate matter concentrations; and determination of gaseous fluoride emission concentrations. These methods can be found in the *Code of Federal Regulations*, Title 40, Parts 53-60, revised as of July 1, 1986.

Method 1, determination of number and location of sampling points, was used to calculate the location of the sample points used on each traverse. The exact location of each point can be found in detail in Appendix C.

EPA Method 2 was used to calculate the stack gas velocity and volumetric flow rate. The standard pitot tube was fabricated according to design criteria in Method 2 that allows a pitot coefficient of 0.99 to be used in the calculations. The pitot tube was not attached to the probe assembly due to the small stack diameter. Velocity measurements were made downstream from the nozzle sampling location. Stack gas temperatures used in the velocity calculations were obtained with a type "K" thermocouple and Omega digital thermometer. Leak checks were performed on the pitot-manometer assembly after each test and showed no leak.

Method 3 was used to determine dry molecular weight, including CO_2 and O_2 concentrations. The grab samples were analyzed immediately with a fyrite analyzer according to procedures outlined in Method 3.

Method 5, Determination of Particulate Matter from Stationary Sources, was used to determine particulate emission concentrations. The sampling train consisted of a calibrated nozzle, union, 316 seamless stainless steel liner heated with 50 feet of 0.4 ohms per foot nichrome wire, glass fiber filter and filter holder, four impingers, umbilical cord, pump, and control console. Filter box, impinger outlet, and dry gas meter temperatures were monitored throughout the test with bimetallic thermometers. The dry gas meter in the control console was calibrated against a Rockwell S-415 test meter that had been standardized with a Rockwell #1464 Bell Prover. The S-415 meter had a calibration coefficient (Y) of 0.999.

Kentucky Method 130 was used to determine gaseous fluoride concentrations. The distilled water impinger catch from the Method 5 testing was analyzed by the specific ion electrode method for fluoride concentrations.

Sampling Procedures

The sampling area for the testing was located on the kiln exhaust stack. A forklift truck was used on each of the two test ports to support the filter/impinger box while the probe traversed the stack. The schematic of the sampling location can be found in Appendix C.

Prior to each test, the sampling train was assembled for testing. 100 milliliters (ml) of distilled water was placed in each of the first two impingers, the third impinger was left empty, and 200.0 grams (g) of silica gel was placed in impinger number 4. The probe was secured in the sampling box, the filter holder assembly was installed, and the system was ready for pre-test leak checks.

After each test, leak checks were performed on the sampling train, Method 3 train, and each side of the pitot tubes. Next, the train was disassembled. The filter holder was removed and sealed to prevent loss of particulate matter. The probe and nozzle were cleaned with reagent grade acetone, with all sample exposed surfaces brushed and rinsed at least six times to insure all particulate matter was removed. This rinse was saved in a 500 ml polyethylene bottle. Next, the contents of the first three impingers were measured with a graduated cylinder, rinsed, and saved for further analysis for fluorides. The silica gel was returned to its container and sealed.

Laboratory Procedures

The following procedures were followed for each repetition:

Container No. 1

A pre-numbed 81.5 millimeter glass fiber filter was desiccated for a minimum of 24 hours, weighed to a constant weight, and transferred to this container. Before the test, the filter was placed in a filter holder. After the test, the filter was carefully removed from the filter holder and returned to the container.

Container No. 2

All sample exposed surfaces between the nozzle and the filter were washed with acetone, including brushing and rinsing at least six times, until no particulate matter remained. The brushes were also rinsed with the acetone to remove any particulate adhering to them.

Container No. 3

200.0 grams of indicating, 6-16 mesh silica gel was weighed and sealed in this container. Before the test, it was added to impinger number four. After the test, if was returned to the container and sealed.

Container No. 4

The contents of impingers 1, 2, and 3 were measured with a graduated cylinder and saved in this container. The container was sealed.

The following procedures were followed for each sample:

Container No. 1

The filter was desiccated for at least 24 hours and weighed to a constant weight. Note: Before each weighing, the SP 180 electronic analytical balance was calibrated with a 100 gram and 1 gram class S weight.

Container No. 2

The contents of this container were transferred to a tared beaker. The volume of the rinse was recorded and the acetone in the sample evaporated. When the beaker was dry, it was desiccated and weighed to a constant weight.

Container No. 3

The silica gel was weighed to the nearest 0.5 gram.

Container No. 4

The contents of this container were transferred to Galbraith Laboratories for analysis for fluorides.

APPENDIX A
LABORATORY RESULTS

PARTICULATE LABORATORY DATA SHEET

Test No.: 1 Source: Fornicer Kiln

Acetone Blank: Volume: 100 ml. Net Wt.: 0.0000 g.

Acetone Density: 0.786 g/ml. Residue: 0 g/ml.

Filter

Filter No.: 291

Final Weight:	0.3645 g.	0.3646 g.	AVG:	0.3646 g.
Tare Weight:	0.3609 g.	0.3610 g.	AVG:	0.3610 g.
Net Weight:			AVG:	0.0036 g.

Probe Wash

Probe Wash Beaker No.: 3 Volume: 160 ml.

Final Weight:	128.9492 g.	128.9490 g.	AVG:	128.9491 g.
Tare Weight:	128.9402 g.	128.9400 g.	AVG:	128.9401 g.
Net Weight:			AVG:	0.0090 g.

Less Acetone Blank Residue: 0 g.

TOTAL PARTICULATE MATTER COLLECTED: 0.0126 g.

PARTICULATE LABORATORY DATA SHEET

Test No.: 2 Source: FORNIKER KILN

Acetone Blank: Volume: 100 ml. Net Wt.: 0.0000 g.

Acetone Density: 0.786 g/ml. Residue: 0 g/ml.

Filter

Filter No.: 290

Final Weight:	0.3696 g.	0.3696 g.	AVG:	0.3696 g.
Tare Weight:	0.3621 g.	0.3620 g.	AVG:	0.3621 g.
Net Weight:			AVG:	0.0075 g.

Probe Wash

Probe Wash Beaker No.: 4 Volume: 175 ml.

Final Weight:	129.9071 g.	129.9069 g.	AVG:	129.9070 g.
Tare Weight:	129.9013 g.	129.9010 g.	AVG:	129.9012 g.
Net Weight:			AVG:	0.0058 g.

Less Acetone Blank Residue: 0 g.

TOTAL PARTICULATE MATTER COLLECTED: 0.0133 g.

PARTICULATE LABORATORY DATA SHEET

Test No.: 3 Source: Forniker Kiln

Acetone Blank: Volume: 100 ml. Net Wt.: 0.0000 g.

Acetone Density: 0.786 g/ml. Residue: 0 g/ml.

Filter

Filter No.: 293

Final Weight: 0.3653 g. 0.3652 g. AVG: 0.3653 g.

Tare Weight: 0.3574 g. 0.3570 g. AVG: 0.3572 g.

Net Weight: AVG: 0.0081 g.

Probe Wash

Probe Wash Beaker No.: 7 Volume: 170 ml.

Final Weight: 128.6236 g. 128.6240 g. AVG: 128.6238 g.

Tare Weight: 128.6155 g. 128.6150 g. AVG: 128.6153 g.

Net Weight: AVG: 0.0085 g.

Less Acetone Blank Residue: 0 g.

TOTAL PARTICULATE MATTER COLLECTED: 0.0166 g.

CERTIFICATE OF ANALYSIS

P.O. BOX 51610, KNOXVILLE, TN 37950-1610
OTHER CARRIERS - 2323 SYCAMORE DR. KNOXVILLE, TN 37921
615/546-1335

Mr. Bruce Lawrie
Air Systems Testing, Inc.
P.O. Box 6278
Marietta, Georgia 30065

April 3, 1989

Received: March 28th

Dear Mr. Lawrie:

Analysis of your compounds gave the following results:

Your #,	Our #,	mg Fluoride/sample,
Florida Tile Test # 1 Imp. Catch 3-7-89	E-8779	5.07
Florida Tile Test # 2 Imp. Catch 3-7-89	E-8780	4.95
Florida Tile Test # 3 Imp. Catch 3-7-89	E-8781	1.78

Sincerely yours,

GALBRAITH LABORATORIES, INC.

Gail R. Hutchens
Exec. Vice-President

GRH:sc

CHAIN OF CUSTODY FORM

Plant: FLORIDA TILE Source: FORKNER KILN

Date Sampled: 3/7-8/89 Run No.: 1-3

SAMPLE RECOVERY

Container No.	Description (if filter, give filter No.)
As marked	FILTER #'s 291, 290, 293
As marked	Probe wash tests 1, 2, 3, & Acetone blank
As marked	IMPINGER catch tests 1, 2, & 3
As marked	IMPINGER Acetone RINSE tests 1, 2, & 3

Person Engaged in Sample Recovery:

Signature & Title: J C Lane

Recovery Location: FLA TILE

Date & Time of Recovery: After each test

Sample Recipient, upon Recovery, if not Recovery person:

Signature: _____

Date & Time of Receipt: _____

Sample Storage: _____

Laboratory Person Receiving Sample:

Signature & Title: J C Lane

Date & Time of Receipt: 3/8/89

Sample Storage: LAB

APPENDIX B
FIELD DATA SHEETS & CALCULATIONS

PARTICULATE TEST FIELD DATA

Company: FLORIDA TILE Source: TUNNEL KILN Test No.: 1
Date: March 7, 1989 Test Team: LAWRIE / FREEMAN
Nozzle Diameter: _____ in. Nozzle Area (Sq.Ft.): _____
Console No.: 1 Meter Calibration: 1.031 Km = 0.699
Stack Diameter: 7.1 in. Stack Area: 0.27 Sq. Ft.
Assumed Moisture: _____ % Stack Static Pressure: 0.0 " w.c.
Stack Temperature: ~460 oF Meter Temperature: ~80 oF
Pressures: Barometric: 29.50 in. Hg. Stack: 29.50 in. Hg.
Probe No.: 3'M1 Filter/Impinger Box No.: 1 Cp = _____
Orsat/Fyrite: % CO2 = 1 %O2 = 19 %N2 = 80
Molecular Weight of Gas: Dry: _____ Wet: _____
K Factor: _____ Minutes/Point: 7.5
Time Start: 11:16 AM E.S.T. Time End: 12:29

Pretest leakchecks OK

Point	Meter Volume	ΔP	ΔH Desire	ΔH Actual	TEMPERATURES Stack	Box	Imp	Meter In	Meter Out	Vacuum
1	366.655	0.23	2.0	2.0	460	235	52	72	72	6
2	372.20	0.17	1.4	1.4	452	240	42	78	72	5
3	376.77	0.21	1.4	1.4	455	245	38	83	73	5
4	381.41	0.21	1.6	1.6	458	245	38	86	74	5
STOP CHANGE PORTS										
1	386.242	0.21	1.5	1.5	456	250	42	79	75	5
2	391.13	0.23	1.7	1.7	457	235	42	82	75	5
3	396.20	0.17	1.4	1.4	455	245	45	85	75	5
4	400.91	0.16	1.3	1.3	457	240	48	87	75	4
END	405.347									

Nozzle: 0.310, 0.310, 0.310, 0.310

Comments:
Post TEST Leak Check
0.002 CFM @ 6 Hg

Pitots OK

Silgel 9.0
IMP 1-3 11
Tot 20.0

STATE OBSERVERS.
JIM NEAL, PATRICK SPRINGSTON, GERALD SLUCHER

PARTICULATE TEST FIELD DATA

Company: FLA TILE Source: FORNIKER KILN Test No.: 2
Date: 3/2/89 Test Team: LAWRIE / FREEMAN
Nozzle Diameter: 0.310 in. Nozzle Area (Sq.Ft.): 0.000524
Console No.: ___ Meter Calibration: 1.031 Km = 0.699
Stack Diameter: 7.1 in. Stack Area: 0.27 Sq. Ft.
Assumed Moisture: 2 % Stack Static Pressure: 0 " w.c.
Stack Temperature: ~460 oF Meter Temperature: ~80 oF
Pressures: Barometric: 29.50 in. Hg. Stack: 29.50 in. Hg.
Probe No.: 3/#1 Filter/Impinger Box No.: 1 Cp = 0.99
Orsat/Fyrite: % CO2 = 1 %O2 = 20 %N2 = 79
Molecular Weight of Gas: Dry: ___ Wet: ___
K Factor: 8 Minutes/Point: 7.5
Time Start: 1:09 PM Time End: 2:21
Pretest leak Checks OK

Point	Meter Volume	ΔP	ΔH Desire	ΔH Actual	TEMPERATURES Stack	Box	Imp	Meter In	Meter Out	Vacuum
1	405.488	0.17	1.4	1.4	491	230	50	74	74	4
2	410.14	0.18	1.5	1.5	460	240	48	79	74	4
3	414.97	0.18	1.5	1.5	458	260	46	84	74	4
4	419.76	0.20	1.6	1.6	481	230	46	86	75	4
	STOP CHANGE PORTS									
1	424.852	0.20	1.6	1.6	453	245	49	78	75	4
2	430.00	0.20	1.6	1.6	458	245	47	84	76	4
3	435.13	0.17	1.4	1.4	462	230	50	87	76	3
4	439.80	0.20	1.6	1.6	455	235	52	88	77	4
END	444.795									

Comments: POST TEST LEAK CHECK 0.022 CFM @ 5 "Hg
PITOTS OK

IMP #3: 30
S. GEL: 7.0
TOTAL: 37.0

PARTICULATE TEST FIELD DATA

Company: FLORIDA TILE Source: FARNIKER KILN Test No.: 3
Date: MAR 8, 1989 Test Team: LAWRIE/FREEMAN
Nozzle Diameter: _____ in. Nozzle Area (Sq.Ft.): 0.000524
Console No.: 1 Meter Calibration: 1.031 KM = 0.699
Stack Diameter: 7.1 in. Stack Area: 0.27 Sq. Ft.
Assumed Moisture: 3 % Stack Static Pressure: _____ " w.c.
Stack Temperature: ~460 oF Meter Temperature: _____ oF
Pressures: Barometric: 29.50 in. Hg. Stack: 29.50 in. Hg.
Probe No.: 3'#1 Filter/Impinger Box No.: 1 Cp = 0.99
Orsat/Pyrite: % CO2 = 1 %O2 = 20 %N2 = _____
Molecular Weight of Gas: Dry: _____ Wet: _____
K Factor: _____ Minutes/Point: 7.5
Time Start: ~~3:00 PM~~ 8:30 AM Time End: 9:37

Point	Meter Volume	ΔP	ΔH Desire	ΔH Actual	TEMPERATURES Stack	Box	Imp	Meter In	Meter Out	Vacuum
1	445.958	0.21	1.7	1.7	458	230	54	76	75	4
2	451.23	0.19	1.6	1.6	462	235	55	82	75	4
3	456.29	0.17	1.4	1.4	495	255	58	86	75	4
4		STOP - NO PRODUCTION								
	~~STOP - CHANGE~~ PORTS									
1	461.144	0.18	1.5	1.5	440	235	62	69	69	4
2	466.07	0.23	1.9	1.9	442	230	46	76	69	4
3	471.45	0.17	1.4	1.4	450	230	44	80	70	4
4	476.10	0.21	1.7	1.7	446	245	42	83	71	4
END	STOP + CHANGE PORTS									
1	481.274	0.23	1.9	1.9	440	240	48	76	73	4
2	486.76	0.21	1.7	1.7	440	240	49	83	73	4
3	491.94	0.22	1.8	1.8	444	235	50	86	74	4
4	497.16	0.20	1.6	1.6	444	245	51	88	75	4
END	502.101									

Comments: POST test leak check 0.020 CFM @ 4 "Hg
PITOTS: OK

IMP 1-329.
S. Gel 12.5
TOTAL: 41.5

Particulate Emission Test Calculations

Company: Florida Tile Source: Forniker Kiln Test No.: 1
Date: March 7, 1989 Test Team: Bruce Lawrie / Jerry Freeman
Nozzle Diameter: 0.310 in. Nozzle Area (Sq.Ft.): 0.000524
Console No.: 1 Meter Calibration: 1.031 Km: 0.699
Stack Diameter: 7.1 in. Stack Area: 0.27 Sq.Ft.
Stack Moisture: 2.4% Stack Static Pressure: 0.0 " w.c.
Stack Temperature: 456 oF Meter Temperature: 78 oF
Pressures: Barometric: 29.50 in. Hg. Stack: 29.50 in. Hg.
Probe No.: 3' #1 Filter/Impinger Box No.: 1 Cp = 0.99
Orsat/Fyrite: % CO2 = 0.0 %O2 = 21.0 %N2 = 79.0
Molecular Weight of Gas: Dry: 28.84 Wet: 28.58
K Factor: 8.2 Minutes/Point: 7.5 Number of Points: 8
Mls: 20.0 Milligrams: 12.6

Vm	^P	Sqrt ^P	^H	Ts	Tm	Tm	I*
366.655	0.23	0.480	2.00	460	72	72	101.8
372.20	0.17	0.412	1.40	452	78	72	96.4
376.77	0.21	0.458	1.40	455	83	73	87.7
381.41	0.21	0.458	1.60	453	86	74	91.0
386.242	0.21	0.458	1.50	456	78	75	92.8
391.13	0.23	0.480	1.70	457	83	75	91.6
396.20	0.17	0.412	1.40	455	85	75	98.6
400.91	0.16	0.400	1.30	457	87	75	95.7
405.347	Final						
			AVERAGES				
38.692		0.445	1.54	456		78	94.4
				916 oR		538	

CALCULATIONS

Volume of Water Vapor Collected (cubic feet):	0.94
Dry gas volume through meter (cubic feet):	38.755
Stack gas moisture content by volume:	2.4%
Stack gas wet molecular weight:	28.58
Actual stack gas volume sampled (cubic feet):	69.82
Stack gas velocity (feet per second):	39.23
Stack gas volumetric flow rate (dscf/minute):	359
Stack gas volumetric flow rate (ACF/minute):	647
Particulate concentration (grains/dscf):	0.0050
Particulate concentration (grains/ACF):	0.0028
Emission rate (pounds per hour):	0.02
Isokinetic sampling rate (percent):	94.5

I* - Point by point isokinetic rate

Particulate Emission Test Calculations

Company: Florida Tile Source: Forniker Kiln Test No.: 2
Date: March 7, 1989 Test Team: Bruce Lawrie / Jerry Freeman
Nozzle Diameter: 0.310 in. Nozzle Area (Sq.Ft.): 0.000524
Console No.: 1 Meter Calibration: 1.031 Km: 0.699
Stack Diameter: 7.1 in. Stack Area: 0.27 Sq.Ft.
Stack Moisture: 4.3% Stack Static Pressure: 0.0 " w.c.
Stack Temperature: 465 oF Meter Temperature: 79 oF
Pressures: Barometric: 29.50 in. Hg. Stack: 29.50 in. Hg.
Probe No.: 3' #1 Filter/Impinger Box No.: 1 Cp = 0.99
Orsat/Fyrite: % CO2 = 1.0 %O2 = 20.0 %N2 = 79.0
Molecular Weight of Gas: Dry: 28.96 Wet: 28.49
K Factor: 7.9 Minutes/Point: 7.5 Number of Points: 8
Mls: 37.0 Milligrams: 13.3

Vm	^P	Sqrt ^P	^H	Ts	Tm	Tm	I*
405.488	0.17	0.412	1.40	491	74	74	102.3
410.14	0.18	0.424	1.50	460	79	74	101.0
414.97	0.18	0.424	1.50	458	84	74	99.6
419.76	0.20	0.447	1.60	481	86	75	101.5
424.852	0.20	0.447	1.60	453	78	75	101.8
430.00	0.20	0.447	1.60	458	84	76	101.1
435.13	0.17	0.412	1.40	462	87	76	99.7
439.80	0.20	0.447	1.60	455	88	77	97.8
444.795	Final						
0.120	Leak						
				AVERAGES			
39.187		0.433	1.53	465		79	100.6
				925 oR		539	

CALCULATIONS

Volume of Water Vapor Collected (cubic feet):	1.74
Dry gas volume through meter (cubic feet):	39.168
Stack gas moisture content by volume:	4.3%
Stack gas wet molecular weight:	28.49
Actual stack gas volume sampled (cubic feet):	72.67
Stack gas velocity (feet per second):	38.42
Stack gas volumetric flow rate (dscf/minute):	342
Stack gas volumetric flow rate (ACF/minute):	634
Particulate concentration (grains/dscf):	0.0052
Particulate concentration (grains/ACF):	0.0028
Emission rate (pounds per hour):	0.02
Isokinetic sampling rate (percent):	100.5

I* - Point by point isokinetic rate

Particulate Emission Test Calculations

Company: Florida Tile Source: Forniker Kiln Test No.: 3
Date: March 8, 1989 Test Team: Bruce Lawrie / Jerry Freeman
Nozzle Diameter: 0.310 in. Nozzle Area (Sq.Ft.): 0.000524
Console No.: 1 Meter Calibration: 1.031 Km: 0.699
Stack Diameter: 7.1 in. Stack Area: 0.27 Sq.Ft.
Stack Moisture: 4.5% Stack Static Pressure: 0.0 " w.c.
Stack Temperature: 444 oF Meter Temperature: 76 oF
Pressures: Barometric: 29.50 in. Hg. Stack: 29.50 in. Hg.
Probe No.: 3' #1 Filter/Impinger Box No.: 1 Cp = 0.99
Orsat/Fyrite: % CO2 = 1.0 %O2 = 20.0 %N2 = 79.0
Molecular Weight of Gas: Dry: 28.96 Wet: 28.47
K Factor: 8.0 Minutes/Point: 7.5 Number of Points: 8
Mls: 41.5 Milligrams: 16.6

Vm	^P	Sqrt ^P	^H	Ts	Tm	Tm	I*
461.144	0.18	0.424	1.50	440	69	69	103.5
466.07	0.23	0.480	1.90	446	76	69	99.8
471.45	0.17	0.412	1.40	450	80	70	100.0
476.10	0.21	0.458	1.70	446	83	71	99.6
481.274	0.23	0.480	1.90	440	76	73	101.1
486.76	0.21	0.458	1.70	440	83	73	99.2
491.94	0.22	0.469	1.80	444	86	74	97.5
497.16	0.20	0.447	1.60	444	88	75	96.5
502.101	Final						
			AVERAGES				
40.957		0.454	1.69	444		76	99.6
				904 oR		536	

CALCULATIONS

Volume of Water Vapor Collected (cubic feet):	1.95
Dry gas volume through meter (cubic feet):	41.173
Stack gas moisture content by volume:	4.5%
Stack gas wet molecular weight:	28.46
Actual stack gas volume sampled (cubic feet):	74.87
Stack gas velocity (feet per second):	39.83
Stack gas volumetric flow rate (dscf/minute):	361
Stack gas volumetric flow rate (ACF/minute):	657
Particulate concentration (grains/dscf):	0.0062
Particulate concentration (grains/ACF):	0.0034
Emission rate (pounds per hour):	0.02
Isokinetic sampling rate (percent):	99.8

I* - Point by point isokinetic rate

TEST CALCULATIONS

I. Determination of Moisture in Stack Gases

a. Volume of Water Vapor Collected (Cubic Feet):

$$Vwstd = 0.04707 * (Vlc)$$

b. Dry Gas Volume Through Meter (Cubic Feet):

$$Vmstd = 17.64 * Vm * Y * [(Pbar + (\hat{}H/13.6)) / Tm]$$

c. Moisture Content: (Bws)

$$Bws = Vwstd / [Vwstd + Vmstd]$$

d. Wet Molecular Weight: (Ms)

$$Ms = [Md * (1-Bws)] + [18.0 * Bws]$$

II. Actual Stack Gas Volume Sampled (Cubic Feet):

$$Vma = [Vmstd * Ts * Pstd] / [(1-Bws) * Tstd * Ps$$

III. Determination of Stack Gas Velocity & Volumetric Flow Rate

a. Stack Gas Velocity (Feet per Second):

$$Vs = Kp * Cp * (\hat{}P) * [SQRT (Ts / (Ps * Ms))]$$

b. Stack Volumetric Flow Rate (Cubic Feet per Minute):

1. Dry Standard Conditions (Qs)

$$Qs = 60 * (1-Bws) * Vs * As * (Tstd/Ts) * (Ps/Pstd)$$

2. Actual Conditions (Qa)

$$Qa = Vs * As * 60$$

IV. Determination of Particulate Concentration (Grainloading)

a. Dry Standard Conditions: (cs)

cs = 0.01543 * (Mn / Vmstd)

b. Actual Conditions: (csl)

csl = 0.01543 * (Mn / Vma)

V. Emission Rate (Pounds per Hour)

E = 60 * Qs * cs / 7000

VII. Determination of Acceptability of Sampling Results: (I)

$$I = \frac{Ts * ((0.00267 * Vlc) + ((Vm*Y/Tm)*(Pbar+(\hat{}H/13.6))))}{0.599 * \theta * Vs * Ps * An}$$

VIII. Excess Air Determination:

% E.A. = [%O2-0.5%CO] / [0.264% N2 (%O2-0.5% N2)] * 100

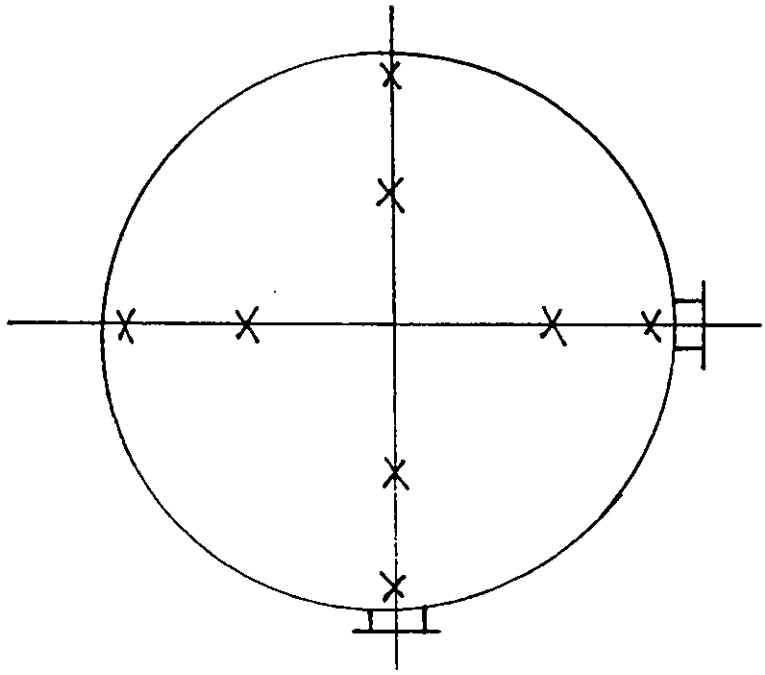
NOMENCLATURE

As	Cross-sectional area of stack, square feet
An	Cross-sectional area of nozzle, square feet
ACF	Actual cubic feet of gas at stack conditions
ACFM	Actual cubic feet of gas per minute at stack conditions
Bws	Proportion by volume of water vapor in gas stream
cs	Lead concentration in stack gas, gr/dscf
csl	Lead concentration in stack gas, gr/ACF
Cp	Pitot tube coefficient
delta H	Pressure drop across orifice meter, inches water
dp	Nozzle diameter, inches
delta P	Velocity head of stack gas, inches water
dscf	Cubic feet of dry gas corrected to standard conditions
E	Lead emission rate, pounds/hour
Kp	Constant (85.49)
Mn	Total lead collected, mg
I	Percent of isokinetic sampling
Pbar	Barometric pressure, inches mercury
Pm	Barometric pressure of dry gas meter, in. mercury
Ps	Absolute stack gas pressure, inches mercury
Pstd	Barometric pressure, standard conditions, 29.92 "Hg
Qa	Volumetric flow rate, actual conditions, ACF/min
Qs	Volumetric flow rate, dry standard conditions, dscf/min
Tm	Absolute average dry gas meter temperature, degree R
Ts	Absolute average stack gas temperature, degree R
Tstd	Absolute temperature at standard conditions, 528 R

θ	Total sampling time, minutes
Vlc	Total volume collected in impingers and silica gel, ml
Vm	Volume of gas sampled through gas meter, cubic feet
Vma	Stack gas volume sampled, ACF
Vmstd	Volume of gas sampled through gas meter, cubic feet
Vs	Average stack gas velocity, feet/sec
Vwstd	Volume of water vapor in gas sampled, standard cubic feet
Y	Dry gas meter calibration factor

APPENDIX C
SCHEMATIC OF SAMPLING LOCATION

Sampling Point Location
for
Forniker Kiln Exhaust



7.1 inch Diameter Stack

Sampling Point	Distance From Stack Wall (Inches)
1	0.5
2	1.8
3	5.3
4	6.6

APPENDIX D
TEST EQUIPMENT & CALIBRATION DATA

MODULAR SAMPLE CASE

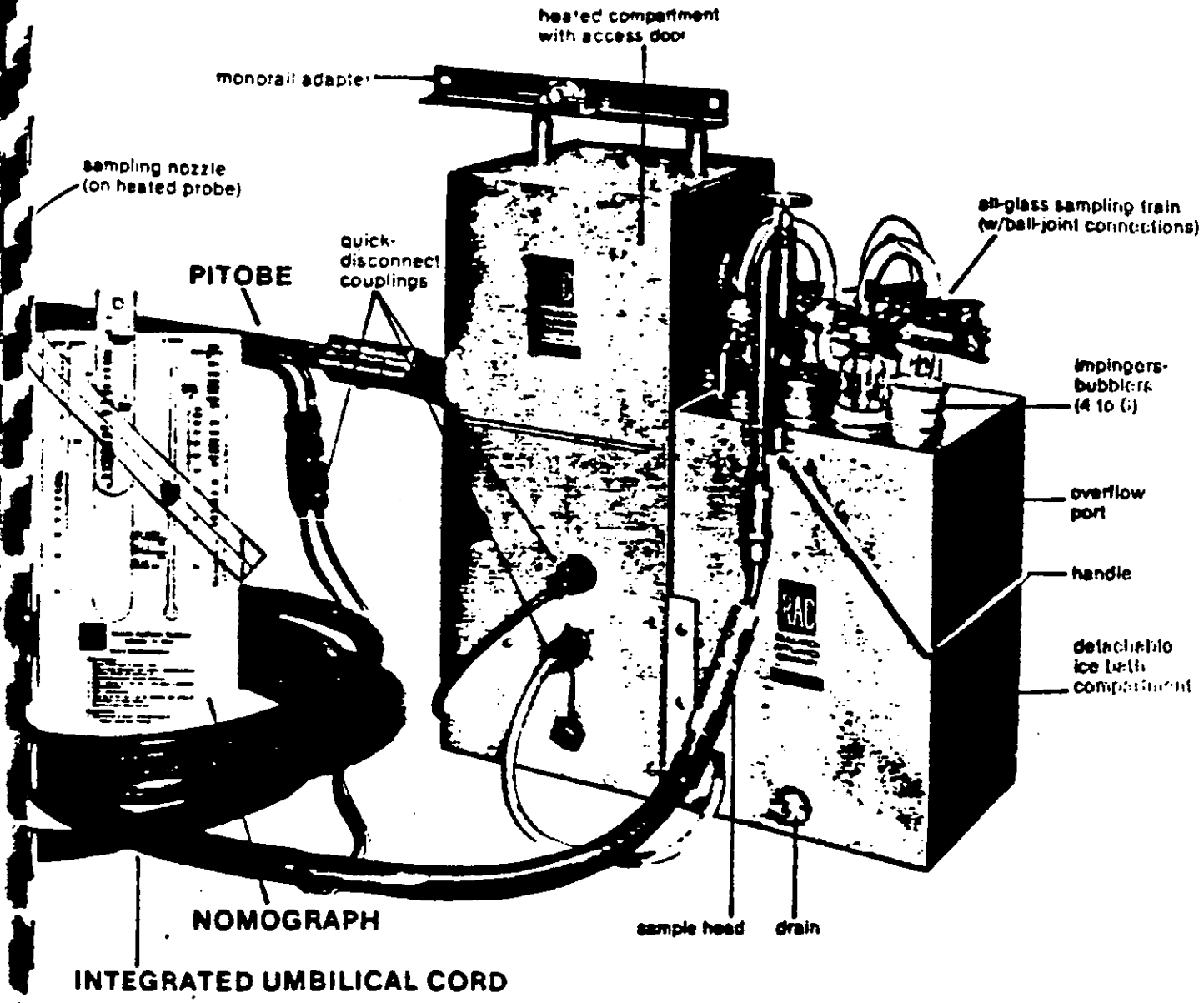


FIGURE 7
RAC Staksampler components & design features.

Heated Compartment:
Deviation from Set Point: ±5°F.
Thermal Gradient: 4°F
(top to bottom)

Glass Sampling Train:
1 cyclone, 1 flask, 1 filter-holder, 4 impinger-bubbler units* (500 ml), 3 "U" connectors, 1 elbow (all with balljoint connections 28/15 inlets and 28/12 outlets), 12 metal clamps.

*Ice bath and sampling train are designed to accommodate 6 impinger-bubbler units

PITOBE ASSEMBLY

Combines heated probe & detachable pitot tube; 3', 5' & 10' effective lengths; stainless steel construction; ball-joint & quick-disconnect attachments; 3' & 5' units with Pyrex glass or stainless steel liners, 10' with stainless steel liner only.

Sampling Nozzles: ¼", ⅜" & ½" ID stainless steel units supplied with pitobe, other optional sizes and materials are available.

UMBILICAL CORD

Contains pitot & sample lines plus power cable, all with quick disconnects; also contains leads for 2-way intercom; supplied in modular 25', 50', 75', 100', 200' & 300' lengths that weigh 10 lbs per section.

ELECTRICAL

System operates on 115 v, 60 Hz, 13.6 amps (total) in steady running; all connections are 3-wire grounding type. Optional 220 v, 50 Hz system available

contain water or suitable chemical reagents). At this stage, the water vapor is removed by a combination of condensation and a column of silica gel, and entrained gases may be collected by reactive chemicals contained in the impinger-bubbler units. The cleaned, dry air then is passed through the umbilical cord to the meter control case, where it is recorded by the dry gas meter and discharged.

Air stream velocity and volume are regulated by, and displayed on, instrumentation in the control console. Air stream temperature measurements also are made and displayed in this console. All data displays are cumulative or real time measurements.

The number of samples that can be taken at one location, in a single day, usually is limited only by the number of modular subsystems available on-site. A full series of samples can be taken by using different, interchangeable impinger modules and pitobes. Each impinger module can be preassembled with the sample-collecting train of proper configuration for the specific effluent to be sampled. The only changes to be made are the disconnection-connection of the impinger modules and pitobes. The same heated compartment, meter control case, and umbilical can be used for all sampling series.

The nomograph is used during sampling operations to correlate manometer readings from the probe with manometer readings from the pitot tube. These calculations reveal when and if adjustments in sampling rate are necessary to maintain isokinetic sampling conditions.

•specifications

METER CONTROL CASE

STANDARD

Contains vacuum pump, inclined-vertical manometer, dry gas meter, thermometers, controls and selector switches; steel w/baked enamel finish; 15" W x 24" H x 13½" D; weight 87 lbs.

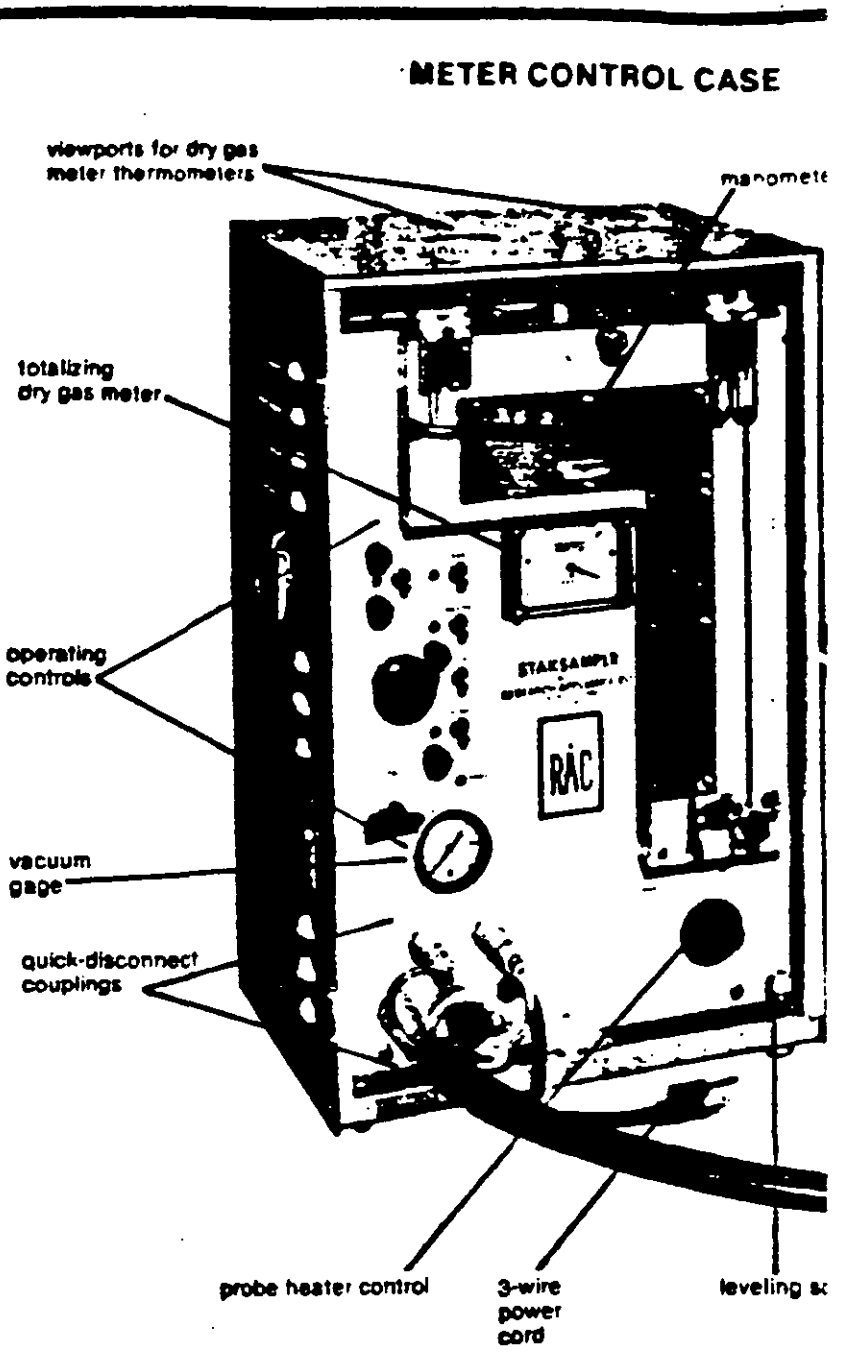
Pump: ¼ hp, 1725 rpm, 5.4 amps, 4 cfm free flow, fused (for overload protection).

Manometer: Dual column, encased design; 0-1.0" water (0.01" MD) inclined scale; 1.1-10" water (0.1" MD) vertical scale, ±1% full scale accuracy.

Dry Gas Meter: 0-999.9 cu ft (digital readout).

LCD

Contains liquid crystal display (LCD) temperature indicator, inclined-vertical manometer, dry gas meter, Type K Chromel-Alumel thermocouples, circuit breaker selector switches and operating controls steel w/baked enamel finish; 20½" W x 17" H x 10" D; weight 49 lbs.



Digital Temperature Indicator: Liquid crystal display for Type K Chromel-Alumel thermocouple sensors; equipped with thermostatically controlled heater; 10 position selector switch; field-selectable temperature scales of −199° to +1999°F or −128° to +1093°C, open thermocouple indication and automatic reference compensation, ±0.25% full scale accuracy.

Manometer: Dual column, encased design, 0-1.0" water (0.01" MD) inclined scale; 1.1-6" water (0.1" MD) vertical scale; ±1% full scale accuracy.

Dry Gas Meter: 0 - 999.9 cu ft (digital readout).

Pump/Motor Assembly: External rotary vane vacuum pump w/totally-enclos fan cooled motor, ¼ hp, 1725 rpm, 5 amps, 4 cfm free flow, w/thermal ov load protection; weight 32 lbs.

MODULAR SAMPLE CASE

Supports pitobe, contains all-glass sa pling train; aluminum construction baked enamel finish. Has two separa compartments. One is insulated and he ed, has a circulating fan for even he distribution and contains particle-c lecting cyclone, flask and filter; the oth is a detachable ice bath containing fr 4 to 6 impinger-bubbler units. Ove size 18½" L x 20½" H x 9¾" D. We approx 32 lbs including glassware.

Digital Temperature Display

Staksampir LCD is a complete stack sampling system which provides accurate digital temperature readouts for 6 different points in the system. Thermocouples replace dial thermometers and are used to obtain temperature readings (1) in the stack (2) at the probe liner, (3) in sample case heated compartment, (4) at outlet of last impinger, (5) at dry gas meter inlet, and (6) at dry gas meter outlet. The meter control case is equipped with a liquid crystal display (LCD) temperature indicator and external pump and is compatible with all existing RAC Staksampirs.

Large Filter Holders

When a high volume of particulate matter is encountered, interchangeable 3" (80 mm, P/N 201012) and 4" (110mm P/N 201013) glass units can be substituted for 2.5" (64mm, P/N 997065) particle filter in sample case heated compartment. All sizes of RAC filter holders are equipped with a fritted glass disc to support the filter media.

Water-Jacketed Pitobes

These jacketed units use circulating water to withstand stack temps over 800°F; available in 3', 5' & 10' effective lengths.

Stainless Steel Impingers-Bubblers

For applications in which breakage of glassware is a common problem, RAC offers optional stainless steel impingers (P/N 201093) & bubbler units (P/N 201092) with ball-joint connections. These unbreakable all-metal units are interchangeable with the std glassware.

Sectionalized Pitot Tube

Three modular sections provide an S-type pitot with effective lengths of 10' & 15'.

Digital Pocket Pyrometer

Pocket-sized, battery powered thermocouple pyrometer provides stable, accurate temperature readings. Type K thermocouple (supplied separately) attaches to pitobe and provides temperatures over a range of 50° to 1900°F (P/N 992726) or 10° to 1100°C (P/N 992726-1).

Slide Rule Nomograph

Performs presampling and during-sampling isokinetic calculations easily and accurately; handy, standard, slide rule body; very accurate and versatile, no assumptions are necessary; calculates nozzle diameter and isokinetic sampling rate (P/N 201014); optional slide rule (P/N 201127; available if meter moisture content is greater than 2.5% and/or dry molecular weight is not 29 ± 1.

Special Probe Liners

In addition to the standard Pyrex glass and Type 304 stainless steel liners furnished as standard with RAC probes, optional liners made of Teflon, Type 316 stainless steel, quartz, and Inconel also are available on special order. These liners are furnished in standard lengths of 3', 5' or 10' (except for Pyrex glass and quartz) and special lengths can be supplied to order.

Flexible Sampling Lines

For sampling operations in confined or physically restricted areas, RAC offers flexible, heated, sample-collecting lines that allow the pitobe to be separated from the sample case by distances up to 20' with no loss in sampling efficiency. Available in 5', 10', 15' & 20' lengths, these flexible lines can be used for gas streams with temps up to 300°F (max), and have std ball-joint connections at both ends. A variable voltage device controls temp range in the sample line and prevents burn-out of integral heating wires. Pitot extension lines may be required.

Stack Interface

This instrument adapts the Staksampir control console for use with the RAC Stack Gas Train sample case, which uses midget (30 ml) impingers for sampling moisture *(EPA Method 4)* and SO_2 *(EPA Method 6)* in stacks or ducts, has flowmeter to monitor the low flow rates required, drying tube & connections for sampling pitot & electrical lines (P/N 997503).

Andersen In-Stack Fractionating Sampler

Precision, multi-stage, stainless steel unit collects & automatically classifies particles into 8 sizes (ranging from +20.0 microns down to 0.36 microns dia) according to their aerodynamic characteristics; isokinetic techniques can be used for sampling in stacks with velocities from 100 to 12,000 fpm & temps to 1500°F; adapts to all RAC probes (P/N 201037).

Gas Stream Hygrometer

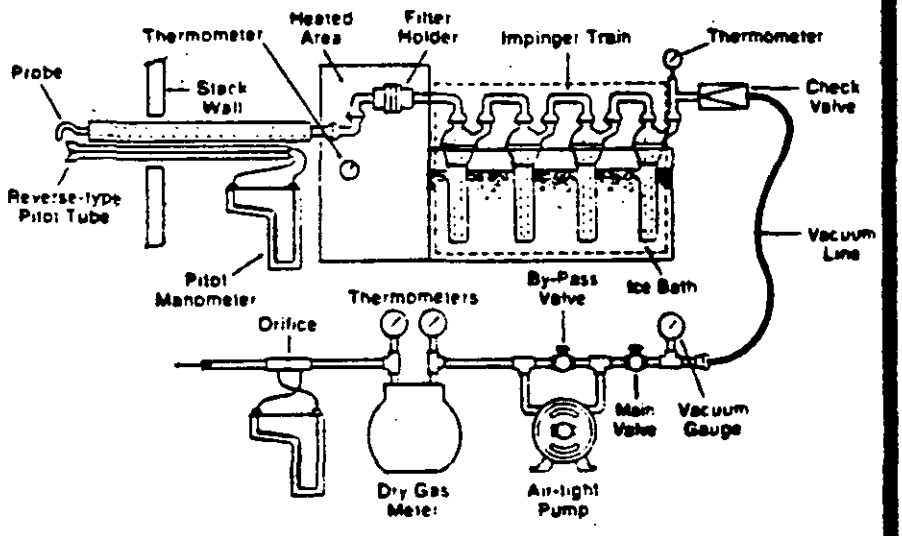
Uses matched (0–220°F) wet-bulb and dry-bulb thermometers to measure percent of water vapor in stack gas streams with temps below 212°F; stainless steel construction (P/N 997517).

Alundum Thimble Filter (In-stack)

Uses 45 x 127mm Alundum (...) thimble of coarse porosity for dry collection of particles entrained in gas streams with temps to 1500°F; glass-fiber and

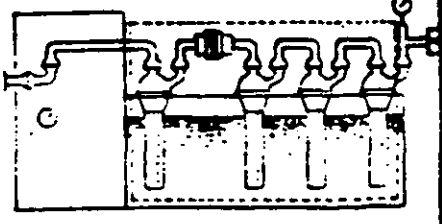
RAC Staksampir Schematic of EPA Particulate Sampling Train (Method 5)

Same basic configuration used to sample Beryllium & Mercury Vapor (Federal Register, Vol. 36, Nos. 234 [Be, Hg] & 247)



Configuration of Sample Case for sampling SO_3, SO_2 & H_2SO_4 MIST (Method 8)

Heated area is by-passed; particulate filter positioned between 1st & 2nd impingers; all other components same as for particulate sampling.
(Federal Register, Vol. 36, No. 247)



AST, Inc.
Post Test Meter Calibration
Console #1

^H	^cm	V1cm	V2cm	V1dgm	V2dgm	Tcm	T1	T2
1.2	0.0	815.921	825.633	744.423	753.976	65	72	63
							83	66
1.2	0.0	825.633	833.831	753.976	762.065	65	78	66
							86	67
1.2	0.0	833.831	840.933	762.065	769.108	65	79	67
							87	68
Pb =	29.05							

MCF = 1.025
MCF = 1.028
MCF = 1.025

Average MCF = 1.026

Calibrated by: JBLam

Date: 4/4/89

THERMOCOUPLE/THERMOMETER CALIBRATIONS

Device	Reading (oF)	ASTM Reference Thermometer (oF)
#1 METER INLET	32/207	33/211
#1 METER OUTLET	32/207	33/211
3' #1 PROBE	33/212	33/211
5' #1 PROBE	33/211	33/211
FILTER BOX #1	215	211
IMP. OUTLET T/C	33/212	33/211
IMP OUT THERMOMETER	30	33

JB Lam
3/27/89