EVALUATOR Dean C. EVALUATION DATE 8-10-92

METHOD 5: SECONDARY EMISSIONS TEST REPORT EVALUATION

STATE: GA FACILITY: PROCTOR & GAMBLE TEST DATE: 7-18-88

PROCESS(ES) TESTED: POWDERED SOAP DETERGENT (Particulate Emissions) SPRAY DRYER

SAMPLING DURATION 3
must have at least 3 runs, each ≥ 1 hour duration, with sampling ≥ 2 minutes at each traverse point, and total sampling volume ≥ 30 dscf

PRODUCTION RATE 3
is process or production rate during testing representative of normal rates

23.8 tons/hr

Max = 24/hr

CONTROL DEVICE(S) 3
are devices described, and their efficiencies given

CYCLONES / PACKED BED

METHOD 1 ✓ 3
are calculations accurate, and is figure provided

24 pts

METHODS 2.3 3
are data and calculations included for gas velocity, cyclonic flow, and molecular weight determination, and is source of barometric pressure noted

Bar. Press = 29.9 in. Hg

METHOD 4 3
~~are data and calculations~~ included for moisture content determination, and is ~~moisture content realistic~~ (< saturation)

FIELD DATA is field data on standard forms, and does raw data correspond with printout 3

BOILER TESTS calculation of F from Orsat accurate

SAMPLING TEMPERATURE 3
both probe and filter must be maintained at 248 ± 25°F or other temperature specified in NSPS

245 – 260 °F

BACK-HALF 2
if any, what method was used to catch and recover condensible matter

M5 ?

EQUIPMENT were a borosilicate glass probe liner and a glass fiber filter used 2

glass mat.?

CALIBRATION were both pre- and post-test calibrations performed for

- meter box 3
- pitot tube 3
- temperature sensor 3
- nozzle (3 #) 3

LEAK CHECKS both pre- and post-test 3

BLANKS were filter and reagent blanks analyzed, and were any problems addressed 3

SAMPLE PREP filter desiccation and tare weights documented 3

ISOKINETICS within 100±10% for all runs 3

98, 97, 95

Georgia Department of Natural Resources
205 Butler Street, S.E., East Floyd Tower, Atlanta, Georgia 30334
Joe D. Tanner, Commissioner
Harold F. Reheis, Director
Environmental Protection Division

February 14, 1992

Mr. John Hamilton
Pacific Environmental Services
3325 Chapel Hill Boulevard
Cedar Terrace
Suite 250
Durham, N.C. 27707

Dear Mr. Hamilton:

As per your request attached is a copy of the test report for the detergent spray dryer at Procter & Gamble, Augusta. four cyclones are used for product recovery followed by two packed bed scrubbers with tubular wet electrostatic precipitators.

Also attached is a test report from a much smaller detergent spray dryer at Time Products in Atlanta. Emissions from this spray dryer are controlled by a spray chamber with a mist eliminator.

Note that the operating capacities are in tons per hour of detergent slurry on a dry basis.

Should you have any questions or comments, please contact me at 404/656-4867.

Sincerely,

James P. Johnston
Environmental Engineer
Air Pollution Compliance Program

enclosures

Georgia Department of Natural Resources
205 Butler Street, S.E., Floyd Towers East, Atlanta, Georgia 30334
J. Leonard Ledbetter, Commissioner
Harold F. Reheis, Assistant Director
Environmental Protection Division
(404) 656-4713

MEMORANDUM

STORAGE

RECEIVED FEB 13 1992 AIR PROTECTION BRANCH

TO: Mr. Marvin M. Lowry

THROUGH: Michael E. Fogle

FROM: L. Webber

SUBJECT: Source Test Report Review

The following tests have been reviewed and were conducted in an acceptable fashion for the purpose intended.

COMPANY & LOCATION: PROCTER & GAMBLE MANUFACTURING CO., AUGUSTA, GA.

SOURCE TESTED: SPRAY DRYER

POLLUTANT DETERMINED: PARTICULATE

REPORT REVIEWED BY: L Webber

TEST WITNESSED BY: SCOTT

DATE(S) OF TESTS: 7/18/88

DATE REC'D BY APB: 8/17/88

TEST RUN:	1	2	3	AVG.
MAXIMUM EXPECTED OPERATING CAPACITY:	~ 24 TONS/hr			
OPERATING CAPACITY:	23.8 TONS/hr			
ALLOWABLE EMISSION RATE:	34.3 lbs/hr			
APPLICABLE REGULATION:	391-3-1-.02(2)(e)(ii)			
CONTROL EQUIPMENT & OPERATIONAL DATA:	Cyclones/Packed Bed Scrubber/Electrostatic Precipitator			
OPACITY (Unofficial data--not for compliance determination):	No data			
GAS TEMPERATURE (°F):	137	146	144	
GAS MOISTURE (%):	17.0	19.0	17.3	
GAS FLOW RATE (ACFM):	130,201	132,720	133,064	
GAS FLOW RATE (DSCFM):	95,640	93,854	96,422	
POLLUTANT CONCENTRATION (GRAINS/DSCF):	0.010	0.006	0.007	
EMISSION RATE: LBS/HR	18.5	26.0	22.4	22.3
PERCENT OF ALLOWABLE:	65			

OTHER INFORMATION:

cc: Mr. John W. Mitchell
Mr. Michael E. Fogle

SM-23
Rev. (9) 8/86

J. D.
9/12/88

Georgia Department of Natural Resources

205 Butler Street, S.E., Floyd Towers East, Atlanta, Georgia 30334

J. Leonard Ledbetter, Commissioner
Harold F. Reheis, Assistant Director
Environmental Protection Division
(404) 656-4713

DATE: 9/6/88

1988

M E M O R A N D U M

TO: Michael E. Fogle, Program Manager
Source Test Unit

FROM: Jimmy Johnston
Environmental Engineer
Air Pollution Compliance Program

SOURCE IDENTITY AND EMISSION POINT:
Procter & Gamble, Augusta
Spray Dryer

DATE(S) TEST PERFORMED: 7/18/88

I have reviewed the attached emission test report and found that the contents comply with State and Federal statutory requirements and all applicable permit conditions. Any differences are indicated below:

☐ No fuel analysis included ☐ No description of control device

☐ Description of process not included

☐ Process input weight rate or BTU input not documented properly

☐ No control device operational parameters

☐ Other - explain

☐ These noted differences should not significantly change the reported emissions to the atmosphere and should not be a basis for report rejection. The source will be notified of them in the test report acceptability letter.

Complete the following:

Applicable Rule or Regulation:
391-3-1-.02(2)(e)(ii)

Maximum expected operating capacity:

Operating capacity:
23.8 tons/hr

Reported emissions to atmosphere:
22.3 #/hr

Computed allowable:
34.3 #/hr

SM-67 (1)
Rev. (3) 8/80

EMISSION DATA SUMMARY

COMPANY: PROCTER & GAMBLE MANUFACTURING CO. DATE OF TEST: 7/18/88

SAMPLING FIRM: ENTROPY ENVIRONMENTALISTS, INC. SOURCE TESTED: SPRAY DRYER

Run Number	"TOTAL1"	"TOTAL2"	"TOTAL3"
Stack Temperature (°F)	136.8	146.2	144.2
Stack Moisture (%)	17.3	19.0	17.3
Stack Gas Flow Rate (ACFM)	130,029.7	132,514.4	132,833.0
Stack Gas Flow Rate (DSCFM)	95,239.4	93,691.0	96,218.6
Pollutant Concentration (gr/DSCF)	0.0230	0.0323	0.0271
Emission Rate (LBS/HR)	18.783	25.957	22.328
Capacity (TONS/HR)	23.8	23.8	23.8
Meter Temperature (°F)	96.7	102.0	109.9
Meter Pressure (in. H_2O)	1.849	1.918	1.795
($\sqrt{\Delta p}$)avg	0.553	0.557	0.562
Sample Volume @ Meter (ft^3)	44.993	45.323	46.045
Sample Volume (DSCF)	42.650	42.771	42.630
Stack Gas Velocity (ft./sec.)	34.07	34.72	34.80
Molecular Weight (lb./lb-mole)	27.06	26.87	27.06
Isokinetics (%)	96.3	96.8	95.2

COMMENTS: TOTAL CATCH

INITIAL: REC

SM-67 (2)
Rev.(3)8/80

EMISSION DATA SUMMARY

COMPANY: PROCTER & GAMBLE MANUFACTURING CO.   DATE OF TEST: 7/18/88

SAMPLING FIRM: ENTROPY ENVIRONMENTALISTS, INC.   SOURCE TESTED: SPRAY DRYER

Run Number	"TOTAL1"	"TOTAL2"	"TOTAL3"
Particulate Mass (gms.)	0.06360	0.08960	0.07480
Initial Meter Volume (ft^3)	1.000	0.000	0.000
Final Meter Volume (ft^3)	45.993	45.323	46.045
H_2O Collected (mls.)	189.0	213.0	189.5
% CO_2	0.0	0.0	0.0
% O_2	20.9	20.9	20.9
Barometric Pressure (in. Hg)	29.90	29.90	29.90
Stack Pressure (in. H_2O)	0.50	1.10	1.20
Time of Test (min.)	60.00	60.00	60.00
Pitot CP	0.840	0.840	0.840
Meter Correction Factor	0.996	1.001	0.996
Nozzle Diameter (in.)	0.300	0.302	0.300
Stack Dimension (in.)	108.0	108.0	108.0
Stack Dimension (in.)	0.0	0.0	0.0
F-Factor	0.0	0.0	0.0

COMMENTS:

INITIAL: REC

THE PROCTER & GAMBLE MANUFACTURING COMPANY

3464 OLD SAVANNAH ROAD
AUGUSTA, GEORGIA 30906

P.O. BOX 1496
AUGUSTA, GEORGIA 30913-1496
TELEPHONE: 404-796-4100

August 8, 1988

RECEIVED

AUG 17 1988

AIR PROTECTION BRANCH

Mr. James P. Johnston
Environmental Engineer
Air Pollution Compliance Program
Georgia Department of Natural Resources
205 Butler Street, S. E.
Floyd Towers East
Atlanta, Georgia 30334

Dear Mr. Johnston,

As required in your letter of April 15, 1988, under the authority of Condition 3 of Air Quality Permit No. 2841-121-9663, we have conducted a particulate matter performance test on our spray dryer.

The performance test was completed prior to August 12, 1988 as directed. The test was conducted and the data was reduced in accordance with methods and procedures approved by the Division prior to testing. An observer from the Division, Mr. Robert Scott, was present during a portion of the testing.

During the test, Procter & Gamble determined and recorded the slurry flow rate, density and solids content, the scrubbant flow rate and ESP parameters. These records are being submitted along with the test report as requested by the Division.

The test report is being submitted to you within 30 days of the completion of the testing as required by the division.

If you have any questions or comments, please contact William T. DeBreau at 404-796-4199.

Sincerely,

R A Bradford

R. A. Bradford
Plant Manager

ENTROPY

ENVIRONMENTALISTS INC.

POST OFFICE BOX 12291
RESEARCH TRIANGLE PARK
NORTH CAROLINA 27709-2291
919-781-3550

STATIONARY SOURCE SAMPLING REPORT

EEI REF. NO. 5949B

THE PROCTER & GAMBLE MANUFACTURING COMPANY

AUGUSTA, GEORGIA

PARTICULATE EMISSIONS TESTING

MSG TOWER STACK

July 18, 1988

REPORT CERTIFICATION

The sampling and analysis performed for this report was carried out under my direction and supervision.

Date August 8, 1988 Signature B. Dwain Ritchie

B. Dwain Ritchie

I have reviewed all testing details and results in this test report and hereby certify that the test report is authentic and accurate.

Date August 8, 1988 Signature D. James Grove

D. James Grove, P.E.

ENTROPY

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INTRODUCTION

1.1 Outline of Test Program. Stationary source sampling was performed at The Procter & Gamble Manufacturing Company in Augusta, Georgia, on July 18, 1988. Three EPA Method 5 runs were performed at the MSG tower stack to determine the particulate emissions for compliance purposes.

1.2 Test Participants. Table 1-1 lists the personnel present during the test program.

TABLE 1-1
TEST PARTICIPANTS

The Procter & Gamble Manufacturing Company	Bill Debreau Test Coordinator
	Wiley Kitchings Test Observer
Georgia Department of Natural Resources	Robert Scott Test Observer
Entropy Environmentalists, Inc.	B. Dwain Ritchie Project Supervisor
	Joseph R. Winslow Engineering Technician

SUMMARY OF RESULTS

2.1 Presentation. Table 2-1 presents the particulate emissions for the testing performed July 18, 1988, at the MSG tower stack. Detailed test results are presented in Appendix A; field and analytical data are given in Appendix B.

2.2 Average Emission Rate. The average emission rate for the filterable particulate was 6.35 lbs/hr. The average emission rate for the filterable plus condensable particulate was 22.3 lbs/hr.

TABLE 2-1

PARTICULATE TESTS SUMMARY OF RESULTS

MSG Tower Stack

	1	2	3	Average
Test Date	7/18/88	7/18/88	7/18/88	
Run Start Time	732	912	1034	
Run Finish Time	835	1017	1136	
<u>Test Train Parameters:</u>				
Volume of Dry Gas Sampled, SCF*	43.557	42.758	42.607	42.974
Percent Isokinetic	98.4	97.1	95.4	97.0
<u>Flue Gas Parameters:</u>				
Temperature, Degrees F	137	146	144	142
Volumetric Air Flow Rates				
SCFM*, Dry	95,640	93,854	96,422	95,305
ACFM, Wet	130,201	132,720	133,064	131,995
<u>Particulate Results, Filterable</u>				
Concentration, grains/DSCF*	0.0103	0.00559	0.00743	0.00776
Emission Rate, lbs per Hour	8.42	4.50	6.14	6.35
<u>Particulate Results, Filterable + Condensable</u>				
Concentration, grains/DSCF*	0.0225	0.0323	0.0271	0.0273
Emission Rate, lbs per Hour	18.5	26.0	22.4	22.3

* 68 Degrees F -- 29.92 Inches Of Mercury (Hg)

PROCESS DESCRIPTION AND OPERATION

3.1 General. The Procter & Gamble Manufacturing Company in Augusta, Georgia, operates a spray dryer system for the production of granular detergent. A slurry containing water enters the spray tower and is mixed with air. Dried granular detergent entrained in the sprayer gases drops out of the tower.

3.2 Source Air Flow. Figure 3-1 is an air flow schematic showing the passage of gases exhausted from the MSG spray tower.

3.3 Operation During Testing. Process data supplied by The Procter & Gamble Manufacturing Company is presented in Appendix D.

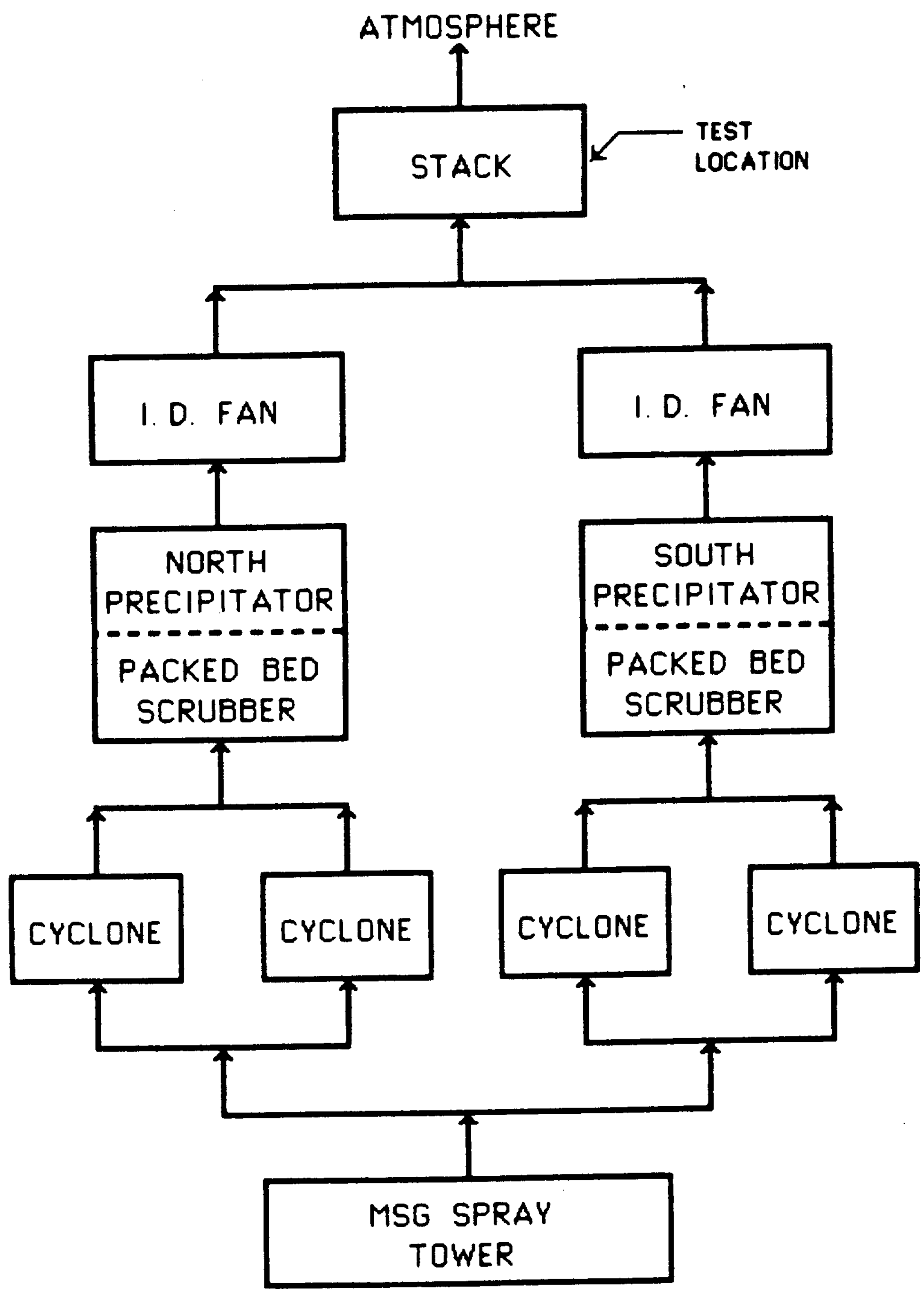


FIGURE 3-1. MSG SPRAY DRYER SYSTEM AIR FLOW SCHEMATIC.

SAMPLING AND ANALYTICAL PROCEDURES

4.1 General. All sampling and analytical procedures were those recommended by the United States Environmental Protection Agency and the Georgia Department of Natural Resources. Descriptions of the sampling equipment and procedures (extracted from 40 CFR 60) are provided in Appendix E.

4.2 Sampling Points. The number and location of the sampling points were determined according to the procedures outlined in EPA Method 1. The stack cross section was divided into 24 equal areas with 12 sampling points on each of two axes, as shown in Figure 4-1.

4.3 Volumetric Air Flow Rates

4.3.1 Flue Gas Velocity. EPA Method 2 was used to take the velocity measurements during the traverses of the stack cross section.

4.3.2 Flue Gas Composition. The flue gas composition and molecular weight were assumed to be that of ambient air.

4.3.3 Flue Gas Moisture. Moisture content was determined by analyzing the sampling train impinger reagents according to the procedures outlined in EPA Method 5.

4.4 Emissions Determinations

4.4.1 Filterable. EPA Method 5 analytical procedures were used to determine the filterable particulate emissions.

4.4.2 Condensable. The sampling train distilled water reagent and acetone rinses were analyzed to determine the condensable particulate emissions. For each run, the reagent was extracted three times with Freon.

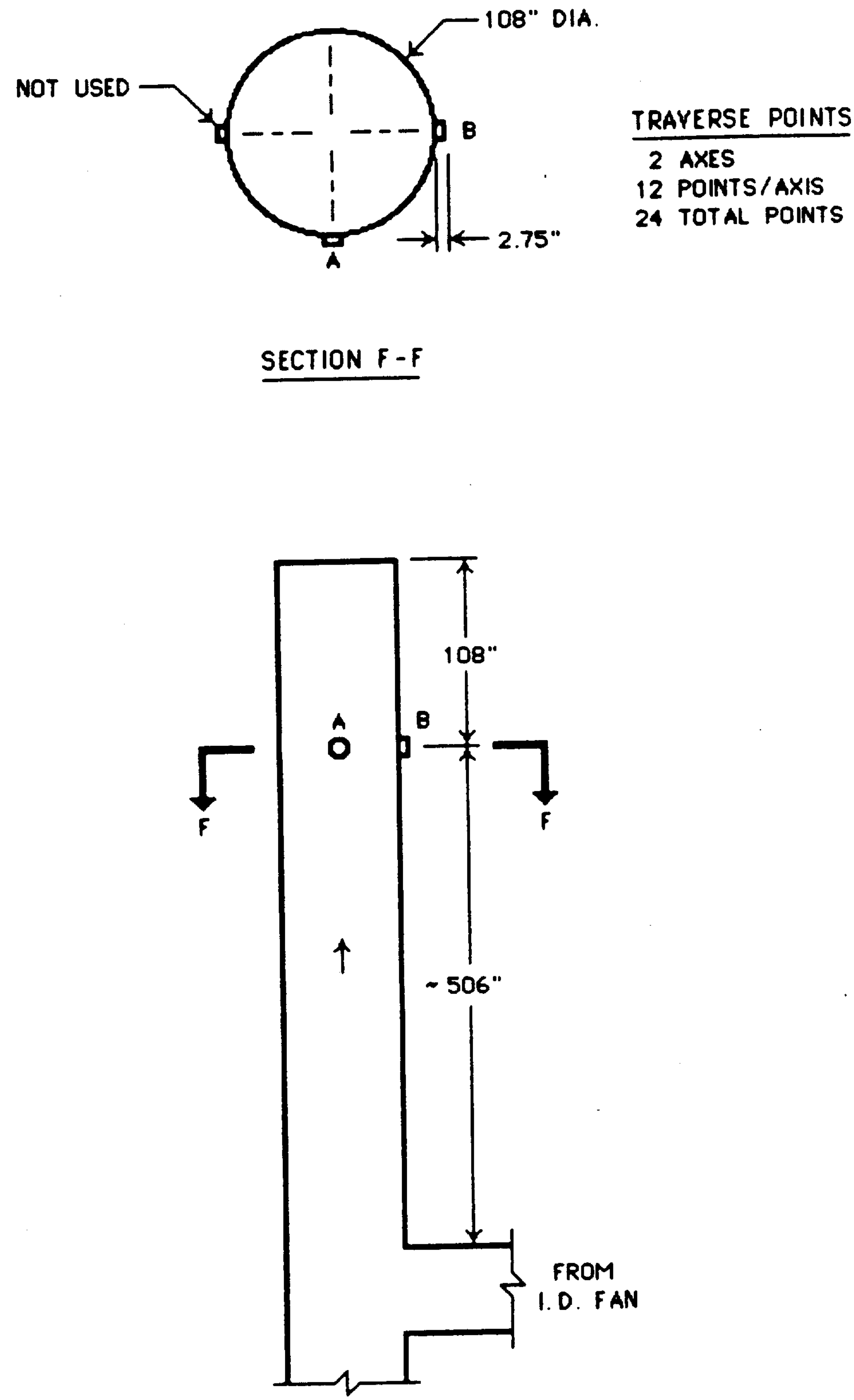


FIGURE 4-1. MSG SPRAY TOWER PRECIPITATOR STACK TEST LOCATION

The Freon extractable phase was evaporated to dryness at room temperature and desiccated. After extraction, the water phase was evaporated to dryness on a steam bath (not exceeding 210°F) and desiccated. An acetone rinse of the impingers and connecting glassware was evaporated to dryness in a fume hood and desiccated. Following desiccation, a gravimetric analysis was performed on each phase to determine the weight of the residue. The sum of the weight of the Freon extractable phase, the water phase, and the acetone rinse phase is reported as condensable particulate.

4.5 Equipment Calibration. Pertinent calibration data are provided in Appendix C.

APPENDIX A

TEST RESULTS AND EXAMPLE CALCULATIONS

FIELD DATA AND RESULTS TABULATION

PLANT: Procter and Gamble Manufacturing Co., Augusta, Georgia

SAMPLING LOCATION: MSG Tower Stack

		1	2	3
	Test Date	7/18/88	7/18/88	7/18/88
	Run Start Time	732	912	1034
	Run Finish Time	835	1017	1136
	Net Traversing Points	12	12	12
Theta	Net Run Time, Minutes	60	60	60
Dia	Nozzle Diameter, Inches	0.300	0.302	0.300
Cp	Pitot Tube Coefficient	0.84	0.84	0.84
Y	Dry Gas Meter Calibration Factor	0.9956	1.0005	0.9956
Pbar	Barometric Pressure, Inches Hg	29.9	29.9	29.9
Delta H	Avg. Pressure Differential of Orifice Meter, Inches H2O	1.85	1.92	1.80
Vm	Volume of Metered Gas Sample, Dry ACF	45.993	45.323	46.045
tm	Dry Gas Meter Temperature, Degrees F	97	102	110
Vm(std)	Volume of Metered Gas Sample, Dry SCF*	43.557	42.758	42.607
Vlc	Total Volume of Liquid Collected in Impingers & Silica Gel, mL	189.0	213.0	189.5
Vw(std)	Volume of Water Vapor, SCF*	8.896	10.026	8.920
%H2O	Moisture Content, Percent by Volume	17.0	19.0	17.3
Mfd	Dry Mole Fraction	0.830	0.810	0.827
Md	Gas Molecular Weight, Lb/Lb-Mole, Dry	28.84	28.84	28.84
Ms	Gas Molecular Weight, Lb/Lb-Mole, Wet	27.00	26.78	26.96
Pg	Flue Gas Static Pressure, Inches H2O	0.5	1.1	1.2
Ps	Absolute Flue Gas Pressure, Inches Hg	29.94	29.98	29.99
ts	Flue Gas Temperature, Degrees F	137	146	144
Delta-p	Average Velocity Head, Inches H2O	0.3055	0.3106	0.3154
vs	Flue Gas Velocity, Feet per Second	34.11	34.77	34.86
A	Stack/Duct Area, Square Inches	9,161	9,161	9,161
Qsd	Volumetric Air Flow Rate, Dry SCFM*	95,640	93,854	96,422
Qaw	Volumetric Air Flow Rate, Wet ACFM	130,201	132,720	133,064
%I	Isokinetic Sampling Rate, Percent	98.4	97.1	95.4

* 68 Degrees F -- 29.92 Inches Mercury (Hg)

(Continued Next Page)

FIELD DATA AND RESULTS TABULATION

PLANT: Procter and Gamble Manufacturing Co., Augusta, Georgia

SAMPLING LOCATION: MSG Tower Stack

		1	2	3
	Filterable Particulate			
mg	Catch Weight, milligrams	29.0	15.5	20.5
Gr/DSCF	Concentration, Grains per DSCF*	0.0103	0.00559	0.00743
Lbs/Hr	Emission Rate, Lbs per Hour	8.42	4.50	6.14
	Filterable + Condensable Particulate			
mg	Catch Weight, milligrams	63.6	89.6	74.8
Gr/DSCF	Concentration, Grains per DSCF*	0.0225	0.0323	0.0271
Lbs/Hr	Emission Rate, Lbs per Hour	18.5	26.0	22.4

* 68 Degrees F -- 29.92 Inches Of Mercury (Hg)

EXAMPLE PARTICULATE TEST CALCULATIONS

MSG Tower Stack
1

Volume of Dry Gas Sampled At Standard Conditions

$$Vm(std) = 17.64 * Y * Vm * \frac{(Pbar + Delta\ H/13.6)}{(460 + tm)}$$

$$Vm(std) = 17.64 * 0.9956 * 45.993 * \frac{(29.9 + 1.85 /13.6)}{(460 + 97)} = 43.557\ DSCF$$

Volume of Water Vapor At Standard Conditions

$$Vw(std) = 0.04707 * Vlc$$

$$Vw(std) = 0.04707 * 189.0 = 8.896\ SCF$$

Percent Moisture, By Volume, As Measured In Flue Gas

$$\%H2O = 100 * Vw(std) / (Vw(std) + Vm(std))$$

$$\%H2O = 100 * 8.896 / (8.896 + 43.557) = 17.0\ \%$$

DRY MOLE FRACTION OF FLUE GAS

$$Mfd = 1 - \%H2O/100$$

$$Mfd = 1 - 17.0 /100 = 0.830$$

WET MOLECULAR WEIGHT OF FLUE GAS

$$Ms = (Md * Mfd) + (0.18 * \%H2O)$$

$$Ms = 28.84 * 0.830 + (0.18 * 17.0) = 27.00\ LB/LB\text{-}MOLE$$

ABSOLUTE FLUE GAS PRESSURE

$$Ps = Pbar + Pg / 13.6$$

$$Ps = 29.9 + (0.5 / 13.6) = 29.94\ IN.\ HG.$$

AVERAGE FLUE GAS VELOCITY [(Delta p)avg is sq. of avg sq. root]

$$vs = 85.49 * Cp * SQRT\left\{\frac{(Delta\ p)avg * (460 + ts)}{Ps * Ms}\right\}$$

$$vs = 85.49 * 0.84 * SQRT\left\{\frac{0.3055 * (460 + 137)}{29.94 * 27.00}\right\} = 34.11 \text{ ft/sec}$$

DRY VOLUMETRIC FLUE GAS FLOW RATE @ STANDARD CONDITIONS

$$Qsd = \frac{60}{144} * Mfd * vs * A * \frac{Tstd}{ts + 460} * \frac{Ps}{Pstd}$$

$$Qsd = \frac{60}{144} * 0.830 * 34.11 * 9{,}161 * \frac{528}{137 + 460} * \frac{29.94}{29.92} = 95{,}640 \text{ SCFM}$$

WET VOLUMETRIC STACK GAS FLOW RATE @ FLUE GAS CONDITIONS

$$Qaw = 60 / 144 * vs * A$$

$$Qaw = 60 / 144 * 34.11 * 9{,}161 = 130{,}201 \text{ ACFM}$$

PERCENT ISOKINETIC OF SAMPLING RATE

$$\%I = \frac{Pstd}{Tstd} * \frac{100}{60} * \frac{(ts + 460) * Vm(std)}{Ps * vs * Mfd * Theta * \text{Area-nozzle, sq.ft.}}$$

$$\%I = \frac{29.92}{528} * \frac{100}{60} * \frac{(137 + 460) * 43.557}{29.94 * 34.11 * 0.830 * 60 * 0.0004909} = 98.4\ \%$$

Grains Per Dry Standard Cubic Foot, Particulate

$$gr/DSCF = \frac{7000}{453{,}592} * \frac{mgs}{Vm(std)}$$

$$gr/DSCF = \frac{7000}{453{,}592} * \frac{29.0}{43.557} = 0.0103 \text{ grains/DSCF}$$

Pounds Per Hour, Particulate

Lb/Hr = (60 / 7000) * Gr/DSCF * Qsd

Lb/Hr = (60 / 7000) * 0.0103 * 95,640 = 8.42 lb/hr

FIELD AND ANALYTICAL DATA

Preliminary Field Data

PLANT NAME Procter & Gamble

LOCATION Augusta, GA

SAMPLING LOCATION Tide Tower - Stack

DUCT DEPTH
FROM INSIDE FAR WALL TO OUTSIDE OF PORT 110 3/4"

NIPPLE LENGTH 2 1/4"

DEPTH OF DUCT 108"

WIDTH (RECTANGULAR DUCT) —

EQUIVALENT DIAMETER:

$$D_E = \frac{2 \times DEPTH \times WIDTH}{DEPTH + WIDTH} = \frac{2(\quad)(\quad)}{(\quad + \quad)} = \_\_\_\_$$

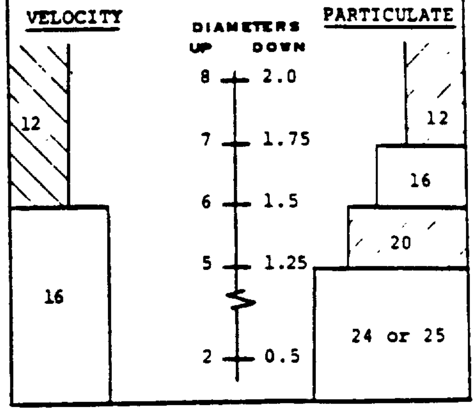
DISTANCE FROM PORTS TO NEAREST FLOW DISTURBANCE

	UPSTREAM	DOWNSTREAM
	[illegible]	12"
DIAMETERS	[illegible]	1.78

STACK AREA = $(54)^2 \pi$ = 9161 IN^2

DRAW HORIZONTAL LINE THROUGH DIAMETERS

If more than 8 and 2 diameters and if duct dia. is less than 24", use 8 or 9 points.



Point	% OF DUCT DEPTH	DISTANCE FROM INSIDE WALL	DISTANCE FROM OUTSIDE OF PORT
1	2.1	2 1/4	5
2	6.7	7 1/4	10
3	11.8	12 3/4	15 1/2
4	17.7	19 1/8	21 7/8
5	25.0	27	29 3/4
6	35.6	38 1/2	41 1/4
7	64.4	69 1/2	72 1/4
8	75.0	81	83 3/4
9	82.3	88 7/8	91 5/8
10	88.2	95 1/4	98
11	93.3	100 3/4	103 1/2
12	97.9	105 3/4	108 1/2
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			

LOCATION OF TRAVERSE POINTS IN CIRCULAR STACKS

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

LOCATION OF TRAVERSE POINTS IN RECTANGULAR STACKS

	2	3	4	5	6	7	8	9	10	11	12
1	25.0	16.7	12.5	10.0	8.3	7.1	6.3	5.6	5.0	4.5	4.2
2	75.0	50.0	37.5	30.0	25.0	21.4	18.8	16.7	15.0	13.6	12.5
3		83.3	62.5	50.0	41.7	35.7	31.3	27.8	25.0	22.7	20.8
4			87.5	70.0	58.3	50.0	43.8	38.9	35.0	31.8	29.2
5				90.0	75.0	64.3	56.3	50.0	45.0	40.9	37.5
6					91.7	78.6	68.8	61.1	55.0	50.0	45.8
7						92.9	81.3	72.2	65.0	59.1	54.2
8							93.8	83.3	75.0	68.2	62.5
9								94.4	85.0	77.3	70.8
10									95.0	86.4	79.2
11										95.5	87.5
12											95.8

ENTROPY ENVIRONMENTALISTS, INC.

PARTICULATE FIELD DATA

COMPANY NAME Proctor & Gamble
ADDRESS Augusta, GA.
SAMPLING LOCATION MSG Tower Stack
DATE 7-18-88 TEAM LEADER DR TECHNICIANS JW
BAROMETRIC PRESSURE, IN. HG 29.90 STATIC PRESSURE, IN. H_2O +.50
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 10 05
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.000 0.000

RUN NUMBER 1
TIME START 0732
TIME FINISH 0835

EQUIPMENT CHECKS

- ✓ PITOTS, PRE-TEST
- __ PITOTS, POST-TEST
- ✓ ORSAT SAMPLING SYSTEM
- ✓ TEDLAR BAG
- ✓ THERMOCOUPLE @ 138 °F

IDENTIFICATION NUMBERS

REAGENT BOX 0215 NOZZLE 308 DIAMETER .310
METER BOX N-7 T/C READOUT 25
UMBILICAL U50 T/C PROBE 12.2
SAMPLE BOX 33 ORSAT PUMP 9
PROBE 11-1 TEDLAR BAG 16

FILTER #	TARE
E7280	4898

NOMOGRAPH SET-UP NOMOGRAPH # DR

ΔH@ 1.83 C FACTOR 0.79
METER TEMP 100 STACK TEMP 138
% MOISTURE 20 REF. ΔP 0.31
K=5.93548

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	PITOT READING (ΔP), IN. H_2O	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
A-1	0/0	348.244	0.20	1.19	1.19	89	1	250	68	134	
2	2½	349.80	0.40	2.37	2.37	90	2	250	62	136	
3	5	351.97	0.40	2.37	2.37	91	2	255	57	137	
4	7½	354.16	0.48	2.85	2.85	93	2	258	55	138	
5	10	356.52	0.48	2.85	2.85	94	2	260	55	134	
6	12½	358.96	0.47	2.79	2.79	95	2	260	55	136	
7	15	361.28	0.25	1.48	1.48	96	1	250	55	137	
8	17½	363.06	0.165	0.98	0.98	96	1	250	55	138	
9	20	364.47	0.137	0.81	0.81	95	1	245	55	139	
10	22½	365.74	0.20	1.19	1.19	95	1	245	57	138	
11	25	367.34	0.27	1.54	1.54	96	1	245	57	138	
12	27½	369.15	0.31	1.84	1.84	96	2	245	57	138	
B-1	30/0	371.07	0.24	1.42	1.49	96	1	245	68	135	
2	2½	372.76	0.30	1.78	1.78	97	2	248	60	135	
3	5	374.63	0.35	2.07	2.07	98	2	250	60	135	
4	7½	376.72	0.35	2.07	2.07	99	2	250	60	138	
5	10	378.76	0.36	2.14	2.14	99	2	255	60	135	
6	12½	380.86	0.32	1.90	1.90	100	2	250	60	138	
7	15	382.82	0.29	1.72	1.72	100	2	250	62	135	
8	17½	384.68	0.30	1.78	1.78	100	2	250	62	136	
9	20	386.61	0.33	1.96	1.96	101	2	247	62	136	
10	22½	388.57	0.30	1.78	1.78	101	2	245	62	136	
11	25	390.46	0.30	1.78	1.78	102	2	245	62	138	
12	27½	392.34	0.29	1.72	1.72	102	2	245	62	138	
	60/OFF	394.237									

V_M	$(\sqrt{\Delta P})^2$	ΔH	T_M	T_S
45.993	0.3055	1.849	97	137

ENTROPY

PARTICULATE FIELD DATA

COMPANY NAME Proctor & Gamble
ADDRESS Augusta GA.
SAMPLING LOCATION MSG Tower Stack
DATE 7-18-88
TEAM LEADER DR
RUN NUMBER 2
TIME START 0912
TIME FINISH 1017
TECHNICIANS JW
BAROMETRIC PRESSURE, IN. HG 29.90
STATIC PRESSURE, IN. H_2O ~~+0.52~~ +.05
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 10 05
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.000 0.000

EQUIPMENT CHECKS

- ✓ PITOTS, PRE-TEST
- ✓ PITOTS, POST-TEST
- — ORSAT SAMPLING SYSTEM
- — TEDLAR BAG
- ✓ THERMOCOUPLE @ 145 °F

IDENTIFICATION NUMBERS

REAGENT BOX 0215 NOZZLE 307 DIAMETER .302
METER BOX N-6 T/C READOUT 25
UMBILICAL USD T/C PROBE 12-8
SAMPLE BOX 22 ORSAT PUMP NA
PROBE 11-2 TEDLAR BAG NA

FILTER #	TARE
E7103	.4844

NOMOGRAPH SET-UP NOMOGRAPH # DR

ΔH@ 1.76 C FACTOR 0.76
METER TEMP 100 STACK TEMP 140 → 147
% MOISTURE 20 22 REF. ΔP 0.305
K=6.03273

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	PITOT READING (ΔP), IN. H_2O	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
B-1	0/0	874.695	0.24	1.45	1.45	91	1	245	68	138	
2	2½	876.45	0.32	1.93	1.93	93	1	250	62	142	
3	5	878.37	0.31	1.87	1.87	95	1	260	60	144	
4	7½	880.37	0.36	2.17	2.17	97	2	260	60	145	
5	10	882.36	0.31	1.87	1.87	98	2	260	60	147	
6	12½	884.33	0.36	2.17	2.17	100	2	260	60	147	
7	15	886.38	0.28	1.69	1.69	101	2	260	58	148	
8	17½	888.27	0.33	1.99	1.99	101	2	265	58	147	
9	20	890.26	0.31	1.87	1.87	102	2	265	58	147	
10	22½	892.20	0.37	2.23	2.23	102	2	265	58	147	
11	25	893.00	0.38	2.29	2.29	101	2	265	58	147	
12	27½	895.05	0.38	2.29	2.29	103	2	265	59	147	
A-1	30/0	897.27	0.28	1.69	1.69	101	1	250	68	144	
2	2½	899.08	0.34	2.05	2.05	103	2	255	60	144	
3	5	901.10	0.40	2.41	2.41	103	2	255	60	146	
4	7½	903.28	0.50	3.02	3.02	104	3	260	60	147	
5	10	905.77	0.50	3.02	3.02	105	3	260	60	147	
6	12½	908.23	0.48	2.90	2.90	107	3	265	61	147	
7	15	910.66	0.23	1.39	1.39	108	1	265	61	148	
8	17½	912.36	0.18	1.09	1.09	108	1	265	61	149	
9	20	913.84	0.18	1.09	1.09	108	1	260	62	149	
10	22½	915.36	0.158	0.95	0.95	108	1	255	62	148	
11	25	916.68	0.21	1.27	1.27	109	1	255	62	147	
12	27½	918.36	0.22	1.33	1.33	109	1	255	62	147	
	60/OFF	920.018									

V_M	$(\sqrt{\Delta P})^2$	ΔH	T_M	T_S
45.323	0.3106	1.918	102	146

ENTROPY

PARTICULATE FIELD DATA

COMPANY NAME Proctor & Gamble RUN NUMBER 3
ADDRESS Augusta, GA. TIME START 1034
SAMPLING LOCATION MSG Tower Stack TIME FINISH 1136
DATE 7-18-88 TEAM LEADER DR TECHNICIANS JW
BAROMETRIC PRESSURE, IN. HG 29.90 STATIC PRESSURE, IN. H_2O +1.22
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 10 03
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.000 0.000

EQUIPMENT CHECKS

- ✓ PITOTS, PRE-TEST
- ✓ PITOTS, POST-TEST
- ✓ ORSAT SAMPLING SYSTEM
- ✓ TEDLAR BAG
- ✓ THERMOCOUPLE @ 145 °F

IDENTIFICATION NUMBERS

REAGENT BOX 0215 NOZZLE 308 DIAMETER .300
METER BOX ~~D50~~ N-7 T/C READOUT 25
UMBILICAL U50 T/C PROBE 12-2
SAMPLE BOX 33 ORSAT PUMP –
PROBE 11-1 TEDLAR BAG –

FILTER #	TARE
E7282	.4915

NOMOGRAPH SET-UP NOMOGRAPH # DR

ΔH@ 1.76 C FACTOR 0.75
METER TEMP 115 STACK TEMP 150
% MOISTURE 22 REF. ΔP 0.33
K=5.57575

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	PITOT READING (ΔP), IN. H_2O	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
B-1	0/0	920.122	0.26	1.45	1.45	104	1	250	68	136	
2	2½	921.86	0.31	1.73	1.73	105	1	250	60	138	
3	5	923.69	0.36	2.01	2.01	106	1	255	57	141	
4	7½	925.79	0.32	1.78	1.78	107	1	255	57	144	
5	10	927.70	0.37	2.06	2.06	108	1	260	57	145	
6	12½	929.81	0.31	1.73	1.73	108	1	260	57	146	
7	15	931.70	0.27	1.51	1.51	108	1	265	57	146	
8	17½	933.47	0.31	1.73	1.73	107	1	265	57	146	
9	20	935.36	0.31	1.73	1.73	107	1	265	57	146	
10	22½	937.25	0.33	1.84	1.84	106	1	260	58	145	
11	25	939.20	0.40	2.23	2.23	106	1	260	58	145	
12	27½	941.37	0.40	2.23	2.23	109	1	260	58	145	
A-1	30/0	943.58	0.31	1.73	1.73	112	1	265	68	145	
2	2½	945.47	0.35	1.95	1.95	114	1	265	62	143	
3	5	947.46	0.44	2.45	2.45	114	1	265	60	144	
4	7½	949.78	0.46	2.56	2.56	115	1	260	60	143	
5	10	952.03	0.48	2.68	2.68	116	1	260	60	144	
6	12½	954.44	0.48	2.68	2.68	116	1	260	60	145	
7	15	956.70	0.24	1.34	1.34	114	1	260	60	145	
8	17½	958.47	0.16	0.89	0.89	111	1	265	62	146	
9	20	959.80	0.175	0.98	0.98	111	1	265	62	146	
10	22½	961.28	0.180	1.00	1.00	111	1	265	62	146	
11	25	962.69	0.24	1.34	1.34	111	1	265	62	145	
12	27½	964.40	0.26	1.45	1.45	111	1	268	62	145	
	60/OFF	966.167									

V_M	$(\sqrt{\Delta P})^2$	ΔH	T_M	T_S
46.045	0.3154	1.795	110	144

ENTROPY

PARTICULATE SAMPLING LABORATORY RESULTS

Plant Name: PROCTER & GAMBLE — EEI Ref# 5949

Sampling Location: MSG Tower Stack

Date Received: 7/25 Date Analyzed: 7/28 Reagent Box(es): 0215

Run Number	1	2	3
Run Date	7/18	7/18	7/18
Sample ID/Container #	F&R 2514	F&R 2515	F&R 2516
	107.7978	104.2785	105.5850
	✓107.7975	✓104.2781	✓105.5848
	107.8005	104.2812	105.5898
Tare Weight., g.	107.2782	103.7778	105.0725
SAMPLE WT., g.	0.5193	0.5003	0.5123
Sample ID/Container #			
	0.0000	0.0000	0.0000
Tare Wt., g.			
SAMPLE WT., g.	0.0000	0.0000	0.0000
Sum of Particulate, mg.	519.3	500.3	512.3
Total Filter Tare, mg.	489.8	484.4	491.5
Blank Residue, mg.	(225 ml) 0.5	(200 ml) 0.4	(150 ml) 0.3
TOTAL PARTICULATE CATCH, mg.	29.0	15.5	20.5

Blank Beaker #	2003
Final wt., mg.	99546.3
Tare wt., mg.	99545.9
Residue, mg.	0.4
Volume, ml.	200

---Legend---
✓ = Final Weight
L = Loose Particulate
F = Filter D = Dish
R = Rinse P = Pan

Notes and Comments

Concentration, mg/ml 0.002

ENTROPY

SUMMARY OF IMPINGERS' WATER ANALYSIS

Plant Name: PROCTER & GAMBLE EEI Ref# 5949

Run Number	1	2	3
Run Date	7/18	7/18	7/18
Sample ID/Container #	1 / 2517	1 / 2518	1 / 2519
	==========	==========	==========
	103.8100		
	103.8103	109.2106	
	103.8111	109.2111	107.3596
	103.8122	109.2129	107.3601
Tare Weight., g.	103.7955	109.1639	107.3300
	==========	==========	==========
SAMPLE WT., g.	0.0145	0.0467	0.0296
Sample ID/Container #	2 / 007	2 / 100	2 / 103
	==========	==========	==========
	193.0298	170.7065	
	193.0300	170.7060	183.9969
	193.0302	170.7073	183.9974
Tare Wt., g.	193.0235	170.6969	183.9937
	==========	==========	==========
SAMPLE WT., g.	0.0063	0.0091	0.0032
Sample ID/Container #	4 / 241	4 / 257	4 / 265
	==========	==========	==========
		132.3727	
	142.8113	132.3731	143.7630
	142.8117	132.3741	143.7633
	142.8135	132.3751	143.7660
Tare Wt., g.	142.7968	132.3537	143.7408
	==========	==========	==========
SAMPLE WT., g.	0.0145	0.0190	0.0222

1 Organic Fraction Catch, mg.	14.5		46.7		29.6
2 Inorganic Fraction Catch,mg	6.3		9.1		3.2
4 Acetone Soluble Catch, mg.	14.5		19.0		22.2
Acetone Residue, mg. (325 ml)	0.7	(325 ml)	0.7	(325 ml)	0.7
Water Residue, mg. (200 ml)	0.0	(200 ml)	0.0	(200 ml)	0.0
TOTAL IMPINGERS' CATCH, mg.	34.6		74.1		54.3
TOTAL TRAIN CATCH, mg.	63.6		89.6		74.8

Procedure Explanation
1 - Extractable with freon
2 - Water catch after extraction and heating to 210 F
3 - Water catch after heating to ______ F
4 - Acetone rinsings of impingers and connecting glassware

Blank Beaker #
Final wt.,mg. 89234.6
Tare wt., mg. 89234.6
Residue, mg. 0.0
Volume, ml. 200
Conc., mg/ml 0.0

MOISTURE SAMPLING LABORATORY RESULTS

Plant Name: PROCTER & GAMBLE — EEI Ref# 5949

Sampling Location: MSG Tower Stack

Date Received: 7/25 Date Analyzed: 7/25 Reagent Box(es): 0215

Run Number	1	2	3
Run Date	7/18	7/18	7/18

ANALYSIS OF MOISTURE CATCH

Reagent 1 (H2O)			
Final Weight, g.	367.0	395.0	370.0
Tared Weight, g.	200.0	200.0	200.0
	==========	==========	==========
Water Catch,g.	167.0	195.0	170.0
Reagent 2 ( )			
Final Weight, g.			
Tared Weight, g.			
	==========	==========	==========
Water Catch,g.	0.0	0.0	0.0
Reagent 3 ( )			
Final Weight, g.			
Tared Weight, g.			
	==========	==========	==========
Water Catch,g.	0.0	0.0	0.0
CONDENSED WATER, g.	167.0	195.0	170.0
Silica Gel:			
Final Weight, g.	222.0	218.0	219.5
Tared Weight, g.	200.0	200.0	200.0
	==========	==========	==========
ADSORBED WATER, g.	22.0	18.0	19.5
TOTAL WATER COLLECTED, g.	189.0	213.0	189.5

CUSTODY SHEET FOR REAGENT BOX # 0215

Date of Makeup 7/14 Initials J.F.J. Locked? ✓

Individual Tare of Reagent: 200 mls. of DI H_2O

Individual Tare of Reagent: ______ mls. of ______

Individual Silica Gel Tare Weight 200 gms.

PLANT NAME Procter and Gamble

SAMPLING LOCATION MS6 Tower Stack

Run Number	Date Used	Initials	Locked?	Date Cleanup	% S. Gel Spent	Initials	Locked
1	7/18	JRW	Y	7/18	50	JRW	Y
2	7/18	JRW	Y	7/18	50	JRW	Y
3	7/18	JRW	Y	7/18	50	JRW	Y

Received in Lab Date 7/24 Initials GAW Locked? ✓

Zero & Span Balance Initials ✓

Sampling Method: M5 W/ BACK 1/2

Remarks:

Filter #	Tare Weight (grams)	Used on Test
E7280	0.4898	1
E7103	0.4844	2
E7282	0.4915	3

ENTROPY ENVIRONMENTALISTS, INC.

APPENDIX C

CALIBRATION DATA

QUALITY ASSURANCE PROCEDURES

General. Each item of field test equipment purchased or constructed by Entropy is assigned a unique, permanent identification number. New items for which calibration is required are calibrated before initial field use. Equipment whose calibration status may change with use or with time is inspected in the field before testing begins, and again upon return from each field use. When an item of equipment is found to be out of calibration, it is adjusted and recalibrated or retired from service. All equipment is periodically recalibrated in full, regardless of the outcome of these regular inspections.

Calibrations are conducted in a manner and at a frequency which meet or exceed U. S. EPA specifications. Entropy follows the calibration procedures outlined in EPA Reference Methods, and those recommended within the Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III (EPA-600/4-77-027b, August, 1977). When the Reference Methods are inapplicable, Entropy uses methods such as those prescribed by the American Society for Testing and Materials (ASTM).

Data obtained during calibrations are recorded on standardized forms, which are checked for completeness and accuracy by the Quality Assurance Manager or the Quality Assurance Director. Data reduction and subsequent calculations are performed using Entropy's in-house computer facilities. Calculations are generally performed at least twice as a check for accuracy. Copies of calibration data are included in the test or project reports.

Inspection and Maintenance. An effective preventive maintenance program is necessary to ensure data quality. Each item of equipment returning from the field is inspected before it is returned to storage. During the course of these inspections, items are cleaned, repaired, reconditioned, and recalibrated where necessary.

Each item of equipment transported to the field for this test program was inspected again before being packed. Entropy performs these quality assurance activities prior to departure for the job site to detect equipment problems which may originate during periods of storage. This minimizes lost time on site due to equipment failure.

Occasional equipment failure in the field is unavoidable despite the most rigorous inspection and maintenance procedures. For this reason, Entropy routinely transports sufficient backup equipment to the job site to have complete redundancy of all critical sampling train components.

Calibration. Emissions sampling equipment that requires calibration includes the nozzle, pitot tube, pressure gauges, thermometers, flow meters, dry gas meters, and barometers. The following sections elaborate on the calibration procedures followed by Entropy for these items of equipment. Calibration data for the specific items of equipment used for this test program follow the text.

Nozzles. Each probe nozzle is uniquely and permanently identified at the time of purchase, and calibrated before initial field use. The inside diameter of the nozzle is measured to the nearest 0.001 in. using a micrometer. Five measurements are made using different diameters each time. If the difference between the high and the low numbers does not exceed 0.004 inch, the average of the five measurements is used. If the difference exceeds this amount, or when the nozzle becomes nicked, dented, or corroded, the nozzle is reshaped, sharpened, and recalibrated.

Pitot Tubes. All Type S pitot tubes used by Entropy, whether separate or attached to a sampling probe, are constructed in-house or by Nutech Corporation. Each pitot is calibrated when new in accordance with the geometry standards contained in EPA Reference Method 2. A Type S pitot tube, constructed and positioned according to these standards, will have a coefficient of 0.84 ± 0.02. This coefficient should not change as long as the pitot tube is not damaged.

Each pitot tube is inspected visually before it is transported to the field. If this inspection indicates damage or raises doubt that the pitot remains in accordance with the EPA geometry standards, the pitot tube is not used until it has been refurbished and recalibrated.

Differential Pressure Gauges. Some meter consoles used by Entropy are equipped with 10 in. W.C. inclined-vertical manometers. Fluid manometers do not require calibration other than leak checks. Manometers are leak-checked in the field prior to each test series, and again upon return from the field.

Most of Entropy's meter consoles are equipped with Magnehelic differential pressure gauges. Each set of gauges is calibrated initially over its full range, 0-10 inches W.C. After each field use, the calibration of the gauge set is checked against an inclined manometer at the average delta p encountered during the test. If the agreement is within ± 5 percent, the calibration is acceptable.

Thermometers

Impinger Thermometer. On site, prior to the start of testing, the thermometer used to monitor the temperature of the gas leaving the last impinger is compared with a mercury-in-glass thermometer which meets ASTM E-1 specifications. The impinger thermometer is adjusted if necessary until it agrees within 2°F of the reference thermometer. (If the thermometer is not adjustable, it is labeled with a correction factor).

Dry Gas Meter Thermometer. The thermometer used to measure the temperature of the metered gas sample is checked prior to each field trip against an ASTM mercury-in-glass thermometer. The dry gas meter thermometer is acceptable if the values agree within 5.4°F. Thermometers not meeting this requirement are adjusted or labeled with a correction factor.

Flue Gas Temperature Sensor. All thermocouples employed by Entropy for the measurement of flue gas temperatures are calibrated upon receipt. Initial calibrations are performed at three points (ice bath, boiling water, and hot oil). An ASTM mercury-in-glass thermometer is used as a reference. The thermocouple is acceptable if the agreement is within 1.5 percent (absolute) at each of the three calibration points.

On site, prior to the start of testing, the reading from the stack gas thermocouple-potentiometer combination is compared with a mercury-in-glass reference thermometer. If the two agree within 1.5 percent (absolute), the thermocouple and potentiometer are considered to be in proper working order for the test series.

After each field use, the thermocouple-potentiometer system is compared with an ASTM mercury-in-glass reference thermometer at a temperature within 10 percent of the average absolute flue gas temperature. If the absolute temperatures agree within 1.5 percent, the temperature data are considered valid.

Dry Gas Meter and Orifice. The dry gas meter and orifice are calibrated simultaneously. There are two calibration procedures. The full calibration is a complete laboratory procedure used to obtain the calibration factor of the dry gas meter before its first use and periodically thereafter. Full calibrations are performed at three different orifice settings (flow rates). A simpler procedure, the posttest calibration, is designed to check whether the calibration factor has changed. Posttest calibrations are performed after each field test series at an intermediate orifice setting (based on the test data) and at the maximum vacuum reached during the test.

Entropy uses as a transfer standard a dry gas meter that is calibrated annually against a spirometer. During the annual calibration, triplicate calibration runs are performed at seven flow rates ranging from 0.25 to 1.40 cfm.

Dry Gas Meter. Each metering system receives a full calibration at the time of purchase, and a posttest calibration after each field use. If the calibration factor, Y, deviates by less than five percent from the initial value, the test data are acceptable. If Y deviates by more than five percent, the meter is recalibrated and the meter coefficient (initial or recalibrated) that yields the lowest sample volume for the test runs is used.

EPA Reference Method 5 calls for another full calibration anytime the posttest calibration check indicates that Y has changed by more than five percent. Standard practice at Entropy is to recalibrate the dry gas meter anytime Y is found to be outside the range $0.98 \leq Y \leq 1.02$.

Orifice. An orifice calibration factor is calculated for each flow setting during a full calibration. If the range of values does not vary by more than 0.15 in. H_2O over the range of 0.4 to 4.0 in. H_2O, the arithmetic average of the values obtained during the calibration is used.

Barometer. Each field barometer is adjusted before each test series to agree within ± 0.1 inches of a reference aneroid barometer. The reference barometer is checked weekly against the station pressure value (corrected for elevation difference) reported by the National Weather Service station at the Raleigh-Durham airport, approximately 2.5 miles from Entropy's location.

Dry Gas Meter Identification: 6838323 Calibration by: T. McDonald Page 1 of 2

Date: 2-26-88 Barometric Pressure (P_b): 29.26 in. Hg

*Date: 2-29-88 *Barometric Pressure (P_b): 29.74 / 29.72 / 29.68 in. Hg

ENTROPY ENVIRONMENTALISTS, INC.

Approx. Flow Rate (Q) cfm	Spirometer Gas Volume (V_s) ft³	Spirometer Temp. (t_s) °F	Dry Gas Meter Gas Volume (V_{ds}) ft³	Dry Gas Meter Temp. (t_{ds}) °F	Pressure (Δp) in. H_2O	Time (O) min.	Flow Rate (Q) cfm	Meter Meter Coeff. (Y_{ds})	Avg. Meter Coeff. ($\bar{Y}_{ds}$)
	2.404	78.8	2.535	76	0.37	10:00	0.2303	0.9425	
	2.532	78.8	2.523	76.5	0.37	10:00	0.2426	0.9984	
	2.587	78.8	2.527	77	0.38	10:00	0.2476	1.0194	
	4.135	78.8	4.075	75	0.67	10:00	0.4026	1.0059	
	4.171	78.8	4.052	75	0.65	10:00	0.4061	1.0205	
	4.162	78.8	4.019	75.5	0.65	10:00	0.4052	1.0276	
	5.036	78.8	4.887	76	0.95	10:00	0.4824	1.0227	
	5.064	80.0	4.900	76	0.95	10:00	0.4840	1.0234	
	5.027	80.6	4.839	76	0.95	10:00	0.4800	1.0276	
	7.787	78.8	7.711	75	2.04	10:00	0.7582	0.9977	
	7.851	78.8	7.684	75	2.03	10:00	0.7644	1.0095	
	7.814	78.8	7.724	75	2.05	10:00	0.7608	0.9995	
	9.900	78.8	9.845	75	3.17	10:00	0.9639	0.9907	
	9.900	78.8	9.773	75	3.17	10:00	0.9639	0.9980	
	10.018	78.8	9.882	76	3.22	10:00	0.9754	1.0005	

(V_s) (t_{ds} + 460) (P_b) (P_b) (V_s)

Dry Gas Meter Identification: 6838323 Calibration by: T. McDowell Page 2 of 2

Date: 2-26-88 Barometric Pressure (P_b): 29.26 in. Hg

*Date: 2-29-88 *Barometric Pressure (P_b): 29.74 / 29.72 / 29.68 in. Hg

ENTROPY ENVIRONMENTALISTS, INC.

Approx. Flow Rate (Q) cfm	Spirometer Gas Volume (V_s) ft³	Spirometer Temp. (t_s) °F	Dry Gas Meter Gas Volume (V_{ds}) ft³	Dry Gas Meter Temp. (t_{ds}) °F	Pressure (Δp) in. H_2O	Time (0) min.	Flow Rate (Q) cfm	Meter Meter Coeff. (Y_{ds})	Avg. Meter Coeff. ($\bar{Y}_{ds}$)
	11.658	77.9	11.640	76.5	4.20	10:00	1.1362	0.9887	
	11.694	77.9	11.594	77	4.275	10:00	1.1397	0.9964	
	11.548	77.9	11.547	77	4.23	10:00	1.1240	0.9881	
	13.042	77.9	12.946	77	5.25	10:00	1.2694	0.9928	
	12.851	78.8	12.884	77.5	5.23	10:00	1.2487	0.9823	
	12.933	79.7	12.859	78	5.17	10:00	1.2546	0.9899	

Yds = 1.001

$(V_s)\ (t_{ds} + 460)\ (P_b)$ $(P_b)\ (V_s)$

Meter Box Number: N6

Calibration by: ATM/SWS

Standard Meter Number: 683F323

Standard Meter Gamma: 1.001

Date: 7-11-88

Barometric Pressure (P_b): 29.58 in. Hg

*Date: 7-11-88

*Barometric Pressure (P_b): 29.59 in. Hg

METERBOX CALIBRATION

Standard Meter			Meter Box Metering System				
Gas Volume (V_{ds}) ft^3	Temp. (t_{ds}) °F	Time (θ) min.	Orifice Setting (ΔH) in. H_2O	Gas Volume (V_d) ft^3	Temp. (t_d) °F	Coeff. (Y_d)	$\Delta H_@$ in. H_2O
4.039	74	10	0.5	4.109	84	1.0011	1.718
4.114	75	10	0.5	4.185	85	1.0012	1.659
8.110	75	10	2.1	8.298	87	.9951	1.787
8.185	75	10	2.1	8.335	90	1.0053	1.745
12.128	75	10	4.8	12.419	94	1.0003	1.803
12.051	75	10	4.8	12.408	97	1.0002	1.816
					Average	1.0005	1.755

$$Y_d = \frac{Y_{ds} * V_{ds} * (t_d + 460) * P_b}{V_d * (t_{ds} + 460) * (P_b + \Delta H/13.6)}$$

$$\Delta H_@ = \frac{0.0317 * \Delta H}{P_b * (t_d + 460)} * \left[\frac{(t_{ds} + 460) * \theta}{Y_{ds} * V_{ds}}\right]^2$$

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6-88 rev

ENTROPY

Meter Box Number: N6

Calibration by: WLS/SWS

Meter Box Vacuum: 3 in. Hg

Job 5949
P+G

Standard Meter Number: 6838323 Standard Meter Gamma: 1.001

Date: 7-29-88 Barometric Pressure (P_b): 29.82 in. Hg

POST TEST CALIBRATION

Standard Meter			Meter Box Metering System				
Gas Volume (V_{ds}) ft^3	Temp. (t_{ds}) °F	Time (Θ) min.	Orifice Setting (ΔH) in. H_2O	Gas Volume (V_d) ft^3	Temp. (t_d) °F	Coeff. (Y_d)	$\Delta H_@$ in. H_2O
7.835	75	10	1.92	8.005	86	.9952	1.739
7.844	75	10	1.92	8.005	87	.9981	1.732
7.822	75	10	1.92	8.005	87	.9953	1.742
					Average	.9962	1.738

$$Y_d = \frac{Y_{ds} * V_{ds} * (t_d + 460) * P_b}{V_d * (t_{ds} + 460) * (P_b + \Delta H/13.6)}$$

$$\Delta H_@ = \frac{0.0317 * \Delta H}{P_b * (t_d + 460)} * \left[\frac{(t_{ds} + 460) * \Theta}{Y_{ds} * V_{ds}}\right]^2$$

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8/86

ENTROPY

Meter Box Number: N7

Calibration by: ATM | BWS

Standard Meter Number: 6838323 Standard Meter Gamma: 1.001

Date: 3-3-88 Barometric Pressure (P_b): 29.73 in. Hg

*Date: ______ *Barometric Pressure (P_b): ______ in. Hg

METERBOX CALIBRATION

Standard Meter			Meter Box Metering System				
Gas Volume (V_{ds}) ft³	Temp. (t_{ds}) °F	Time (θ) min.	Orifice Setting (ΔH) in. H_2O	Gas Volume (V_d) ft³	Temp. (t_d) °F	Coeff. (Y_d)	$\Delta H_@$ in. H_2O
3.912	68	10	0.50	3.979	73	0.9922	1.818
3.930	70	10	0.50	4.015	74	0.9860	1.812
7.958	70	10	2.10	8.078	78	0.9958	1.842
7.955	70	10	2.10	8.129	81	0.9947	1.834
12.016	69	10	4.80	12.036	76	1.0007	1.847
11.991	70	10	4.80	12.125	84	1.0042	1.834
					Average	0.9956	1.831

$$Y_d = \frac{Y_{ds} * V_{ds} * (t_d + 460) * P_b}{V_d * (t_{ds} + 460) * (P_b + H/13.6)}$$

$$\Delta H_@ = \frac{0.0317 * \Delta H}{P_b * (t_d + 460)} * \left[\frac{(t_{ds} + 460) * \theta}{Y_{ds} * V_{ds}}\right]^2$$

Meter Box Number: N7

Calibration by: JG

Meter Box Vacuum: 2 in. Hg

Job 5949B
P+G

Standard Meter Number: 6838323

Standard Meter Gamma: 1.001

Date: 8-4-88

Barometric Pressure (P_b): 29.8 in. Hg

POST TEST CALIBRATION

Standard Meter			Meter Box Metering System				
Gas Volume (V_{ds}) ft^3	Temp. (t_{ds}) °F	Time (θ) min.	Orifice Setting (ΔH) in. H_2O	Gas Volume (V_d) ft^3	Temp. (t_d) °F	Coeff. (Y_d)	$\Delta H_@$ in. H_2O
7.367	74	10	1.8	7.502	84	0.997	1.84
7.342	74	10	1.8	7.488	86	0.999	1.85
7.376	74	10	1.8	7.516	88	1.003	1.83
					Average	0.999	1.84

$$Y_d = \frac{Y_{ds} * V_{ds} * (t_d + 460) * P_b}{V_d * (t_{ds} + 460) * (P_b + \Delta H/13.6)}$$

$$\Delta H_@ = \frac{0.0317 * \Delta H}{P_b * (t_d + 460)} * \left[\frac{(t_{ds} + 460) * \theta}{Y_{ds} * V_{ds}}\right]^2$$

NOZZLE NUMBER: 307

Date	Initials	Dia. 1	Dia. 2	Dia. 3	Dia. 4	Dia. 5	Average
2-3-83	PLO	.305	.304	.305	.304	.306	0.305"
04-07-83	HEC	0.302	0.301	0.303	0.301	0.302	0.302
7-6-84	TTM	.307	.307	.307	.308	.307	0.307
10-23-84	ATM	.301	.301	.300	.302	.300	0.301
1-7-86	GT	.302	.305	.304	.306	.305	0.304
6-30-86	BB	.300	.302	.300	.303	.302	0.301
10/23/86	J.E.	.301	.304	.305	.302	.304	0.303
1/19/87	JE	.305	.307	.309	.306	.307	0.307
3/10/87	ST	.307	.306	.306	.307	.307	0.307
3-20-87	SH	.304	.304	.305	.305	.304	.304
5-12-87	TMS	.302	.303	.302	.302	.303	0.302
6/16/87	JE	.303	.302	.305	.304	.305	0.304
9/1/87	J.E.	.305	.307	.306	.304	.305	0.305
4/13/88	J.E.	.301	.302	.302	.302	.303	0.302

NOTE: All diameters measured in inches.

NOZZLE NUMBER: 308

Date	Initials	Dia. 1	Dia. 2	Dia. 3	Dia. 4	Dia. 5	Average
12-2-82	ST	.308	.304	.308	.305	.306	0.306
04-07-83	HEC	0.306	0.303	0.307	0.306	0.305	0.305
7-6-84	TTM	.306	.308	.308	.307	.308	0.307
10-23-84	ATM	.302	.304	.303	.302	.304	0.303
6-30-86	BB	.300	.301	.300	.302	.303	0.301
10/23/86	G.E	.304	.306	.304	.304	.306	0.305
1/15/87	JE	.307	.304	.306	.305	.308	0.306
3/10/87	ST	.308	.307	.308	.309	.307	0.308
3-20-87	SH	.301	.305	.304	.305	.302	.303
5-12-87	TMc	.300	.303	.301	.301	.300	0.301
6/16/87	JE	.304	.304	.305	.306	.306	0.305
9/1/87	G.E	.301	.305	.305	.302	.304	0.303
4/13/88	JE.	300	.303	.300	.299	.300	0.300

NOTE: All diameters measured in inches.

ENTROPY ENVIRONMENTALISTS, INC.

APPENDIX D

PROCESS DATA

PLANT OPERATING DATA FORM

PLANT AUGUSTA
OBSERVER BILL DEBREAU

PRODUCT DETERGENT
DATE 7-18-88
TIME 7:32AM

STACK

STACK GAS TEMP., DRY BULB, DEG. F ______ MOISTURE ______
STACK GAS TEMP., WET BULB, DEG. F ______

ELECTROSTATIC PRECIPITATORS	NORTH	SOUTH
VOLTAGE, KV	49	51
CURRENT, MA	.7	.45
DATE LAST CLEANED		

SCRUBBERS	NORTH	SOUTH
WATER FLOW RATE, GPM	65	65
INLET TEMP., DEG. F		
OUTLET TEMP., DEG. F		
AIR INLET TEMP., DEG. F		
DATE LAST CLEANED		
DATE LAST BED INSPECTION		

PASTE

ACID MIX/PASTE

TIME ______ RATE ______
AS COMPLETENESS ______ AB COMPLETENESS ______
OVERALL COMPLETENESS ______ LAS SUBSTITUTION ______
H20 ______ COLOR ______
pH ______ SURFACTANT ______
SECONDARY TEMP., DEG. F ______

BASE GRANULES

RATE ______ H20 ______ CAKE ______
SURFACTANT ______ BASE OF TOWER TEMP., DEG. F ______

TOWER AIR

INLET TEMP., DEG. F ______
OUTLET, EXHAUST (TOP OF TOWER) TEMP., DEG. F ______
TOWER BALANCE (AT FURNACE) ______

CRUTCHER

TEMP., DEG. F ______ AMPS ______
MIX FLOW RATE 144,158LB/HR MOISTURE (SOLIDS) 33%
MIX DENSITY 1.2 AVG. SPEC.GRAV.

DROP TANK

TEMP., DEG. F ______ AMPS ______

MISC. DATA

NOZZLE PRES. (7TH) ______ NOZZLE TEMP., DEG. F ______
HPP DISCHARGE PRES. ______

APPENDIX E

SAMPLING AND ANALYTICAL PROCEDURES

METHOD 1—SAMPLE AND VELOCITY TRAVERSES FOR STATIONARY SOURCES

1. *Principle and Applicability*

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

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

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

2. *Procedure*

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

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

where L=length and W=width.

An alternative procedure is available for determining the acceptability of a measurement location not meeting the criteria above. This procedure, determination of gas flow angles at the sampling points and comparing the results with acceptability criteria, is described in Section 2.5.

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-SECTION LAYOUT FOR RECTANGULAR STACKS

Number of traverse points	Matrix layout
9	3x
12	4x
16	4x
20	5x
25	5x
30	6x
36	6x
42	7x
49	7x

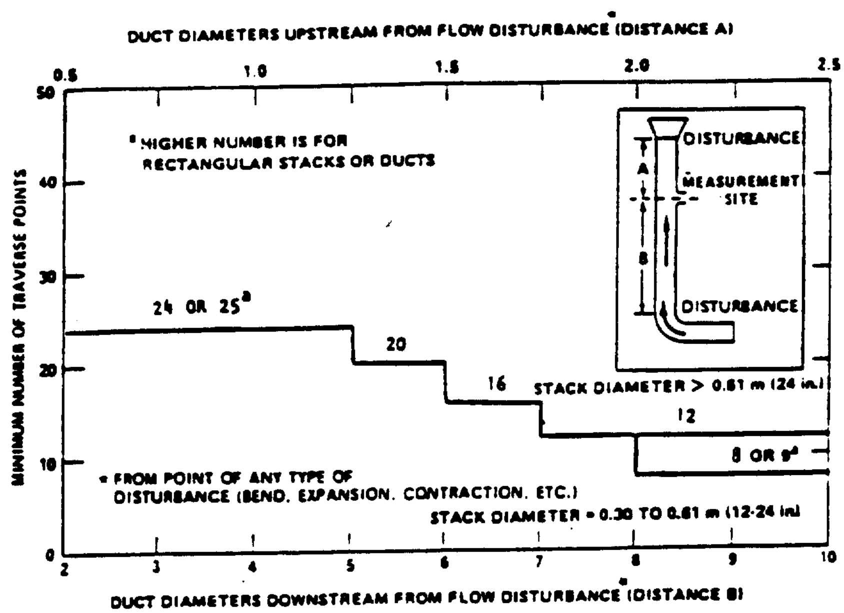

Figure 1-1. Minimum number of traverse points for particulate traverses.

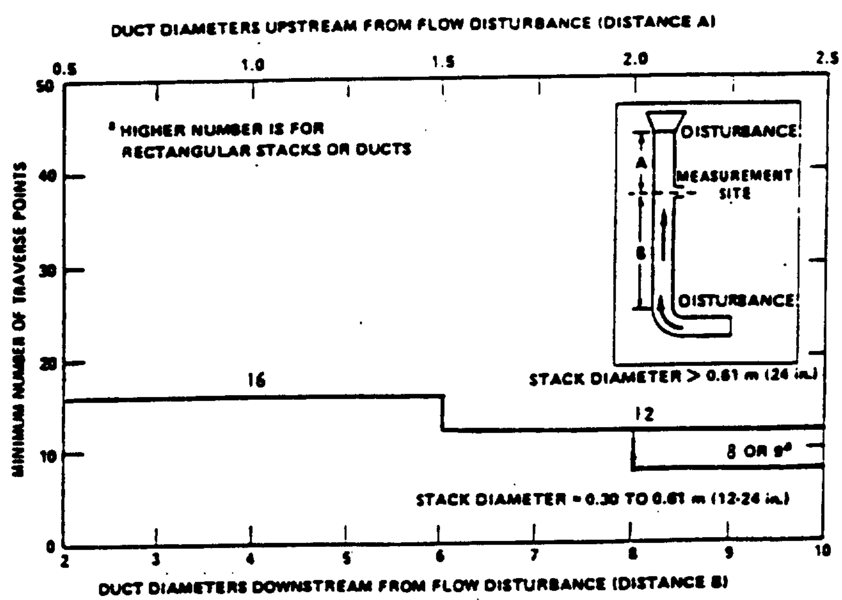

Figure 1-2. Minimum number of traverse points for velocity (nonparticulate) traverses.

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.

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

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

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

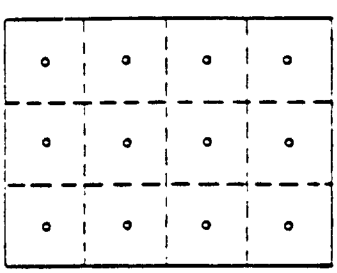

Figure 1-4. Example showing rectangular stack cross section divided into 12 equal areas, with a traverse point at centroid of each area.

Level and zero the manometer. Connect a Type S pitot tube to the manometer. Position the Type S pitot tube at each traverse point, in succession, so that the planes of the face openings of the pitot tube are perpendicular to the stack cross-sectional plane; when the Type S pitot tube is in this position, it is at "0° reference." Note the differential pressure (Δp) reading at each traverse point. If a null (zero) pitot reading is obtained at 0° reference at a given traverse point, an acceptable flow condition exists at that point. If the pitot reading is not zero at 0° reference, rotate the pitot tube (up to ±90° yaw angle), until a null reading is obtained. Carefully determine and record the value of the rotation angle (α) to the nearest degree. After the null technique has been applied at each traverse point, 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 20°, 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.

The alternative procedure described in Section 2.5 may be used to determine the rotation angles in lieu of the procedure described above. The limit of acceptability for the average value of α would remain 20°.

2.5 Alternative Measurement Site Selection Procedure. This alternative applies to sources where measurement locations are less than 2 equivalent stack or duct diameters downstream or less than ½ duct diameter upstream from a flow disturbance. The alternative should be limited to ducts larger than 24 in. in diameter where blockage and wall effects are minimal. A directional flow-sensing probe is used to measure pitch and yaw angles of the gas flow at 40 or more traverse points; the resultant angle is calculated and compared with acceptable criteria for mean and standard deviation.

Note.—Both the pitch and yaw angles are measured from a line passing through the traverse point and parallel to the stack axis. The pitch angle is the angle of the gas flow component in the plane that INCLUDES the traverse line and is parallel to the stack axis. The yaw angle is the angle of the gas flow component in the plane PERPENDICULAR to the traverse line at the traverse point and is measured from the line passing through the traverse point and parallel to the stack axis.

2.5.1 Apparatus.

2.5.1.1 Directional Probe. Any directional probe, such as United Sensor Type DA Three-Dimensional Directional Probe, capable of measuring both the pitch and yaw angles of gas flows is acceptable. (Note: Mention of trade name or specific products does not constitute endorsement by the U.S. Environmental Protection Agency.) Assign an identification number to the directional probe, and permanently mark or engrave th number on the body of the probe. The pressure holes of directional probes are susceptible to plugging when used in particulate-laden gas streams. Therefore, a system for cleaning the pressure holes by "back-purging" with pressurized air is required.

2.5.1.2 Differential Pressure Gauges. Inclined manometers, U-tube manometers, other differential pressure gauges (e.g., magnehelic gauges) that meet the specifications described in Method 2, § 2.2.

Note.—If the differential pressure gauge produces both negative and positive readin then both negative and positive pressure readings shall be calibrated at a minimum c three points as specified in Method 2, § 2.2.

2.5.2 Traverse Points. Use a minimum o: 40 traverse points for circular ducts and 42 points for rectangular ducts for the gas flow angle determinations. Follow § 2.3 and Tab 1-1 or 1-2 for the location and layout of the traverse points. If the measurement locatior is determined to be acceptable according tc the criteria in this alternative procedure, us the same traverse point number and locatic for sampling and velocity measurements.

2.5.3 Measurement Procedure.

2.5.3.1 Prepare the directional probe an differential pressure gauges as recommend by the manufacturer. Capillary tubing or surge tanks may be used to dampen pressur fluctuations. It is recommended, but not required, that a pretest leak check be conducted. To perform a leak check, pressurize or use suction on the impact opening until a reading of at least 7.6 cm (3 in.) H_2O registers on the differential pressu gauge, then plug the impact opening. The pressure of a leak-free system will remain stable for at least 15 seconds.

2.5.3.2 Level and zero the manometers. Since the manometer level and zero may d because of vibrations and temperature changes, periodically check the level and zero during the traverse.

2.5.3.3 Position the probe at the appropriate locations in the gas stream, and rotate until zero deflection is indicated for t yaw angle pressure gauge. Determine and record the yaw angle. Record the pressure gauge readings for the pitch angle, and determine the pitch angle from the calibrati curve. Repeat this procedure for each traverse point. Complete a "back-purge" of the pressure lines and the impact openings prior to measurements of each traverse poi.

A post-test check as described in § 2.5.3.1 is required. If the criteria for a leak-free system are not met, repair the equipment, a repeat the flow angle measurements.

2.5.4 Calculate the resultant angle at eac traverse point, the average resultant angle, and the standard deviation using the following equations. Complete the calculations retaining at least one extra significant figure beyond that of the acquire data. Round the values after the final calculations.

2.5.4.1 Calculate the resultant angle at each traverse point:

R_i = arc cosine [(cosine Y_i)(cosine P_i)] Eq. 1-2

Where:

R_i = Resultant angle at traverse point i, degree.

Y_i = Yaw angle at traverse point i, degree.

P_i = Pitch angle at traverse point i, degree.

2.5.4.2 Calculate the average resultant for the measurements:

$$\bar{R} = \frac{\Sigma R_i}{n} \qquad \text{Eq. 1-3}$$

where:

$\bar{R}$ = Average resultant angle, degree.

n = Total number of traverse points.

2.5.4.3 Calculate the standard deviations:

$$S_d = \sqrt{\frac{\sum_{i=1}^{n} (R_i - \bar{R})^2}{(n-1)}} \qquad \text{Eq. 1-4}$$

Where:

S_d = Standard deviation, degree.

2.5.5 The measurement location is acceptable if $\bar{R}$< 20° and S_d<10°.

2.5.6 Calibration. Use a flow system as described in Sections 4.1.2.1 and 4.1.2.2 of Method 2. In addition, the flow system shall have the capacity to generate two test-section velocities: one between 365 and 730 m/min (1200 and 2400 ft/min) and one between 730 and 1100 m/min (2400 and 3600 ft/min).

2.5.6.1 Cut two entry ports in the test section. The axes through the entry ports shall be perpendicular to each other and intersect in the centroid of the test section. The ports should be elongated slots parallel to the axis of the test section and of sufficient length to allow measurement of pitch angles while maintaining the pitot head position at the test-section centroid. To facilitate alignment of the directional probe during calibration, the test section should be constructed of plexiglass or some other transparent material. All calibration measurements should be made at the same point in the test section, preferably at the centroid of the test-section.

2.5.6.2 To ensure that the gas flow is parallel to the central axis of the test section, follow the procedure in Section 2.4 for cyclonic flow determination to measure the gas flow angles at the centroid of the test section from two test ports located 90° apart. The gas flow angle measured in each port must be ± 2° of 0°. Straightening vanes should be installed, if necessary, to meet this criterion.

2.5.6.3 Pitch Angle Calibration. Perform a calibration traverse according to the manufacturer's recommended protocol in 5° increments for angles from −60° to +60° at one velocity in each of the two ranges specified above. Average the pressure ratio values obtained for each angle in the two flow ranges, and plot a calibration curve with the average values of the pressure ratio (or other suitable measurement factor as recommended by the manufacturer) versus the pitch angle. Draw a smooth line through the data points. Plot also the data values for each traverse point. Determine the differences between the measured data values and the angle from the calibration curve at the same pressure ratio. The difference at each comparison must be within 2° for angles between 0° and 40° and within 3° for angles between 40° and 60°.

2.5.6.4 Yaw Angle Calibration. Mark the three-dimensional probe to allow the determination of the yaw position of the probe. This is usually a line extending the length of the probe and aligned with the impact opening. To determine the accuracy of measurements of the yaw angle, only the zero or null position need be calilbrated as follows. Place the directional probe in the test section, and rotate the probe until the zero position is found. With a protractor or other angle measuring device, measure the angle indicated by the yaw angle indicator on the three-demensional probe. This should be within 2° of 0°. Repeat this measurement for any other points along the length of the pitot where yaw angle measurements could be read in order to account for variations in the pitot markings used to indicate pitot head positions.

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specified above. Average the pressure ratio values obtained for each angle in the two flow ranges, and plot a calibration curve with the average values of the pressure ratio (or other suitable measurement factor as recommended by the manufacturers) versus the pitch angle. Draw a smooth line through the data points. Plot also the data values for each traverse point. Determine the differences between the measured data values and the angle from the calibration curve at the same pressure ratio. The difference at each comparison must be within ±2° for angles between 0° and 40° and with ±3° for angles between 40° and 60°.

2.5.6.4. Yaw Angle Calibration. Mark the three-dimensional probe to allow the determination of the yaw position of the probe. This is usually a line extending the length of the probe and aligned with the impact opening. To determine the accuracy of measurements of the yaw angle, only the zero or null position need be calibrated as follows. Place the directional probe in the test section and rotate the probe until the zero position is found. With a protractor or other angle measuring device, measure the angle indicated by the yaw angle indicator on the three-dimensional probe. This should be within ±2° of 0°. Report this measurement for any other points along the length of the pitot where yaw angle measurements could be read in order to account for variations in the pitot markings used to indicate pitot head positions.

5. By adding Citations 13 and 14 to Section 3, as follows:

3. Bibliography

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