#11

SOURCE SAMPLING REPORT

for

GEORGIA-PACIFIC CORPORATION

Dudley, North Carolina

Performed By:

ENVIRONMENTAL TESTING, INC.
Charlotte, North Carolina

SEAL 5178 JAMES S. McCORMACK

9/30/83

James S. McCormack, PE
September 1983

File: WB_DUD.WQ1
Date: 08/19/94

GEORGIA-PACIFIC, DUDLEY, NC
DETERMINATION OF EMISSION FACTORS FOR 9/20-21/83 EMISSION TEST

Source	Type of control	Pollutant	Run No.	Emission rate, lb/hr	Process rate, ton/hr	Emission factor		Volumetric flow rate, DSCFM	Concen. ppm
						kg/Mg	lb/ton		
Dryer	none	filt. PM	1	81.7	19.1	2.1	4.3		
		filt. PM	2	61.13	18.5	1.6	3.3		
		filt. PM	3	79.29	19.8	2.0	4.0		
					Average	1.9	3.9	Rating:	B
		cond. organic PM	1	29.52	19.1	0.77	1.5		
		cond. organic PM	2	48.89	18.5	1.3	2.6		
		cond. organic PM	3	80.6	19.8	2.0	4.1		
					Average	1.4	2.8	Rating:	B
	WESP	filt. PM	1	7.712	19.1	0.20	0.40		
		filt. PM	2	7.219	18.5	0.19	0.39		
		filt. PM	3	5.824	19.8	0.15	0.29		
					Average	0.18	0.36	Rating:	B
		cond. organic PM	1	0.7532	19.1	0.020	0.039		
		cond. organic PM	2	1.16	18.5	0.031	0.063		
		cond. organic PM	3	1.931	19.8	0.049	0.098		
					Average	0.033	0.067	Rating:	B
	none	CO2	1	13,717	19.1	359	717	96,543	2.07
		CO2	2	13,458	18.5	363	726	96,583	2.03
		CO2	3	13,378	19.8	339	677	97,454	2.00
					Average	353	707	Rating:	B

GEORGIA-PACIFIC, DUDLEY, NC
DETERMINATION OF PRODUCTION RATES FOR 9/20-21/83 EMISSION TEST

		Feed rate,	Moisture content		Production rate,
Run	Dryer	ton/hr	Inlet	Outlet	ton/hr
1	1	11.20	48.2%	4.4%	6.06
	2	12.79	46.7%	4.7%	7.14
	3	10.63	46.7%	4.6%	5.93
	Total	34.62	--	--	19.12
2	1	11.09	46.4%	5.5%	6.27
	2	12.83	45.3%	5.9%	7.43
	3	8.54	46.3%	5.5%	4.84
	Total	32.46	--	--	18.54
3	1	11.16	46.4%	5.3%	6.30
	2	12.77	45.4%	5.5%	7.36
	3	10.33	44.0%	5.5%	6.10
	Total	34.26	--	--	19.76

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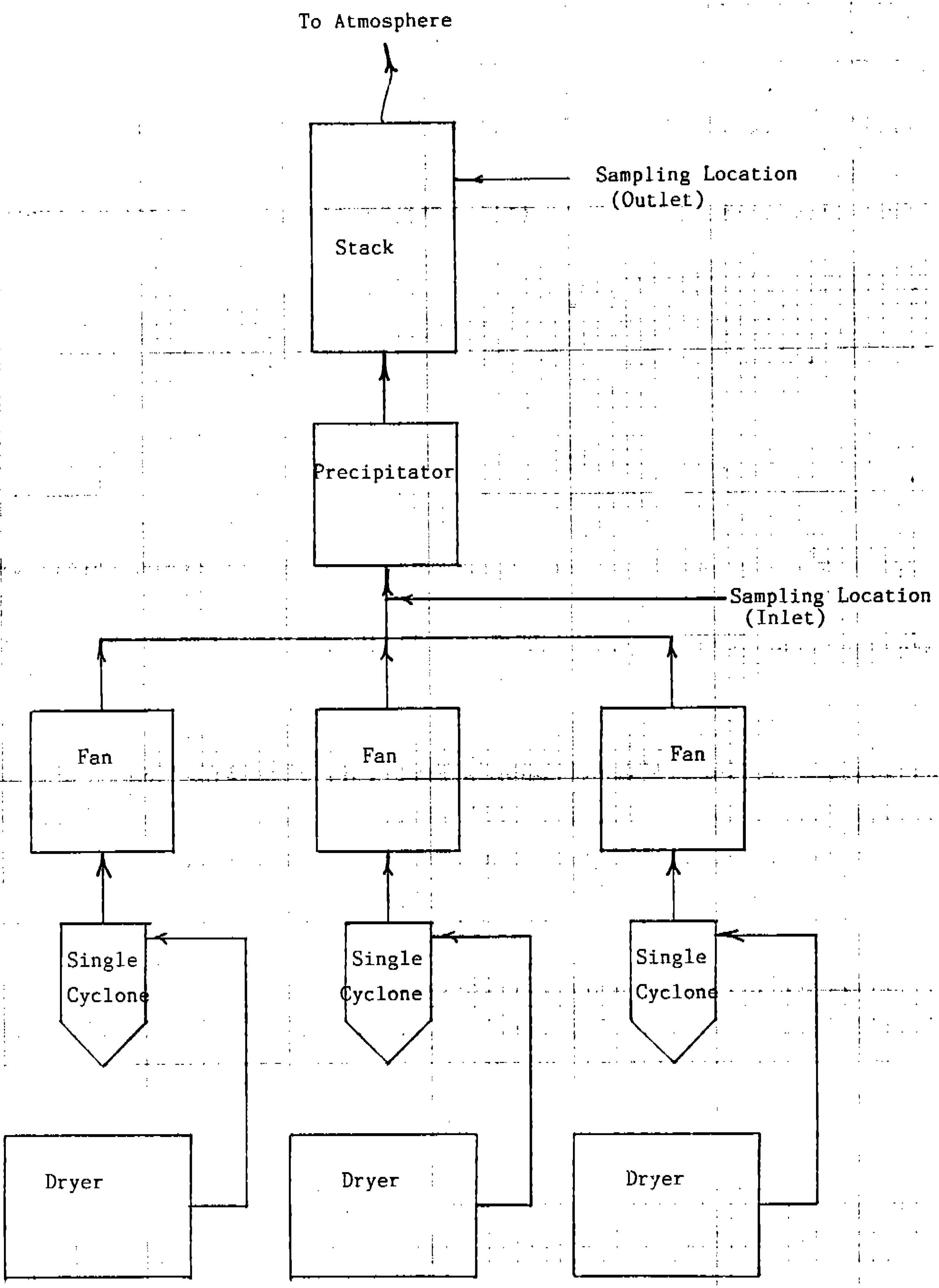
INTRODUCTION

Source sampling was performed at the Georgia-Pacific Corporation Comply Plant, Dudley, North Carolina, on September 20 and 21, 1983. The purpose of the sampling was two-fold: to determine particulate emissions from three green chip dryers for compliance purposes and to determine precipitator efficiency for guarantee purposes. Two simultaneous samples at the precipitator inlet and at the stack were made on September 20, 1983, and two simultaneous samples at the same locations were made on September 21, 1983. The first set of samples on September 21, 1983 was voided due to the failure of a post test leak check.

All measurements for stack gas flow rate, particulate concentrations and emission rates were made in accordance with the recommendations of the U.S. Environmental Protection Agency and the N.C. Department of Natural Resources and Community Development (DNRCD). Mr. Vic Copeland, DNRCD, was present as an observer.

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



FLOW DIAGRAM

Figure 1

SUMMARY OF RESULTS

Tables 1 and 2 present the results of the particulate sampling. Results at the precipitator outlet indicated a mean particulate concentration of 0.0017 grains per dry standard cubic foot and a mean particulate emission rate of 6.92 pounds per hour. The precipitator inlet results indicated a mean particulate concentration of 0.0892 grains per dry standard cubic foot and a mean particulate emission rate of 74.04 pounds per hour. Based on the mean emission rate, the precipitator efficiency was 90.66 percent. Process weight rate data is shown in Appendix C.

Based on the results of the sampling, the mean mass emission rate was in compliance with Prevention of Significant Deterioration permit limitation of 30 pounds per hour.

Table 1

SUMMARY OF RESULTS, PARTICULATE SAMPLING OUTLET

Run Number	1	2	4	
Date	9/20/83	9/20/83	9/21/83	
% Isokinetic	98.83	95.03	101.76	
% Excess Air	1016.5	1117.0	861.6	
Volume of Gas Sampled SCF* Dry	67.224	66.688	68.054	
Stack Gas Flow Rate, SCFM* Dry	87,589	88,277	88,882	Ave 88249
Stack Gas Flow Rate, ACFM	117,810	118,003	118,470	
Particulates: **				
Catch, mgrams	44.85	41.32	33.79	
Concentration, grains/ SCF* Dry	0.0103	0.0095	0.0077	Ave
Emission Rate, lbs/hr	7.712	7.219	5.824	6.92

EMISSION FACTOR
FOR FEED RATE OF
FOR PROD. RATE OF

* 68°F, 29.92 in. Hg.

** Front half only

(Back half data in Appendix A)

TABLE 2

SUMMARY OF RESULTS, PARTICULATE SAMPLING, INLET

Run Number	1	2	4
Date	9/20/83	9/20/83	9/21/83
% Isokinetcs	108.48	102.54	101.83
% Excess Air	1016.5	1117.0	861.6
Volume of Gas Sampled, SCF* Dry	25.825	24.977	25.312
Stack Gas Flow Rate, SCFM* Dry	96,543	96,583	97,454
Stack Gas Flow Rate, ACFM	135,560	132,430	137,230
Particulates: **			
Catch, mgrams	165.59	119.79	156.03
Concentration, grains/ SCF* Dry	0.0988	0.0739	0.0949
Emission Rate, lbs/hr	81.70	61.13	79.29

avg. 74.0

dry 243 tons/14.73 hr = 16.5 tons/hr

4.5 lb/ton

* 68°F, 29.92 in. Hg.

** Front half only
(Back half data in Appendix A)

based on Feed

74/31.01 = 2.4

PROCESS DESCRIPTION AND OPERATION

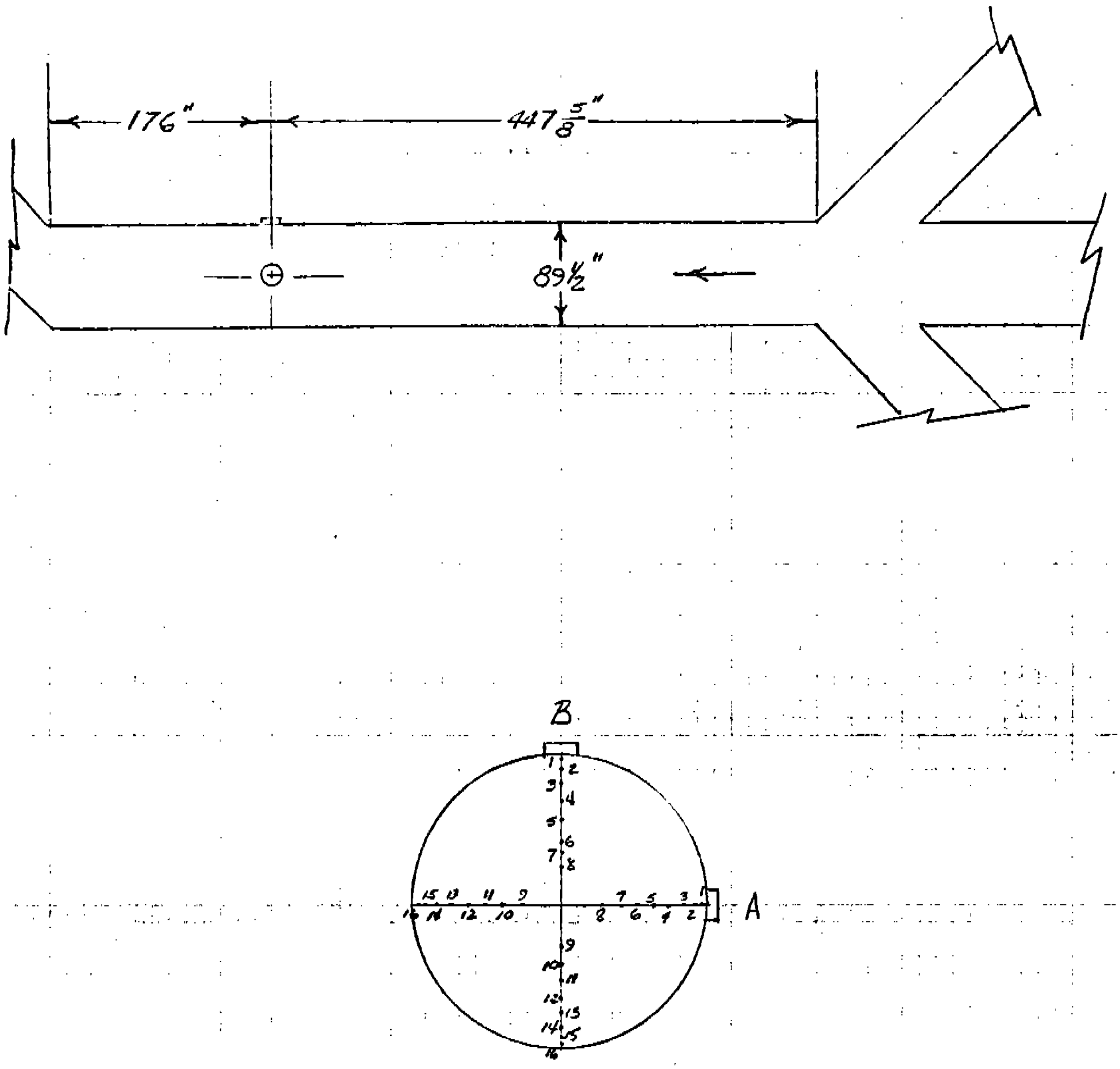
Three dryers in parallel are used to dry green flakes or chips to be used in the production of either Comply panels or oriented strand board. The green chips are fed into the dryers and, after drying, are conveyed to dry chip bins for use in the manufacturing process. The dryers are fired with sander dust from the manufacturing process.

The dryer gases pass from each dryer into three simple cyclones in parallel. The stack gases exiting from the three simple cyclones pass through three fans in parallel and combine to enter a wet electrostatic precipitator to a stack to the atmosphere. The precipitator was manufactured by United-McGill Corporation.

LOCATION OF SAMPLING PORTS AND POINTS

The dimensions of the precipitator inlet duct and stack are shown in Figures 2 and 3. The inlet duct was divided into 32 equal areas. The sampling point in each area was sampled for two minutes a point which yielded a total test time of 64 minutes per sample. The stack was divided into 36 equal areas. The sampling point in each area was sampled for two minutes a point which yielded a total test time of 72 minutes per sample. The first traverse at each location was begun simultaneously as were the second traverses.

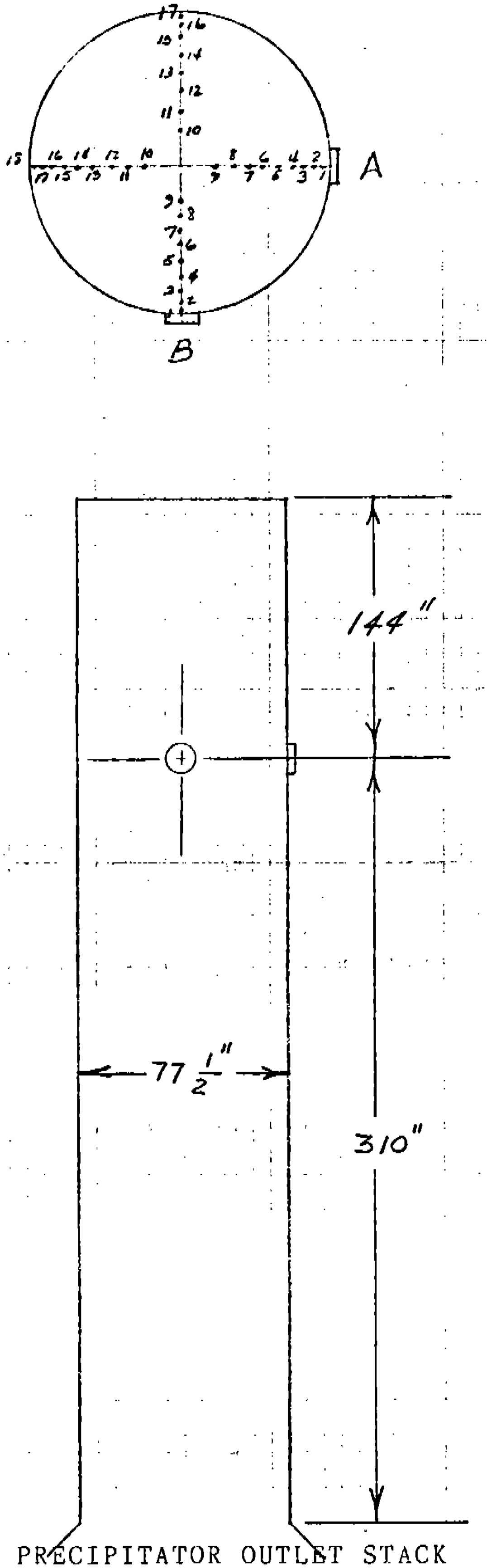
The number of sampling points was determined by the distance of the sampling ports from disturbances in the gas flow as described in Method 1, Federal Register, Volume 42, No. 180, 18 August 1977.



PRECIPITATOR INLET

LOCATION OF SAMPLING PORTS AND POINTS

Figure 2



PRECIPITATOR OUTLET STACK

LOCATION OF SAMPLING PORTS AND POINTS

Figure 3

SAMPLING AND ANALYTICAL PROCEDURES

All sampling and analytical procedures used were those recommended by the U.S. Environmental Protection Agency and the N.C. DNRCD. Complete details are found in Appendix E which is a copy of the Federal Register, Volume 42, Number 160, dated 18 August 1977.

Sample point locations and velocity measurements were made by Methods 1 and 2. Gas composition was determined by Method 3 on integrated bag samples at the stack location. Method 5 was used for particulate determination.

Condensable hydrocarbons were extracted with Freon in accordance with EPA Method 413.1. The resulting material was then ashed in a muffle furnace at 550°C for 15 minutes. The difference between the beginning and final weights was considered to be hydrocarbon.

APPENDICIES

SUMMARY OF PARTICULATE RESULTS

APPENDIX A

GEORGIA PACIFIC - DUDLEY, N.C. OUTLET

RUN NUMBER		1	2	4
DATE		9/20/83	9/20/83	9/21/83
DN	SAMPLE NOZZLE DIA., IN	.255	.258	.251
TT	NET TIME OF TEST, MIN	72	72	72
PB	BAROMETRIC PRESSURE, IN HG	30.05	30.05	29.78
PM	AVERAGE ORIFICE PRESSURE DROP, IN H2O	3.469	3.506	3.539
VM	VOLUME OF DRY GAS SAMPLED CU FT AT METER CONDITIONS	69.73	69.40	71.11
TM	AVERAGE GAS METER TEMP DEGREES	94.47	96.36	93.72
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*, SCF	67.224	66.688	68.054
VW	TOTAL H2O COLLECTED IN IMPINGERS + SILICA GEL, ML	253.9	245.4	258.6
VWV	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*, SCF	11.96	11.56	12.18
PMV	PERCENT MOISTURE BY VOL	15.10	14.77	15.18
MD	MOLE FRACTION DRY GAS	.8490	.8523	.8482
PCO2	PERCENT CO2 BY VOL., DRY	2.07	2.03	2.00
PO2	PERCENT O2 BY VOL., DRY	19.00	19.13	18.77
PCO	PERCENT CO BY VOL., DRY	0.00	0.00	0.00
PN2	PERCENT N2 BY VOL., DRY	78.93	78.83	79.23
MWD	MOLECULAR WT-DRY STK GAS	29.09	29.09	29.07
MW	MOLECULAR WT-STK GAS	27.42	27.45	27.39
CP	PITOT TUBE COEFFICIENT	.84	.84	.84
DPS	AVERAGE VELOCITY HEAD OF STACK GAS, IN H20	.9698	.9731	.9796
TS	AVERAGE STACK TEMPERATURE	144.11	142.72	132.72

PSI	STATIC PRES OF STK GAS IN HG	-.0618	-.0618	-.0603
PS	STACK PRESSURE, ABSOLUTE	29.99	29.99	29.72
VS	AV STK GAS VELOCITY, FPM	3581.6	3587.5	3601.7
AS	STACK AREA , IN SQRD	4717.3	4717.3	4717.3
QS	STK FLOW RATE, DRY, STD COND.	87589	88277	88882
QSW	STK FLOW RATE, WET, STD COND.	103167	103574	104786
QA	ACTUAL STK FLOW RATE	117810	118003	118470
PERI	PERCENT ISOKINETIC	98.83	95.03	101.76
FMF	PARTICULATE, MG, FRONT	44.85	41.32	33.79
FBF	HYDROCARBON MG, BACK	4.38	6.64	11.20
CAN	PARTICULATE, GR/DSCF , Front	.0103	.0095	.0077
CBN	HYDROCARBON GR/DSCF BACK	.0010	.0015	.0025
CAM	PARTICULATE, GR/WSCF , Front	.0121	.0112	.0090
CBM	HYDROCARBON GR/WSCF BACK	.0012	.0018	.0030
CAT	PARTICULATE, GR/ACF , Front	.0076	.0071	.0057
CBT	HYDROCARBON GR/ACF BACK	.00075	.0012	.0019
CAW	PARTICULATE, LB/HR, Front	7.712	7.219	5.824
CBW	HYDROCARBON LB/HR BACK	.7532	1.160	1.971
PEA	PERCENT EXCESS AIR	1016.5	1117.0	861.6
FNP	NET SAMPLING POINTS	36	36	36

*68 DEG F. 29.92 IN HG

8.47 8.38 7.76

Avg = 8.20

93.5 % CE

SUMMARY OF PARTICULATE RESULTS APPENDIX A

GEORGIA PACIFIC - DUDLEY, NC INLET

RUN NUMBER		1	2	4
DATE		9/20/83	9/20/83	9/21/83
DN	SAMPLE NOZZLE DIA., IN	.176	.178	.179
TT	NET TIME OF TEST, MIN	64	64	64
PB	BAROMETRIC PRESSURE, IN HG	30.05	30.05	29.78
PM	AVERAGE ORIFICE PRESSURE DROP, IN H20	.5853	.5703	.5994
VM	VOLUME OF DRY GAS SAMPLED CU FT AT METER CONDITIONS	26.65	26.24	26.67
TM	AVERAGE GAS METER TEMP DEGREES	89.66	97.55	94.34
VMSTD	VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS*, SCF	25.825	24.977	25.312
VW	TOTAL H20 COLLECTED IN IMPINGERS + SILICA GEL, ML	92.6	81.1	97.6
VWV	VOLUME OF WATER VAPOR AT STANDARD CONDITIONS*, SCF	4.361	3.819	4.596
PMV	PERCENT MOISTURE BY VOL	14.45	13.26	15.37
MD	MOLE FRACTION DRY GAS	.8555	.8674	.8463
PCO2	PERCENT CO2 BY VOL., DRY	2.07	2.03	2.00
PO2	PERCENT O2 BY VOL., DRY	19.00	19.13	18.77
PCO	PERCENT CO BY VOL., DRY	0.00	0.00	0.00
PN2	PERCENT N2 BY VOL., DRY	78.93	78.83	79.23
MWD	MOLECULAR WT-DRY STK GAS	29.09	29.09	29.07
MW	MOLECULAR WT-STK GAS	27.49	27.62	27.37
CP	PITOT TUBE COEFFICIENT	.84	.84	.84
DPS	AVERAGE VELOCITY HEAD OF STACK GAS, IN H20	.8169	.8039	.8294
TS	AVERAGE STACK TEMPERATURE	184.84	178.41	174.25

PSI	STATIC PRES OF STK GAS IN HG	+.3897	+.3897	+.3897
PS	STACK PRESSURE, ABSOLUTE	30.43	30.43	30.17
VS	AV STK GAS VELOCITY, FPM	3090.2	3018.9	3128.3
AS	STACK AREA , IN SQRD	6291.3	6291.3	6291.3
QS	STK FLOW RATE, DRY, STD COND.	96543	96583	97454
QSW	STK FLOW RATE, WET, STD COND.	112844	111350	115149
QA	ACTUAL STK FLOW RATE	135560	132430	137230
PERI	PERCENT ISOKINETIC	108.48	102.54	101.83
FMF	PARTICULATE, MG, FRONT	165.59	119.79	156.03
FBF	HYDROCARBON MG BACK	59.84	95.79	158.61
CAN	PARTICULATE, GR/DSCF FRONT	.0988	.0739	.0949
CBN	HYDROCARBON GR/DSCF BACK	.0357	.0591	.0965
CAM	PARTICULATE, GR/WSCF FRONT	.1154	.0852	.1122
CBM	HYDROCARBON GR/WSCF BACK	.0417	.0681	.1140
CAT	PARTICULATE, GR/ACF FRONT	.0703	.0539	.0674
CBT	HYDROCARBON GR/ACF BACK	.0254	.0431	.0685
CAW	PARTICULATE, LB/HR FRONT	81.70	61.13	79.29
CBW	HYDROCARBON. LB/HR BACK	29.52	48.89	80.60
PEA	PERCENT EXCESS AIR	1016.5	1117.0	861.6
FNP	NET SAMPLING POINTS	32	32	32
	*68 DEG F. 29.92 IN HG	111.22	110.02	159.89

AVG = 127.04

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PARTICULATE CALCULATIONS TEST 3

G P DUDLEY, NC PRECIP OUTLET


VOLUME OF DRY GAS SAMPLED AT STD. CONDITIONS
            17.64 * VM *(PR + PM / 13.6)
VMSTD = ---------------------------------- =                  68.054
                     TM + 460

VOLUME OF WATER VAPOR AT STD. CONDITIONS
VMV = .04709 * VW =                                           12.18

PERCENT MOISTURE IN STACK GAS
           100 * VMV
PMV = ------------- =                                         15.18
          VMSTD + VMV

MOLE FRACTION OF DRY STACK GAS
       100 - PMV
MD = ---------- =                                             .8482
          100

AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS
MWD = .44 * PCO2 + .32 * PO2 + .28 *(PN2+PCO) =               29.07

MOLECULAR WEIGHT OF STACK GAS
MW = MWD * MD + 18 * (1-MD) =                                 27.39

STACK GAS VELOCITY AT STACK CONDITIONS
VS = 5129.4 * CP * DPS * SQRT(TS + 460)/(PS * MW) =          3601.7

STACK GAS VOLUMETRIC FLOW AT STD. CONDITIONS, DRY
       .123 * VS * AS * PS * MD
QS = ------------------------------ =                         88882
               TS + 460

STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS
       QS * (TS + 460)
QA = --------------- =                                        118470
       17.64 * PS * MD

PERCENT ISOKINETIC
         1039 * (TS + 460) * VMSTD
PERI = ----------------------------- =                        101.76
         VS * TT * PS * MD * DN * DN

PERCENT EXCESS AIR
            (PO2 - .5 * PCO) 100
PEA = ------------------------ =                              861.64
       .2644 * PN2 - PO2 + .5 * PCO
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```
CAN = .0154 * FMF/VMSTD =                                  .0077

PARTICULATE LOADING -- PROBE, CYCLONE, FILTER
          (AT STACK CONDITIONS)
      17.64 * CAN * PS * MD
CAT = --------------------- =                              .0057
          TS + 460

PARTICULATE LB/HR -- PROBE, CYCLONE, FILTER
          (AT STACK CONDITIONS)
CAW = .00857 * CAN * QS =                                  5.824




CBN = .0154 * FMF/VMSTD =                                  .0025

PARTICULATE LOADING -- PROBE, CYCLONE, FILTER
          (AT STACK CONDITIONS)
      17.64 * CBN * PS * MD
CBT = ----------------------- =                            .0019
          TS + 460

PARTICULATE LB/HR -- PROBE, CYCLONE, FILTER
          (AT STACK CONDITIONS)
CBW = .00857 * CBN * QS =                                  1.931
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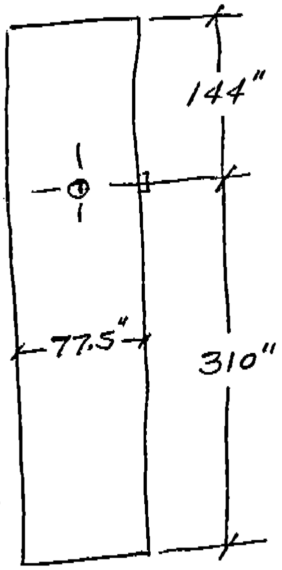
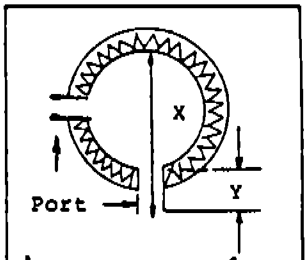
APPENDIX B

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS



Plant GP-Dudley Precip. Outlet
Date
Sampling location Precip Outlet Stk
Inside of far wall to outside of nipple (X) 79.25"
Inside of near wall to outside of nipple (nipple length) (Y) 1.75"
Stack I.D. (X-Y) 77.5"
Nearest upstream disturbance 4.0 dd
Nearest downstream disturbance 1.86 dd
Calculated by JSM-PRJ



SCHEMATIC OF SAMPLING LOCATION

1	2	3	4	5	
TRAVERSE POINT NUMBER	FRACTION OF STACK I.D	STACK I.D	PRODUCT OF COLUMNS 2 AND 3 (TO NEAREST 1/8 INCH)	NIPPLE LENGTH	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5)
A 1	1.4	77.5"	1.09"	1.75"	2.84"
2	4.4		3.41		5.16
3	7.6		5.81		7.56
4	10.9		8.45		10.20
5	14.6		11.32		13.07
6	18.8		14.57		16.32
7	23.6		18.29		20.04
8	29.6		22.94		24.69
9	38.2		29.61		31.36
10	61.8		47.90		49.65
11	70.4		54.56		56.31
12	76.4		59.21		60.96
13	81.2		62.93		64.68
14	85.4		66.19		67.94
15	89.1		69.05		70.80
16	92.5		71.69		73.44
17	95.6		74.09		75.84
18	98.6		76.42		78.17

Pitot tube Lk Ck

⊕ <0.10" @ 2.30" ok
⊖ <0.10" @ 2.60 ok

Plant and city	Run date
GP - Dudley	9 / 20 / 83

Sampling location	Clock time
Precip Stk	0831

Wb = 123°F
Db = 139

Δ = 16

Run number	Operator	Amb. temp., °F	Bar. press., in. Hg	Static press., in. H_2O
1	K. O'NEAL	69°F	30.05	-0.82

Molecular wt.	Stack inside dimension, in.		Pitot tube (Cp)
	Diam. or side 1	side 2	
	77.5	77.5	.84

Field data

Traverse point number	Position, in.	Velocity head (Δp_s), in. H_2O	Stack temp., °F	Cyclonic flow determination	
				Δp_s at 0° reference	Angle (α) which yields a null Δp
A 1	2.84	1.05	139	0.30	3
2	5.16	1.30		0.30	5
3	7.56	1.30		0.10	3
4	10.20	1.20		0.00	0
5	13.07	1.15		0.00	0
6	16.32	1.10		0.10	4
7	20.04	1.05		0.00	0
8	24.69	.97		0.00	0
9	31.36	.92		0.10	4
10	49.65	.90		0.40	5
11	56.31	.91		0.40	3
12	60.96	.90		0.60	4
13	64.68	.93		0.10	5
14	67.94	.97		0.12	2
15	70.80	.99		0.11	4
16	73.44	1.00		0.15	4
17	75.84	1.00		0.14	3
18	78.17	.92	139	0.17	3
		$\overline{\Delta p_s} = 1.03$			
				Average angle (α)[a]	3.25

ok ✓

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

Figure 1.7. Method 2 gas velocity and volume data form.

Observer: Vic Copeland

Agency: NC DNRCD

PARTICULATE FIELD DATA

VERY IMPORTANT - FILL IN ALL BLANKS

Plant GP-Dudley
Run No. 1
Location Precip Stk
Date 9/20/83
Operator K.O'Neal
Sample Box No. 1
Meter Box No. RAC S-134P
Meter ΔH@ 1.98
C Factor .95

Leak Checks: Beg. @ 15" .006
End @ 8" .006

Pitot Tube: <0.1" @ 2.65 "H_2O
: <0.1' @ 3.20 "H_2O

Static Pres., in H_2O: -.84
Start: 1000
Finish: 1147
Filter # 25 Probe # 4

W_b 123 °F D_b 139 °F
Ambient Temp °F 72
Bar. Press. in. Hg. 30.05
Assumed Moisture % 15
Heater Box Setting, °F 250±25
Probe Tip Dia., In. .255
Probe Length 8' SS
Probe Heater Setting 80%
Average Δp 1.03 0.50
Average ΔH 3.80 Ref

Point	Clock Time	Dry Gas Meter, Cu.Ft.	Pitot Manometer (Δp) in. H_2O	Orifice Manometer (ΔH) in. H_2O		Dry Gas Temp. °F		Pump Vacuum in. Hg Gauge	Box Temp. °F	Impinger Temp °F	Stack Temp °F	% CO_2	% O_2
				Desired	Actual	Inlet	Outlet						
A 1	0	640.00	.82	3.00	3.00	77	77	5.5	250	60	146		
2	2	641.83	1.1	4.00	4.00	83	77	6.5	240	59	145		
3	4	643.89	1.2	4.30	4.30	89	78	7.0	230	55	145		
4	6	646.05	1.2	4.30	4.30	94	78	7.0	220	55	145		
5	8	648.22	1.15	4.20	4.20	98	89	7.0	240	60	145		
6	10	650.38	1.1	4.00	4.00	101	80	6.5	240	65	145		
7	12	652.49	1.05	3.85	3.85	103	81	6.5	220	65	145		
8	14	654.58	.98	3.6	3.6	104	81	6.0	230	65	145		
9	16	656.57	.93	3.4	3.4	106	82	5.5	260	65	145		
10	18	658.59	.85	3.15	3.15	106	83	5.5	260	65	145		
11	20	660.42	.83	3.05	3.05	104	84	5.5	260	65	145		
12	22	662.28	.86	3.2	3.2	108	85	5.5	240	65	145		
13	24	664.17	.87	3.2	3.2	109	86	5.5	240	65	148		
14	26	666.08	.91	3.35	3.35	110	87	5.5	250	65	148		
15	28	667.98	.95	3.5	3.5	113	87	6.0	275	65	148		
16	30	669.95	.98	3.6	3.6	114	89	6.0	260	60	148		
17	32	671.97	.96	3.55	3.55	113	89	6.0	270	60	148		
18	34	673.98	.61	2.3	2.3	89	86	5.0	250	60	140		
B 1	36/0	675.58	.84	3.05	3.05	95	88	5.5	225	65	140		

METHOD 5

Point	Clock Time	Dry Gas Meter, Cu.Ft.	Pitot Manometer (Δp) in. H_2O	Orifice Manometer (ΔH) in. H_2O		Dry Gas Temp. °F		Pump Vacuum in. Hg Gauge	Box Temp. °F	Impinger Temp °F	Stack Temp °F	% CO_2	% O_2
				Desired	Actual	Inlet	Outlet						
-2	2	677.40	.95	3.50	3.50	101	88	6.0	225	60	145		
3	4	679.43	.96	3.55	3.55	104	88	6.0	225	60	145		
4	6	681.36	.92	3.40	3.40	106	88	5.5	225	60	142		
5	8	683.70	.90	3.30	3.30	108	89	6.0	225	60	142		
6	10	685.24	.86	3.20	3.20	109	89	6.0	225	60	144		
7	12	687.12	.82	3.05	3.05	709	90	6.0	225	63	144		
8	14	688.96	.78	2.90	2.90	107	90	5.5	225	55	145		
9	16	690.78	.90	3.30	3.30	107	90	6.5	225	55	145		
10	18	692.74	.94	3.45	3.45	110	91	6.5	225	55	145		
11	20	694.62	.96	3.55	3.55	111	91	6.5	225	55	145		
12	22	696.62	.98	3.6	3.6	111	91	7.0	230	55	145		
13	~~24~~0	698.61	1.05	3.9	3.9	89	85	6.5	230	50	140		
14	~~26~~2	700.65	1.00	~~1.00~~3.7	3.7	95	86	6.5	230	45	140		
15	~~28~~4	702.68	1.00	3.7	3.7	100	86	6.0	240	50	140		
16	~~30~~6	704.66	.99	3.65	3.65	106	87	6.0	260	50	140		
17	~~32~~8	706.63	.94	3.45	3.45	109	87	6.0	200	55	140		
18	~~34~~10	708.65	.85	3.10	3.10	112	87	5.5	225	55	140		
	~~36~~12	710.43											

no pro heat

probe ht ok

[illegible] 1113

METHOD 5

Observer: Vic Copelan

Agency: NC ONRCO

Plant GP-Dudley

Run No. 2

Location Precip Stk

Date 9/20/87

Operator K. O'Neal

Sample Box No. 2

Meter Box No. 5-1348

Meter $\Delta H_@$ 1.98

C Factor .95

PARTICULATE FIELD DATA

VERY IMPORTANT - FILL IN ALL BLANKS

Leak Checks: Beg. @ 15" .003

End @ 8" .005

Pitot Tube: <.10" ok @ 2.00 "H_2O

: <.10" ok @ 230 "H_2O

Static Pres., in H_2O: -.84

Start: 1342

Finish: 1527

Filter # 26 Probe # 5

W_b 123 °F D_b 139 °F

Ambient Temp °F 85

Bar. Press. in. Hg. 30.05

Assumed Moisture % 15%

Heater Box Setting, °F 250±25

Probe Tip Dia., In. .258

Probe Length 8' SS

Probe Heater Setting 85%

Average Δp 1.03 .50

Average ΔH 3.80 Ref

Point	Clock Time	Dry Gas Meter, Cu.Ft.	Pitot Manometer (Δp) in. H_2O	Orifice Manometer (ΔH) in. H_2O		Dry Gas Temp. °F		Pump Vacuum in. Hg Gauge	Box Temp. °F	Impinger Temp °F	Stack Temp °F	% CO_2	%O_2
				Desired	Actual	Inlet	Outlet						
A 1	0	710.60	.78	2.90	2.90	86	85	5.0	240	62	143		
2	2	712.37	1.15	4.20	4.20	91	87	6.0	230	65	142		
3	4	714.45	1.2	4.3	4.3	96	87	6.0	240	50	142		
4	6	716.61	1.2	4.3	4.3	101	87	6.0	260	55	144		
5	8	718.74	1.15	4.2	4.2	105	88	6.5	230	55	145		
6	10	720.86	1.1	4.05	4.05	107	89	6.0	250	60	145		
7	12	722.95	1.0	3.65	3.65	108	89	5.5	240	60	145		
8	14	724.94	.95	3.5	3.5	109	90	5.5	240	65	145		
9	16	726.88	.90	3.3	3.3	109	90	5.0	250	65	145		
10	18	728.77	.82	3.0	3.0	106	91	5.0	225	65	145		
11	20	730.63	.84	3.1	3.1	107	91	5.0	225	61	146		
12	22	732.51	.81	3.0	3.0	108	91	5.0	240	60	146		
13	24	734.24	.85	3.1	3.1	109	92	5.5	240	60	148		
14	26	736.09	.87	3.2	3.2	111	92	6.0	260	50	140		
15	28	738.06	.89	3.25	3.25	111	92	5.5	230	60	148		
16	30	739.96	.94	3.5	3.5	112	92	5.5	230	60	147		
17	32	741.97	.98	3.65	3.65	114	93	6.0	250	60	147		
18	34	743.87	.88	3.25	3.25	116	93	5.5	260	65	145		
B 1	36/0	745.79	.58	2.15	2.15	101	92	4.5	270	62	142		

METHOD 5

Point	Clock Time	Dry Gas Meter, Cu.Ft.	Pitot Manometer (Δp) in. H_2O	Orifice Manometer (ΔH) in. H_2O		Dry Gas Temp. °F		Pump Vacuum in. Hg Gauge	Box Temp. °F	Impinger Temp °F	Stack Temp °F	% CO_2	% O_2
				Desired	Actual	Inlet	Outlet						
2	2	747.30	.83	3.05	3.05	103	93	6.0	250	59	144		
3	4	749.20	.88	3.25	3.25	106	92	6.0	260	58	144		
4	6	751.18	.94	3.45	3.45	108	92	6.0	270	60	144		
5	8	752.97	.92	3.4	3.4	109	92	60	230	60	146		
6	10	754.87	.86	3.2	3.2	111	92	5.5	225	60	146		
7	12	756.90	.82	3.05	3.05	112	92	5.5	225	60	146		
8	14 0	758.64	.94	3.45	3.45	85	85	6.0	250	60	145		
9	~~16~~ 2	760.58	.96	3.55	3.55	90	86	6.0	225	50	140		
10	~~18~~ 4	762.35	1.05	3.9	3.9	94	85	5.5	225	50	140		
11	~~20~~ 6	764.45	1.0	3.7	3.7	96	85	6.0	225	55	138		
12	~~22~~ 8	766.48	1.05	3.9	3.9	98	85	65	225	55	137		
13	~~24~~ 10	768.56	1.05	3.9	3.9	100	85	6.5	230	55	136		
14	~~26~~ 12	770.47	1.05	3.9	3.9	101	84	6.5	240	55	137		
15	~~28~~ 14	772.52	1.05	3.9	3.9	102	84	6.5	225	60	137		
16	~~30~~ 16	774.63	1.05	3.9	3.9	103	85	6.5	225	60	136		
17	~~32~~ 18	776.72	1.05	3.9	3.9	107	85	6.5	230	60	136		
18	~~34~~ 20	778.81	.86	3.2	3.2	10.9	85	6.0	230	60	136		
	36 22	780.70											

Observer:

Agency:

PARTICULATE FIELD DATA

VERY IMPORTANT - FILL IN ALL BLANKS

Plant	CP-Dudley	Wb 123 °F	Db 139 °F
Run No.	4	Ambient Temp °F	78°F
Location	Preip-Outlet Stk	Bar. Press. in. Hg.	29.78
Date	9/21/83	Assumed Moisture %	15%
Operator	JSM	Heater Box Setting, °F	250°F
Sample Box No.	3	Probe Tip Dia., In.	.251
Meter Box No.	RAC 1348	Probe Length	8' 55
Meter ΔH@	1.98@ Y=0.99	Probe Heater Setting	85%
C Factor	.95	Average Δp	.50
		Average ΔH	Ref

Leak Checks: Beg. @ 15" .007

End @21" .007

Pitot Tube: <0.1 @ 3.7 "H_2O

: <0.1 @ 4.8 "H_2O

Static Pres., in H_2O: -.82

Start: 1313

Finish:

Filter # 44 Probe # 3

Point	Clock Time	Dry Gas Meter, Cu.Ft.	Pitot Manometer (Δp) in. H_2O	Orifice Manometer (ΔH) in. H_2O		Dry Gas Temp. °F		Pump Vacuum in. Hg Gauge	Box Temp. °F	Impinger Temp °F	Stack Temp °F	% CO_2	% O_2
				Desired	Actual	Inlet	Outlet						
A 1	0	856.74	1.05	3.8	3.8	78	78	14.0	260	60	131		
2	2	858.60	1.1	4.0	4.0	84	78	16.0	250	59	131		
3	4	860.65	1.2	4.35	4.35	89	79	17.0	275	56	132		
4	6	862.70	1.05	3.8	3.8	91	79	20.0	275	56	132		
5	8	864.74	1.1	4.0	4.0	91	80	15.0	270	54	132		
6	10	866.77	1.1	4.0	4.0	96	81	16.0	225	66	133		
7	12	868.82	1.0	3.65	3.65	99	81	16.0	225	66	133		
8	14	870.87	.95	3.5	3.5	102	82	15.0	225	68	133		
9	16	872.90	.90	3.3	3.3	104	84	13.0	225	68	133		
10	18	874.88	.83	3.05	3.05	105	83	12.0	225	68	133		
11	20	876.81	.83	3.05	3.05	103	83	11.0	230	62	134		
12	22	878.70	.86	3.2	3.2	104	84	12.0	240	59	133		
13	24	880.61	.89	3.25	3.25	105	85	12.0	260	58	134		
14	26	882.52	.91	3.35	3.35	106	86	12.0	275	56	134		
15	28	884.44	.95	3.55	3.55	106	86	13.0	275	56	134		
16	30	886.42	.98	3.65	3.65	107	87	14.0	275	58	133		
17	32	888.45	.98	3.65	3.65	107	87	15.0	275	58	132		
18	34	890.47	.96	3.55	3.55	108	88	14.0	270	58	133		
B 1	36/0	892.68	.76	2.8	2.8	99	86	9.0	260	58	132		

METHOD 5

Point	Clock Time	Dry Gas Meter, Cu.Ft.	Pitot Manometer (Δp) in. H_2O	Orifice Manometer (ΔH) in. H_2O		Dry Gas Temp. °F		Pump Vacuum in. Hg Gauge	Box Temp. °F	Impinger Temp °F	Stack Temp °F	% CO_2	% O_2
				Desired	Actual	Inlet	Outlet						
2	2	894.28	.84	3.1	3.1	101	86	10.0	260	60	133		
3	4	896.13	.93	3.5	3.5	103	86	12.0	265	58	133		
4	6	898.07	1.05	3.85	3.85	104	86	15.0	270	56	133		
5	8	900.09	1.0	3.65	3.65	105	86	14.0	270	54	133		
6	10	902.13	.96	3.55	3.55	106	86	14.0	270	53	131		
7	12	904.15	.85	3.15	3.15	107	85	13.0	275	58	131		
8	14	906.18	.81	2.95	2.95	107	86	11.0	275	56	131		
9	16	908.06	.81	2.95	2.95	107	87	11.0	275	55	131		
10	18	909.85	.91	3.4	3.4	107	87	13.0	275	55	131		
11	20	911.95	.97	3.65	3.65	107	87	15.0	265	55	132		
12	22	913.90	1.0	3.7	3.7	107	87	15.5	265	60	133		
13	24	915.95	1.05	3.85	3.85	107	85	16.0	265	61	134		
14	26	918.03	1.05	3.85	3.85	107	87	17.0	260	62	134		
15	28	920.13	1.05	3.85	3.85	108	87	17.5	260	62	134		
16	30	922.24	1.05	3.85	3.85	110	87	18.0	265	64	134		
17	32	924.34	1.0	3.65	3.65	112	87	17.0	260	65	134		
18	34	926.44	.91	3.4	3.4	113	87	16.0	260	65	134		
	36	928.57											

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METHOD 3

ORSAT ANALYSIS AND DRY MOLECULAR WEIGHT DETERMINATION

PLANT G-P Dudley, NC Precip Outlet – Stk

DATE 9/20/83

SAMPLING TIME (24-hr CLOCK) 1000 – 1147

SAMPLING LOCATION Precip outlet – Stk

SAMPLE TYPE [✓ BAG], INTEGRATED, [✓ CONTINUOUS]

ANALYTICAL METHOD Orsat

AMBIENT TEMPERATURE 72°F

OPERATOR K. O'NEAL

COMMENTS: RUN NO. 1

ORSAT LK CK @ 4 MIN

BURET 18.3
18.3
0.0 ✓

PIPET NO LK ✓

O_2 CK @ 4 passes
20.8 ✓

GAS \ RUN	1		2		3		AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS–DRY BASIS M_d lb/lb-mole
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET			
CO_2	2.1	2.1	2.0	2.0	2.1	2.1	2.07	44/100	.9108
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2)	21.0	18.9	21.1	19.1	21.1	19.0	19.00	32/100	6.0800
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2)	21.0	0.0	21.1	0.0	21.1	0.0	0.00	28/100	0.0000
N_2 (NET IS 100 MINUS ACTUAL CO)	—	79.0	—	78.9	—	78.9	78.93	28/100	22.1004
								TOTAL	29.0912

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METHOD 3

ORSAT ANALYSIS AND DRY MOLECULAR WEIGHT DETERMINATION

PLANT G-P DUDLEY, NC

DATE 9/20/83

SAMPLING TIME (24-hr CLOCK) 1342-1527

SAMPLING LOCATION PRECIP OUTLET — STK

SAMPLE ~~TYPE~~ [✓ BAG], INTEGRATED, [✓ CONTINUOUS]

ANALYTICAL METHOD ORSAT

AMBIENT TEMPERATURE 85°F

OPERATOR K. O'NEAL

COMMENTS: RUN NO. 2

ORSAT LK CK @ 4 MIN

BURET 22.5 / 22.5 / 0.0 ✓

PIPET NO LK ✓

O_2 CK @ 4 PASSES

21.0 ✓

RUN / GAS	1		2		3		AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS-DRY BASIS M_d lb/lb-mole
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET			
CO_2	2.1	2.1	2.0	2.0	2.0	2.0	2.03	44/100	.8947
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2)	21.1	19.0	21.2	19.2	21.2	19.2	19.13	32/100	6.1227
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2)	21.1	0.0	21.2	0.0	21.2	0.0	0.00	28/100	0.0000
N_2 (NET IS 100 MINUS ACTUAL CO)	—	78.9	—	78.8	—	78.8	78.83	28/100	22.0733
								TOTAL	29.0907

ORSAT ANALYSIS AND DRY MOLECULAR WEIGHT DETERMINATION

PLANT G-P Dudley, NC

DATE 9/21/83

SAMPLING TIME (24-hr CLOCK)

SAMPLING LOCATION PRECIP. OUTLET — STK

SAMPLE TYPE ([✓ BAG], INTEGRATED, [✓ CONTINUOUS]) @ 500 cc/MIN

ANALYTICAL METHOD ORSAT

AMBIENT TEMPERATURE 76°F

OPERATOR JSM

COMMENTS: RUN NO. 4

ORSAT LK CK @ 4 MIN

BURET $\frac{20.0}{0.0}$ ✓

PIPET OK

O_2 CK @ 4 PASSES
20.7

RUN / GAS	1 ACTUAL READING	1 NET	2 ACTUAL READING	2 NET	3 ACTUAL READING	3 NET	AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS-DRY BASIS M_d lb/lb-mole
CO_2	2.0	2.0	2.0	2.0	2.0	2.0	2.00	44/100	0.880
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2)	20.8	18.8	20.7	18.7	20.8	18.8	18.77	32/100	6.005
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2)	20.8	0.0	20.7	0.0	20.8	0.0	0.00	28/100	0.000
N_2 (NET IS 100 MINUS ACTUAL CO)	—	—	—	—	—	—	79.23	28/100	22.184
								TOTAL	29.069

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PARTICULATE SAMPLE RECOVERY AND INTEGRITY SHEET

Plant GP-Dudley Sample Date 9-20-83
Sample Location Precip outlet - Stk Recovery Date 9-22-83
Run No. 1 Sample Box No. 1 Probe No. 4
Filter No.(s) 25 Recovered By KO

MOISTURE RECOVERY

Impingers Cont. No.(s) 4-1 Silica Gel Cont. No.(s) 4-1
Final volume (wt) 435 ml(g) Final wt. 218.9 g
Initial volume (wt) 200 ml(g) Initial wt. 200.00 g
Net volume (wt) 235 ml(g) Net wt. 18.9 g
Description of water clear Silica gel % spent 80%
Total Moisture 253.9 g

PARTICULATE RECOVERY

Filter Cont. No.(s) 4-1 Sealed ✓ By KO
Description of Particulate on filter light buff
Probe Rinse Cont. No. 4-1P Liquid level marked ✓
Acetone Blank Cont. No. ______ Liquid level marked ✓ Vol. 220
Impinger Water Cont. No. ______ Liquid level marked ______
______ Blank Cont. No. ______ Liquid level marked ______

ACETONE WASH BLANK, mg 2.01 Conc. 0.0091 mg/mg

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED, mg		
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
3	103,835.68	103,815.75	19.93
25	434.20	407.27	26.93
TOTAL			46.86
Less acetone blank			2.01
Weight of particulate matter			44.85

Additional Notes and Comments:

LABORATORY CUSTODY

Received by KO Date 9-24-83
Remarks
Stored and Locked ✓

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PARTICULATE SAMPLE RECOVERY AND INTEGRITY SHEET

Plant GP Dudley Sample Date 9/20/83

Sample Location PRECIP. OUTLET- STK Recovery Date 9/22/83

Run No. 2 Sample Box No. 2 Probe No. 5

Filter No.(s) 26 Recovered By KO

MOISTURE RECOVERY

Impingers Cont. No.(s) 4-2 Silica Gel Cont. No.(s) 4-2

Final volume (wt) 425 ml(g) Final wt. 220.4 g

Initial volume (wt) 200 ml(g) Initial wt. 200.0 g

Net volume (wt) 225 ml(g) Net wt. 20.4 g

Description of water clear Silica gel % spent 20%

Total Moisture 245.4 g

PARTICULATE RECOVERY

Filter Cont. No.(s) 4-2 Sealed ✓ By KO

Description of Particulate on filter light buff

Probe Rinse Cont. No. 4-2P Liquid level marked ✓

Acetone Blank Cont. No. ______ Liquid level marked ✓ Vol. ______

Impinger Water Cont. No. ______ Liquid level marked ______

______ Blank Cont. No. ______ Liquid level marked ______

ACETONE WASH BLANK, mg 2.01 **Conc.** 0.0091 **mg/mg**

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED, mg		
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
11	96,584.99	96,568.91	16.08
26	432.60	405.35	27.25
TOTAL			43.33
Less acetone blank			- 2.01
Weight of particulate matter			41.32

Additional Notes and Comments:

LABORATORY CUSTODY

Received by KO Date 9-24-83

Remarks ______

Stored and Locked ✓

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PARTICULATE SAMPLE RECOVERY AND INTEGRITY SHEET

Plant GP Dudley Sample Date 9/21/83

Sample Location PRECIP. OUTLET - STK Recovery Date 9/22/93

Run No. 4 Sample Box No. 3 Probe No. 6

Filter No.(s) 44 Recovered By KO

MOISTURE RECOVERY

Impingers Cont. No.(s) 4-4 Silica Gel Cont. No.(s) 4-4

Final volume (wt) 432 ml(g) Final wt. 226.6 g

Initial volume (wt) 200 ml(g) Initial wt. 200.0 g

Net volume (wt) 232 ml(g) Net wt. 26.6 g

Description of water clear Silica gel % spent 100

Total Moisture 258.6 g

PARTICULATE RECOVERY

Filter Cont. No.(s) 4-4 Sealed ✓ By KO

Description of Particulate on filter light buff

Probe Rinse Cont. No. 4-4P. Liquid level marked ✓

Acetone Blank Cont. No. ______ Liquid level marked ✓ Vol. ______

Impinger Water Cont. No. ______ Liquid level marked ______

______ Blank Cont. No. ______ Liquid level marked ______

ACETONE WASH BLANK, mg 2.01 Conc. 0.0091 mg/mg

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED, mg		
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
C	106,803.49	106,792.47	11.02
44	431.4	406.36	24.78
TOTAL			35.80
Less acetone blank			2.01
Weight of particulate matter			33.79

Additional Notes and Comments:

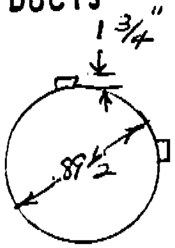
LABORATORY CUSTODY

Received by KO Date 9-24-83

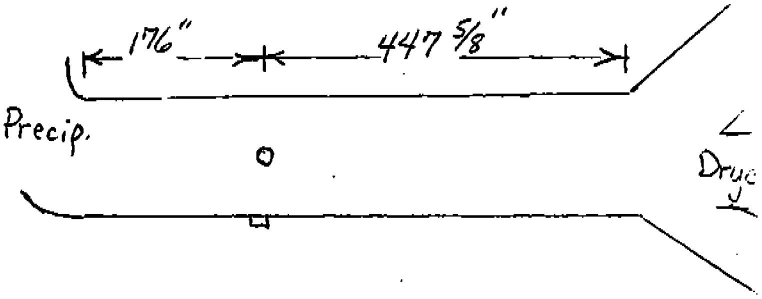
Remarks ______

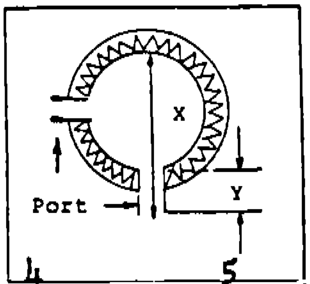
Stored and Locked ✓

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS



Plant Georgia Pacific, Dudley, NC
Date 9
Sampling location Precip. Inlet
Inside of far wall to outside of nipple (X) 91¼
Inside of near wall to outside of nipple (nipple length) (Y) 1¾
Stack I.D. (X-Y) 89½
Nearest upstream disturbance 1.97 dd
Nearest downstream disturbance 5.00 dd
Calculated by (RW)





SCHEMATIC OF SAMPLING LOCATION

1 TRAVERSE POINT NUMBER	2 FRACTION OF STACK I.D	3 STACK I.D	4 PRODUCT OF COLUMNS 2 AND 3 (TO NEAREST 1/8 INCH)	5 NIPPLE LENGTH	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5)
1	.016	89½	1.432	1¾	3.18
2	.049		4.386		6.14
3	.085		7.608		9.36
4	.125		11.188		12.94
5	.169		15.126		16.88
6	.220		19.690		21.44
7	.283		25.329		27.08
8	.375		33.563		35.31
9	.625		55.938		57.69
10	.717		64.172		65.92
11	.780		69.810		71.56
12	.831		74.375		76.13
13	.875		78.313		80.06
14	.915		81.893		83.64
15	.951		85.115		86.87
16	.984	89½	88.068	1¾	89.82

Plant and city	Run date
GP Dudley, Precip Inlet	09/20/83

$W_b = 128$

D_b 186

Δ 58

Sampling location	Clock time
Precip Inlet	0904

15%

Run number	Operator	Amb. temp., °F	Bar. press., in. Hg	Static press., in. H_2O
1	PD	74°	30.05	+5.3" ~~30.05~~

C = 0.9

$T_m = 95$

Molecular wt.	Stack inside dimension, in. Diam. or side 1	Stack inside dimension, in. side 2	Pitot tube (Cp)
	89.5	89.5	.84

Field data

Traverse point number	Position, in.	Velocity head (Δp_s), in. H_2O	Stack temp., °F	Cyclonic flow determination: Δp_s at 0° reference	Cyclonic flow determination: Angle (α) which yields a null Δp
1	3.18	0.71	186		
2	6.14	~~65~~ 0.77		.45	4
3	9.36	0.77	↑	~~.4~~	
4	12.94	0.72		.43	5
5	16.88	0.73			
6	21.44	0.74		.28	10
7	27.08	0.74			
8	35.31	0.73		.32	13
9	57.69	0.73			
10	65.92	0.70		.14	8
11	71.56	0.69			
12	76.13	0.68		.00	0
13	80.06	0.68			
14	83.64	0.69		.21	4
15	86.87	0.70	↓		
16	89.82	0.71	184	.10	2
		$\bar{5}$ 0.72			

Average angle (α)[a]: 5.75

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

Figure 1.7. Method 2 gas velocity and volume data form.

Observer: NC DNRCD

Agency: Vic Copeland

Plant GP Dudley

Run No. 1

Location Precip Inlet

Date 9-20-83

Operator [illegible]

Sample Box No. 4

Meter Box No. 1965

Meter $\Delta H_@$ 1.96 Y = 0.99

C Factor 0.95

PARTICULATE FIELD DATA

VERY IMPORTANT - FILL IN ALL BLANKS

Leak Checks: Beg. @ 15" 0.003
see next page also End @ 6" 0.002

Pitot Tube: ⊕ <0.1 OK @ 2.55" H_2O
⊖ :<0.1 OK @ 5.7 "H_2O

Static Pres., in H_2O: +5.3
Start: 1000
Finish: 1141
Filter # 2,3 Probe # 1

W_b 128 °F D_b 186 °F

Ambient Temp °F 76°

Bar. Press. in. Hg. 30.05

Assumed Moisture % 15%

Heater Box Setting, °F 250

Probe Tip Dia., In. 0.176

Probe Length 9'7"

Probe Heater Setting 80%

Average Δp 0.72 2.15

Average ΔH 0.63 Ref

10% gel
285 ml H_2O

See Outlet for Fyrite & Orsat Data

METHOD 5

Point	Clock Time	Dry Gas Meter, Cu.Ft.	Pitot Manometer (Δp) in. H_2O	Orifice Manometer (ΔH) in. H_2O Desired	Orifice Manometer (ΔH) in. H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Pump Vacuum in. Hg Gauge	Box Temp. °F	Impinger Temp °F	Stack Temp °F	% CO_2	% O_2
A 1	0	617.25	0.47	0.41	0.41	79	79	1.5	227	58	184		
2	2	617.99	0.52	0.46	0.46	80	79	1.5	228	57	184		
3	4	618.74	0.57	0.50	0.50	81	79	1.5	228	51	184		
4	6	619.54	0.63	0.55	0.55	83	79	1.5	228	47	187		
5	8	620.35	0.67	0.59	0.59	85	79	1.5	227	47	188		
6	10	621.18	.69	.60	.60	86	80	1.5	229	48	188		
7	12	622.04	.72	.63	.63	89	81	2.0	229	48	188		
8	14	622.92	.77	.67	.67	90	82	2.0	230	49	189		
9	16	623.83	.77	.67	.67	91	83	2.0	231	50	189		
10	18	624.72	.76	.66	.66	93	83	2.0	230	50	189		
11	20	625.60	.75	.65	.65	94	84	2.0	229	50	188		
12	22	626.48	.73	.64	.64	95	85	2.0	230	50	188		
13	24	627.35	.68	.59	.59	96	86	2.0	228	51	188		
14	26	628.20	.68	.59	.59	96	87	2.0	229	51	189		
15	28	629.04	.65	.57	.57	97	87	2.0	230	52	188		
16	30	629.99	.58	.51	.51	97	88	2.0	227	53	188		
B 1	32/0	630.73/630.64	0.61	.53	.53	89	89	2.0	230	61	183		
2	2	631.54	.71	.63	.63	90	89	2.0	235	51	183		
3	4	632.43	.74	.64	.64	92	89	2.0	229	51	184		

630.73
630.64
.09

METHOD 5

Point	Clock Time	Dry Gas Meter, Cu.Ft.	Pitot Manometer (Δp) in. H_2O	Orifice Manometer (ΔH) in. H_2O		Dry Gas Temp. °F		Pump Vacuum in. Hg Gauge	Box Temp. °F	Impinger Temp °F	Stack Temp °F	% CO_2	% O_2
				Desired	Actual	Inlet	Outlet						
4	6	633.28	.71	.63	.63	94	89	2.0	245	51	184		
5	8	634.16	.70	.61	.61	95	90	2.0	244	51	184		
6	10	635.01	.68	.60	.60	97	90	2.0	243	51	183		
7	12	635.85	.67	.59	.59	97	90	2.0	242	52	183		
8	14	636.75	.66	.58	.58	98	91	2.0	245	52	182		
9	16	637.52	.68	.60	.60	99	91	2.0	245	52	182		
10	18	638.36	.70	.61	.61	99	92	2.5	245	53	183		
11	20	639.20	.69	.60	.60	100	93	3.0	250	54	183		
12	22	640.00	.68	.60	.60	101	93	5.0	247	56	182		
13	24	640.83	.66	.58	.58	102	93	10.0	247	56	182	17.0"	Vacuum
14	26	641.59	.66	.58	.58	91	91	1.5	225	62	181	21.0"	final
15	28	642.61	.62	.54	.54	92	92	1.5	227	59	179		
16	30	643.45	.60	.52	.52	94	93	2.0	230	59	178		
	32	644.26											

Filter Begin to load ←

Time
1113 Stop
1135 Start
Filter Change

641.77
641.59

.011 @23"
.004 @ 15"

METHOD 5

Observer: Nc DNRCD

Agency: Vic Copeland

Plant GP Dudley

Run No. 2

Location Precip Inlet

Date 9-20-83

Operator PD

Sample Box No. 5

Meter Box No. 1965

Meter $\Delta H_@$ 1.96 Y=0.99

C Factor 0.95

PARTICULATE FIELD DATA

VERY IMPORTANT - FILL IN ALL BLANKS

Leak Checks: Beg. @ 15" 0.004

End @ 7" 0.005

Pitot Tube: <0.1 OK @ 2.8 "H_2O

: <0.1 OK @ 3.1 "H_2O

Static Pres., in H_2O: +5.3

Start: 1342

Finish: 1523

Filter # 4 Probe # 2

W_b 128 °F D_b 186 °F

Ambient Temp °F 87

Bar. Press. in. Hg. 30.05

Assumed Moisture % 15

Heater Box Setting, °F 250

Probe Tip Dia., In. 0.178

Probe Length 9' 7"

Probe Heater Setting 80%

Average Δp 0.72 2.15

Average ΔH 0.63 Ref

5% gel

275 ml H_2

Point	Clock Time	Dry Gas Meter, Cu.Ft.	Pitot Manometer (Δp) In. H_2O	Orifice Manometer (ΔH) in. H_2O		Dry Gas Temp. °F		Pump Vacuum in. Hg Gauge	Box Temp. °F	Impinger Temp °F	Stack Temp °F	% CO_2	%O_2
				Desired	Actual	Inlet	Outlet						
A 1	0	644.55	.46	.41	.41	92	92	1.0	270	59	178		
2	2	645.33	.49	.43	.43	93	93	1.5	268	57	178		
3	4	646.05	.54	.47	.47	94	93	1.5	272	55	179		
4	6	646.80	.58	.51	.58	95	94	1.5	273	55	181		
5	8	647.58	.62	.54	.54	97	94	1.5	271	51	182		
6	10	648.38	.66	.58	.58	98	94	1.5	275	48	182		
7	12	649.21	.68	.60	.60	100	95	1.5	274	46	182		
8	14	650.05	.71	.63	.63	101	95	1.5	272	45	182		
9	16	650.94	.73	.64	.64	102	95	1.5	269	46	180		
10	18	651.83	.73	.64	.64	102	96	1.5	275	48	180		
11	20	652.70	.71	.63	.63	103	96	1.5	270	51	180		
12	22	653.56	.74	.65	.65	104	97	2.0	268	52	181		
13	24	654.44	.73	.64	.64	105	98	2.0	265	53	181		
14	26	655.30	.68	.60	.60	105	98	1.5	269	55	182		
15	28	656.17	.63	.55	.55	105	99	1.5	274	56	182		
16	30	656.98	.54	.47	.47	106	99	1.5	275	56	183		
B 1	32/0	657.71	.54	.47	.47	101	99	1.5	274	59	182		
2	2	658.47	.59	.51	.51	101	100	1.5	271	57	182		
3	4	659.24	.63	.55	.55	102	101	1.5	270	55	183		

METHOD 5

Leak check

663.48
663.38
0.10

3.0
93

Point	Clock Time	Dry Gas Meter, Cu.Ft.	Pitot Manometer (Δp) in. H_2O	Orifice Manometer (ΔH) in. H_2O		Dry Gas Temp. °F		Pump Vacuum in. Hg Gauge	Box Temp. °F	Impinger Temp °F	Stack Temp °F	% CO_2	% O_2
				Desired	Actual	Inlet	Outlet						
- 4	6	660.05	.65	.57	.57	103	101	2.0	269	55	183		
5	8	660.90	.64	.56	.56	103	101	2.0	270	55	183		
6	10	661.72	.63	.55	.55	104	101	2.0	274	56	182		
7	12	662.55	.67	.59	.59	105	102	2.0	270	56	183		
8	14	663.48/663.38	.70	.61	.61	94	94	2.0	265	62	175		
9	16	664.33	.77	.67	.67	94	94	2.0	260	60	173		
10	18	665.23	.77	.67	.67	95	95	2.0	262	58	173		
11	20	666.11	.74	.64	.64	95	95	2.0	264	58	173		
12	22	667.00	.77	.67	.67	94	94	2.0	265	58	172		
13	24	667.87	.70	.61	.61	94	94	2.0	264	58	170		
14	26	668.73	.64	.56	.56	93	93	2.0	261	59	168		
15	28	669.54	.60	.52	.52	93	93	2.0	265	59	167		
16	30	670.35	.50	.44	.44	93	92	2.0	264	59	167		
17	32	671.05											

stop 1435
start 1505
Rain

METHOD 5

PARTICULATE FIELD DATA

VERY IMPORTANT - FILL IN ALL BLANKS

Observer: NC DNRCD

Agency:

Plant G-P Dudley

Run No. 4

Location Precip. Inlet

Date 9-21-83

Operator (PY)

Sample Box No. 3

Meter Box No. 1965

Meter $\Delta H_@$ 1.96 Y= 0.99

C Factor 0.95

Leak Checks: Beg. @ 15" 0.003

End @13" 0.005

Pitot Tube: <0.1 ok @ 3.0 "H_2O

: <0.1 ok @ 3.2 "H_2O

Static Pres., in H_2O: +5.3

Start: 1312

Finish: 1424

Filter # 6 Probe # 3

W_b 128 °F D_b 186 °F

Ambient Temp °F 78

Bar. Press. in. Hg. 29.78

Assumed Moisture % 15%

Heater Box Setting, °F 250

Probe Tip Dia., In. 0.179

Probe Length 9'7"

Probe Heater Setting 80%

Average Δp 0.72 2.15

Average ΔH 0.63 Ref

290 ml

5% apart

Point	Clock Time	Dry Gas Meter, Cu.Ft.	Pitot Manometer (Δp) in. H_2O	Orifice Manometer (ΔH) in. H_2O		Dry Gas Temp. °F		Pump Vacuum in. Hg Gauge	Box Temp. °F	Impinger Temp °F	Stack Temp °F	% CO_2	% O_2
				Desired	Actual	Inlet	Outlet						
A 1	0	700.65	.54	.48	.48	85	85	4.5	245	61	174		
2	2	701.40	.54	.48	.48	85	85	5.0	246	60	176		
3	4	702.16	.60	.53	.53	86	85	6.0	250	60	177		
4	6	702.93	.66	.58	.58	87	85	6.5	250	60	177		
5	8	703.77	.70	.61	.61	90	86	7.0	252	59	178		
6	10	704.60	.70	.61	.61	91	86	7.0	255	58	178		
7	12	705.46	.74	.64	.64	93	87	7.5	252	59	179		
8	14	706.32	.77	.67	.67	95	87	8.0	255	59	179		
9	16	707.21	.78	.68	.68	96	87	8.5	255	59	180		
10	18	708.09	.76	.66	.66	99	89	8.0	257	60	180		
11	20	708.97	.73	.64	.64	100	90	8.0	254	60	180		
12	22	709.83	.76	.66	.66	101	91	8.0	255	62	180		
13	24	710.73	.80	.69	.69	102	92	8.5	255	63	180		
14	26	711.65	.76	.66	.66	102	93	8.0	257	63	180	Rain	
15	28	712.53	.71	.62	.62	102	93	8.0	255	63	179		
16	30	713.39	.63	.54	.54	102	94	7.0	254	62	178		
B 1	32/0	714.20	.59	.51	.51	98	93	6.0	250	62	176		
2	2	714.99	.69	.60	.60	99	94	7.0	248	60	176		
3	4	715.84	.73	.64	.64	99	94	7.5	245	59	175		

2.64

METHOD 5

Point	Clock Time	Dry Gas Meter, Cu.Ft.	Pitot Manometer (Δp) in. H_2O	Orifice Manometer (ΔH) in. H_2O		Dry Gas Temp. °F		Pump Vacuum in. Hg Gauge	Box Temp. °F	Impinger Temp °F	Stack Temp °F	% CO_2	% O_2
				Desired	Actual	Inlet	Outlet						
4	6	716.72	.73	.63	.63	99	95	8.0	250	59	174		
5	8	717.61	.72	.62	.62	99	95	7.5	252	59	174		
6	10	718.47	.70	.61	.61	99	94	7.5	248	59	173	Rain	heavy
7	12	719.30	.69	.60	.60	99	94	7.5	244	60	172		
8	14	720.14	.69	.60	.60	100	95	7.5	240	60	170		
9	16	721.00	.73	.63	.63	100	95	7.5	235	60	168		
10	18	721.85	.77	.67	.67	100	95	8.0	238	60	167		
11	20	722.76	.76	.66	.66	101	96	8.5	240	60	167		
12	22	723.64	.72	.62	.62	101	95	8.5	240	60	167		
13	24	724.55	.70	.61	.61	101	95	9.0	243	60	167	Rain	Stop
14	26	725.34	.63	.54	.54	101	94	9.0	245	62	166		
15	28	726.13	.51	.45	.45	100	94	8.5	250	63	165		
16	30	726.86	.50	.44	.44	100	94	8.5	251	63	164		
	32	727.59											

1400

[illegible]

PARTICULATE SAMPLE RECOVERY AND INTEGRITY SHEET

Plant G P - Dudley Sample Date 9-20-83

Sample Location Precip Inlet Stk Recovery Date 9-22-83

Run No. 1 Sample Box No. 4 Probe No. 1

Filter No.(s) 2,3 Recovered By KO

MOISTURE RECOVERY

Impingers Cont. No.(s) 5-1 Silica Gel Cont. No.(s) 5-1

Final volume (wt) 285.0 ml(g) Final wt. 207.6 g

Initial volume (wt) 200.0 ml(g) Initial wt. 200.0 g

Net volume (wt) 85.0 ml(g) Net wt. 7.6 g

Description of water clear Silica gel % spent 10

Total Moisture 92.6 g

PARTICULATE RECOVERY

Filter Cont. No.(s) 5-1 Sealed ✓ By KO

Description of Particulate on filter light buff

Probe Rinse Cont. No. 5-1,2 Liquid level marked ✓

Acetone Blank Cont. No. ______ Liquid level marked ✓ Vol. ______

Impinger Water Cont. No. ______ Liquid level marked ______

______ Blank Cont. No. ______ Liquid level marked ______

ACETONE WASH BLANK, mg 2.01 Conc. 0.0091 mg/mg

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED, mg		
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
5	102,083.76	102,065.94	17.82
2,3	1225.12	1075.34	149.78
TOTAL			167.60
		Less acetone blank	2.01
		Weight of particulate matter	165.59

Additional Notes and Comments:

LABORATORY CUSTODY

Received by KO Date 9-24-83

Remarks

Stored and Locked ✓

environmental testing inc

PARTICULATE SAMPLE RECOVERY AND INTEGRITY SHEET

Plant CP Dudley Sample Date 9-20-83

Sample Location Precip - Inlet Stk Recovery Date 9-22-83

Run No. 2 Sample Box No. 5 Probe No. 2

Filter No.(s) 4 Recovered By KO

MOISTURE RECOVERY

Impingers Cont. No.(s) 5-2 Silica Gel Cont. No.(s) 5-2

Final volume (wt) 275.0 ml(g) Final wt. 206.1 g

Initial volume (wt) 200.0 ml(g) Initial wt. 200.0 g

Net volume (wt) 75.0 ml(g) Net wt. 6.1 g

Description of water Clear Silica gel % spent 5

Total Moisture 81.1 g

PARTICULATE RECOVERY

Filter Cont. No.(s) 5-2 Sealed ✓ By KO

Description of Particulate on filter light buff

Probe Rinse Cont. No. 5-2p Liquid level marked ✓

Acetone Blank Cont. No. ______ Liquid level marked ✓ Vol. ______

Impinger Water Cont. No. ______ Liquid level marked ______

______ Blank Cont. No. ______ Liquid level marked ______

ACETONE WASH BLANK, mg 2.01 Conc. 0.0091 mg/mg

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED, mg		
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
6	100,146.54	100,120.00	26.54
4	630.26	535.00	95.26
TOTAL			121.80
	Less acetone blank		2.01
	Weight of particulate matter		119.79

Additional Notes and Comments:

LABORATORY CUSTODY

Received by KO Date 9-24-83

Remarks ______

Stored and Locked ✓

environmental testing inc.

PARTICULATE SAMPLE RECOVERY AND INTEGRITY SHEET

Plant GP Dudley Sample Date 9-21-83

Sample Location Precip outlet Stk Recovery Date 9-23-83

Run No. 4 Sample Box No. 3 Probe No. 3

Filter No.(s) 6 Recovered By KO

MOISTURE RECOVERY

Impingers Cont. No.(s) 5-4 Silica Gel Cont. No.(s) 5-4

Final volume (wt) 290.0 ml(g) Final wt. 207.6 g

Initial volume (wt) 200.0 ml(g) Initial wt. 200.0 g

Net volume (wt) 90.0 ml(g) Net wt. 7.6 g

Description of water clear Silica gel % spent 5

Total Moisture 97.6 g

PARTICULATE RECOVERY

Filter Cont. No.(s) 5-4 Sealed ✓ By KO

Description of Particulate on filter light buff

Probe Rinse Cont. No. 5-4P Liquid level marked ✓

Acetone Blank Cont. No. ____ Liquid level marked ✓ Vol. ____

Impinger Water Cont. No. ____ Liquid level marked ____

____ Blank Cont. No. ____ Liquid level marked ____

ACETONE WASH BLANK, mg 2.01 Conc. 0.0091 mg/mg

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED, mg		
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
7	101,015.09	100,988.95	26.14
6	668.14	536.24	131.90
TOTAL			158.04
	Less acetone blank		2.01
	Weight of particulate matter		156.03

Additional Notes and Comments:

LABORATORY CUSTODY

Received by KO Date 9-24-83

Remarks ____

Stored and Locked ✓

LABORATORY DATA FOR BACK HALF CALCULATIONS

Precipitator Outlet

Run	1	2	4
Oil & Grease, mg/l	10.07	15.62	25.92
Volume Extracted, ml	435	425	432
Oil & Grease, mg	4.38	6.64	11.20

Precipitator Inlet

Run	1	2	4
Oil & Grease, mg/l	209.97	348.32	546.92
Volume Extracted, ml	285	275	290
Oil & Grease, mg	59.84	95.79	158.61

Georgia-Pacific Corporation

COM-PLY PLANT
P. O. Box 600
Dudley, N. Carolina 28333
Telephone (919) 736-4385

September 28, 1983

Mr. James S. McCormack, P.E.
Environmental Testing, Inc.
1700 University Commercial Place
Charlotte, NC 28213

RE: Dudley Green Flake Dryer Test Process Data

Dear Mr. McCormack,

Table I below shows a summary of process data collected on the three Green Flake Dryers during the September 20 and 21, 1983 Electrostatic Precipitator Compliance Test.

DRYER PROCESS DATA

		Avg. Wood Flow, Green tons/hr	Avg. Inlet Temp, °F	Avg. Outlet Temp, °F	Avg. Inlet Wood Mois.% W.B.	Avg. Outlet Mois. % W.B.
Run #1	Dryer #1	11.20	524°	225°	48.2%	4.4%
	Dryer #2	12.79	712°	203°	46.7%	4.7%
	Dryer #3	10.63	617°	218°	46.7%	4.6%
Run #2	Dryer #1	11.09	667°	220°	46.4%	5.5%
	Dryer #2	12.83	752°	190°	45.3%	5.9%
	Dryer #3	8.54	541°	211°	46.3%	5.5%
Run #4	Dryer #1	11.16	622°	214°	46.4%	5.3%
	Dryer #2	12.77	744°	190°	45.4%	5.5%
	Dryer #3	10.33	435°	204°	44.0%	5.5%

TABLE I

As shown, total production figures for Runs #1, #2 and #4 were 34.62, 32.46, and 34.26 green tons/hour respectively. This represents a three-run average of 94% of our rated production of 36.0 green tons/hour.

Table II below shows a summary of Electrostatic Precipitator (ESP) operation parameter data taken during the test. It should be noted that these operating conditions are subject to change as ESP continuous mist and washdown cycles are optimized and the automatic voltage control (AVC) program is installed by United McGill. The AVC was not in place during the test, however, since this system optimizes ESP field strength, the installation of the AVC program will only improve performance.

ESP OPERATION PARAMETER DATA

	Run #1	Run #2	Run #4
Inlet Temp °F	174°	168°	163°
Outlet Temp °F	127°	124°	125°
Water Flow GPM	60	60	60
Duct Press "W.G.	3.3	3.4	3.3
#1 Field Kilovolts, D.C.	27.9	27.6	27.3
#1 Field Milliamps x 10, D.C.	10.1	10.4	10.8
#2 Field Kilovolts, D.C.	28.1	28.1	28.6
#2 Field Milliamps x 10, D.C.	12.4	12.3	13.0
#3 Field Kilovolts, D.C.	27.4	27.7	28.0
#3 Field Milliamps x 10, D.C.	13.0	13.4	14.2

TABLE II

Attached are copies of all field data sheets, recorder charts and a production summary. If any additional data is needed or if any questions arise, feel free to give Gerald Tice, Senior Environmental Engineer, or myself a call.

Sincerely,

Lawrence P.E. Otwell
Environmental Engineer
Eastern Wood Products Mfg. Division

LO/1d

cc: Gerald W. Tice

Georgia-Pacific GP

BY: L. Ot   DATE: 9/20/8
PROJECT: ESP
PLANT: Dudley OSB
SUBJECT: Stack Test Process Data

				# tons						
Run #1		Furnish Flow			Wood Moisture Content					
		Dryer #1	Dryer #2	Dryer #3	Dryer #1		Dryer #2		Dryer #3	
	Time	% Feed	% Feed	Integ Reading	In	Out	In	Out	In	Out
Begin	10:00AM	80.5%	78%	1178.14	48.8	4.0	47.8	4.0	47.2	4.3
	10:20AM	80.5%	80%							
	10:30AM	80.5%	80%							
	10:40AM	80.5%	80.5%							
	10:50AM	80.5%	80.5%		49.8	4.0	46.6	5.4	46.2	4.4
	11:00AM	80.5%	80.5%							
	11:10AM	80.5%	80.0%							
	11:20AM	80.5%	80.0%							
	11:30AM	80.5%	79.5%							
	11:40AM	80.5%	80.0%							
End	11:50AM	80.5%	80.0%	1197.62	460	5.2	458	4.8	46.6	5.0
	ΔT = 110 min	Ave 80.5	11|879 Ave 79.91	(19.48 tons/110 min) x 60 min/hr. = 10.63 tons/hr.						
Run #2										
Begin	1:42AM	80.0%	79.5%	1216.10	45.4	4.8	46.4	5.8	46.0	4.6
	1:52AM	80.0%	80.5%							
	2:02PM	80.0%	80.5%							
	2:12PM	80.0%	80.5%							
	2:22AM	79.5%	80.5%							
	2:32AM	79.5%	80.5%							
Stop	2:34AM			1224.58						
Resume	3:05AM	80.5%	80%	1225.60	49.6	6.0	44.8	6.2	45.4	6.4
	3:15AM	80.0%	80.0%							
	3:25PM	79.0%	80.0%							
End	3:39AM	79.0%	80.0%	1229.36	44.2	5.6	44.8	5.8	47.4	5.
	ΔT = 86 min	10|797 Ave 79.70	10|802 Avg 80.2	(12.24 tons/86 min) x 60 min/hr. = 8.54 tons/hr.						
Run #3										
Begin	8:30AM	80.0%	80.0%	1296.00	46.8	5.8	47.4	5.7	46.6	11
	8:40AM	79.0%	79.0%							
	8:50AM	79.5%	79.0%							
	9:00AM	79.5%	79.5%							

Georgia-Pacific GP

BY: L. Otwell DATE: 9/21/83
PROJECT: ESP
PLANT: Dudley OSB SUBJECT: Stack Test + Process Data

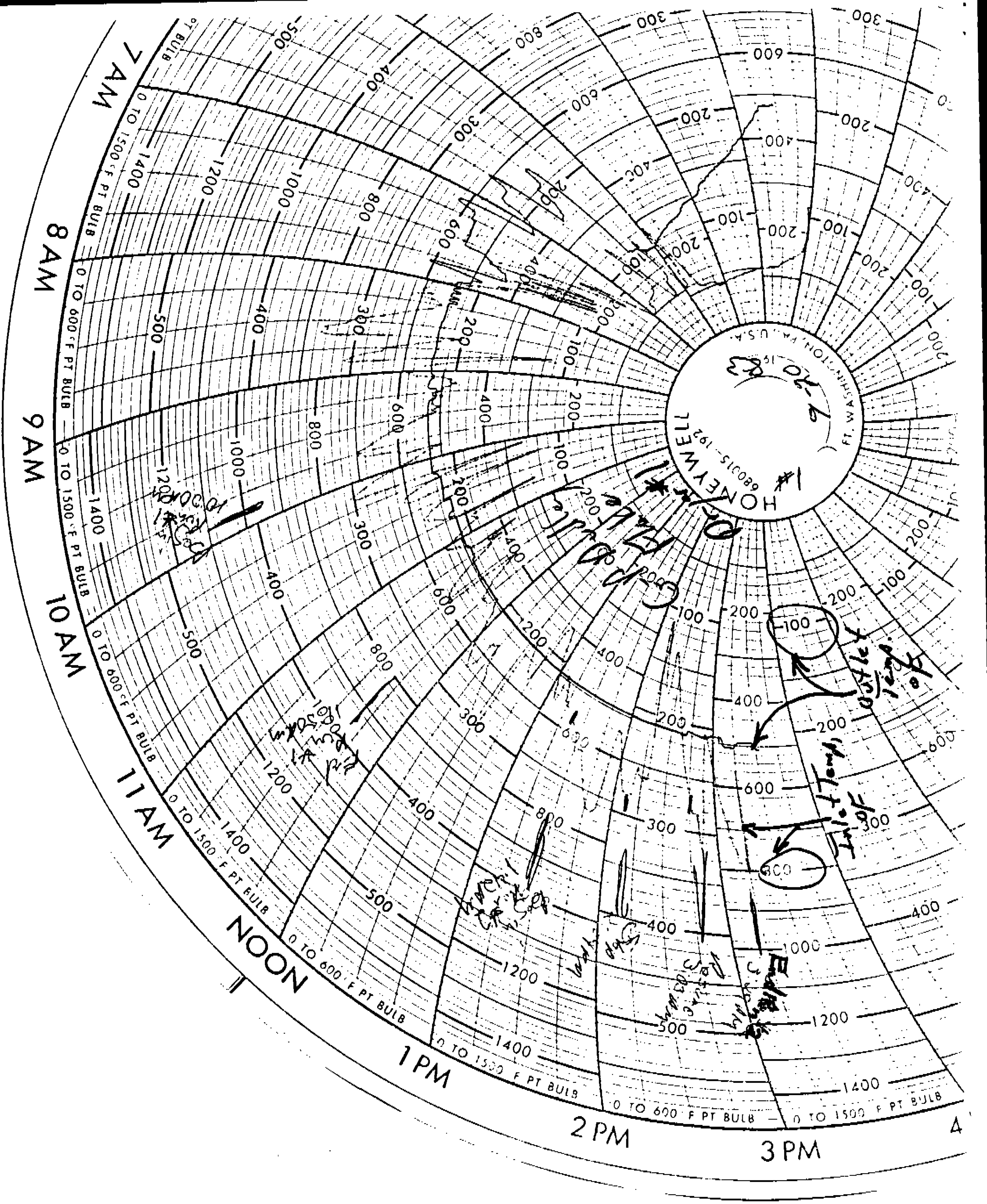
* tons

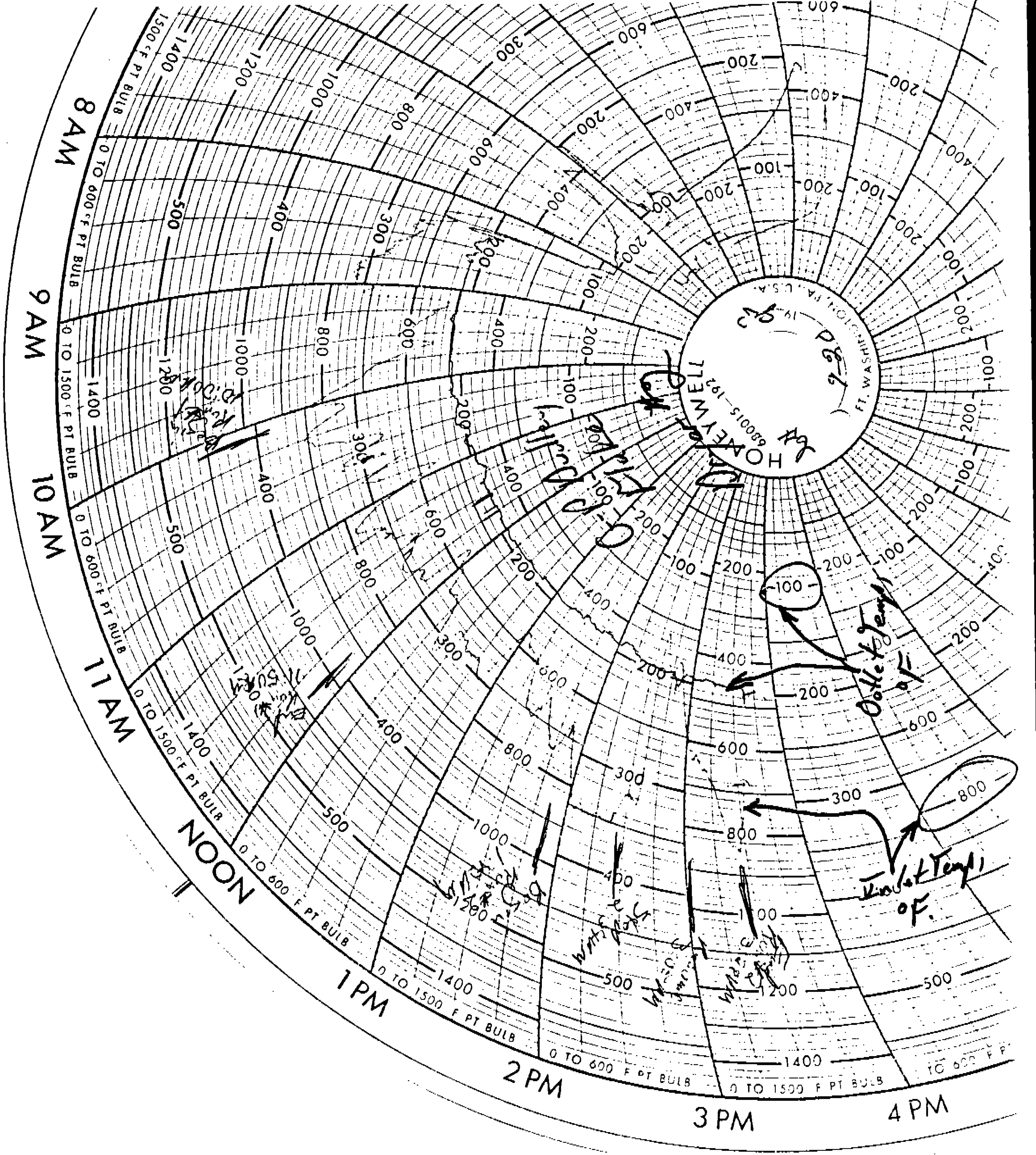
Run #3 cont'd		Furnish Flow			Wood Moisture Content					
		Dryer #1	Dryer #2	Dryer #3	Dryer #1		Dryer #2		Dryer #3	
	Time	% Feed	% Feed	Integ Reading *	In	Out	In	Out	In	Out
Stop	9:15			1304.00	49.2	5.4	42.4	4.8	47.0	6.
Resume	9:47	80%	78%	1309.81						
	9:57	80.5%	77%							
Stop	10:05			1312.38						
Resume	10:55	79.5%	79.5%	1314.44						
	11:05	80.0%	79.0%							
End	11:11			1316.99	45.8	5.0	47.4	5.2	48.8	5.

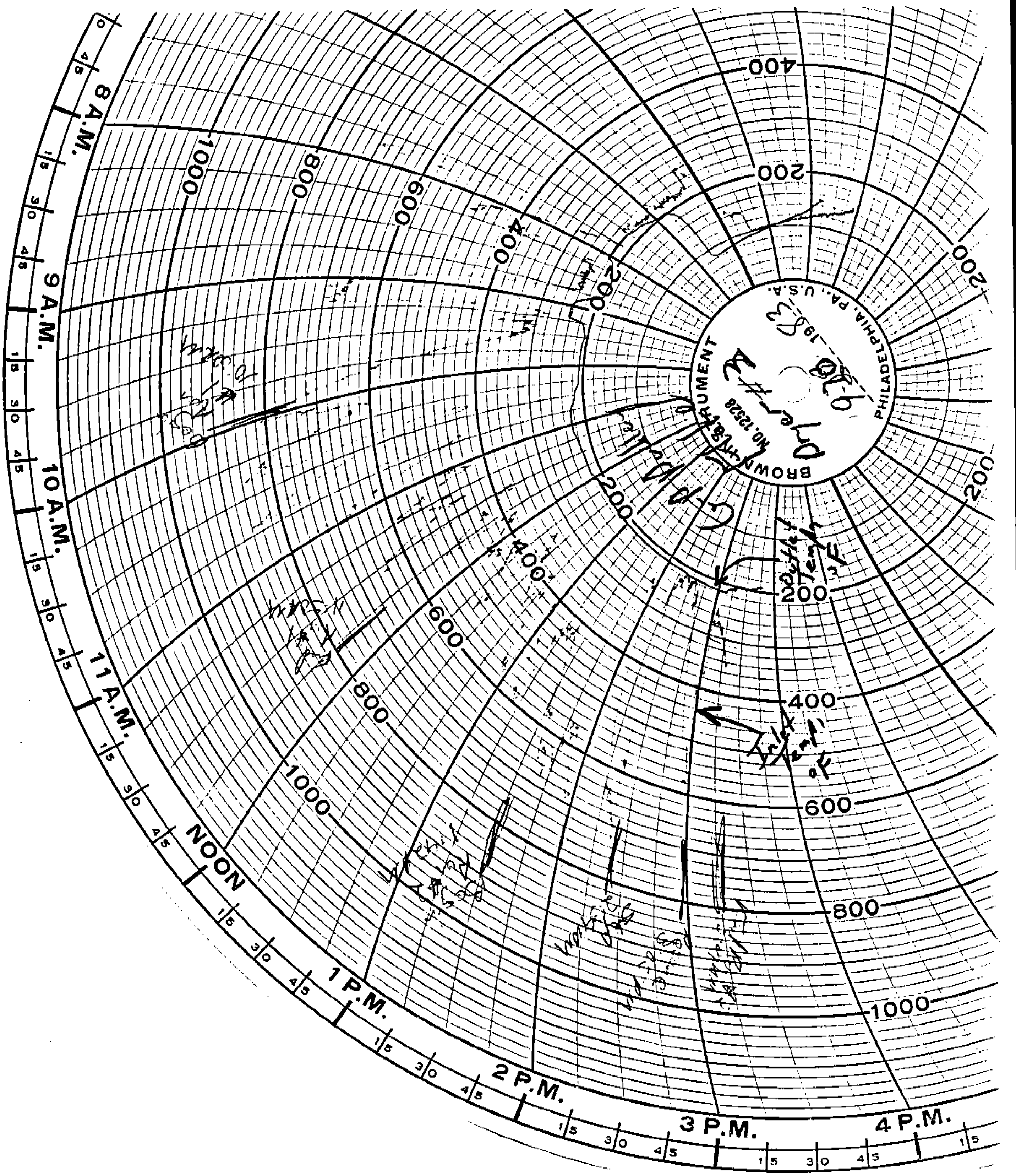
Run #4

Begin	1:13 PM	80.5%	80%	1328.15	50.2	5.4	47.5	5.6	40.0	4.
	1:23	80.5%	80%							
	1:33	80.5%	79.5%							
	1:43	80.0%	80.0%							
	1:53	80.0%	79.0%		44.8	5.0	43.2	5.4	48.0	4.
	2:03	80.5%	80.0%							
	2:13	80.0%	80.0%							
	2:23	80.0%	80.0%							
End	2:31	80.0%	80.0%	1341.58	44.2	5.6	45.4	5.4	—	7.

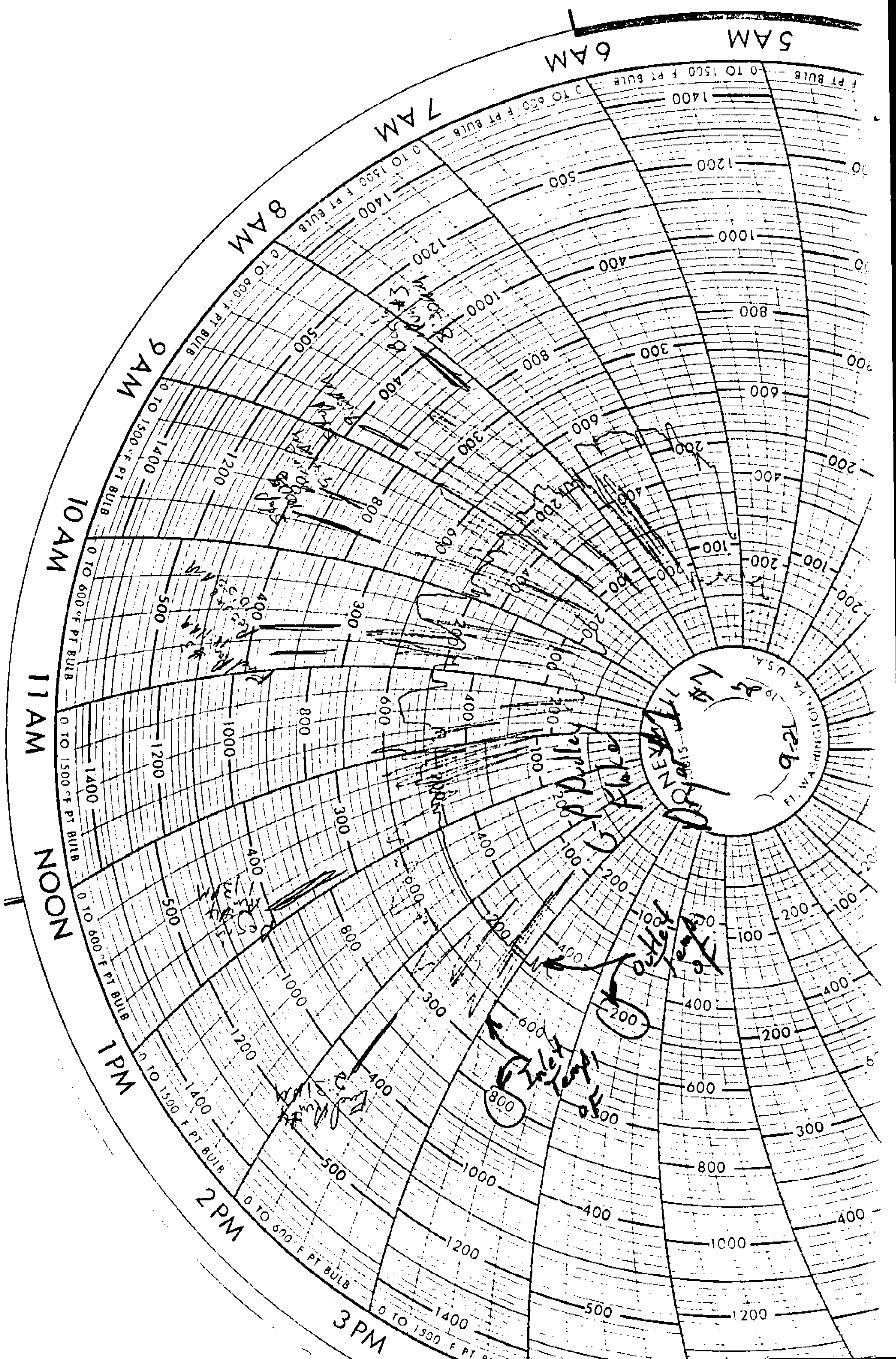
ΔT = 78 min 9)722 9)718.5 (13.48 tons/78 min) X 60 min/hr = 10.33 tons/hr.

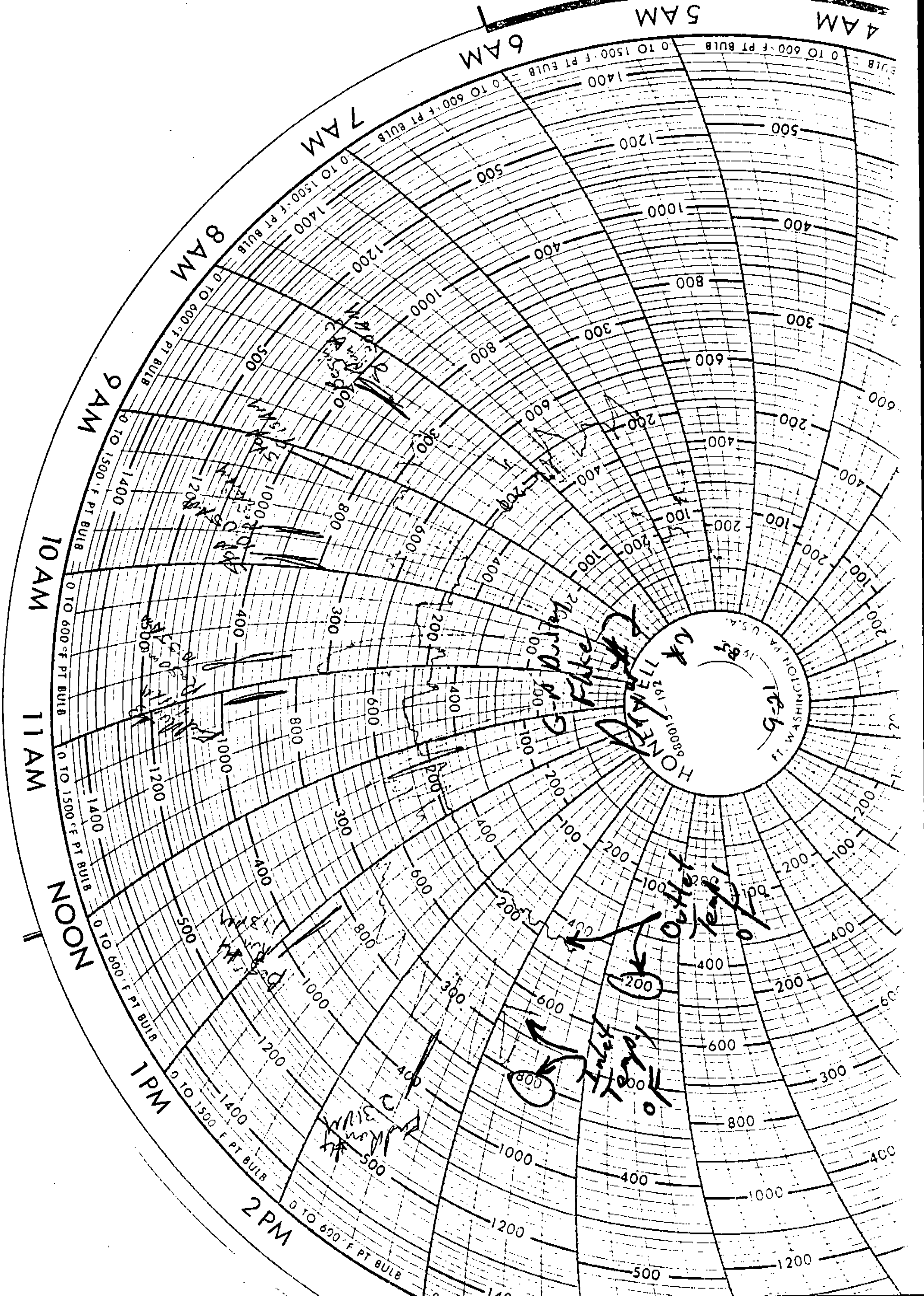

HONEYWELL
680015-192
FT. WASHINGTON, PA. U.S.A.
#1
6-20
7 AM
8 AM
9 AM
10 AM
11 AM
NOON
1 PM
2 PM
3 PM
4
0 TO 1500°F PT BULB
0 TO 600°F PT BULB

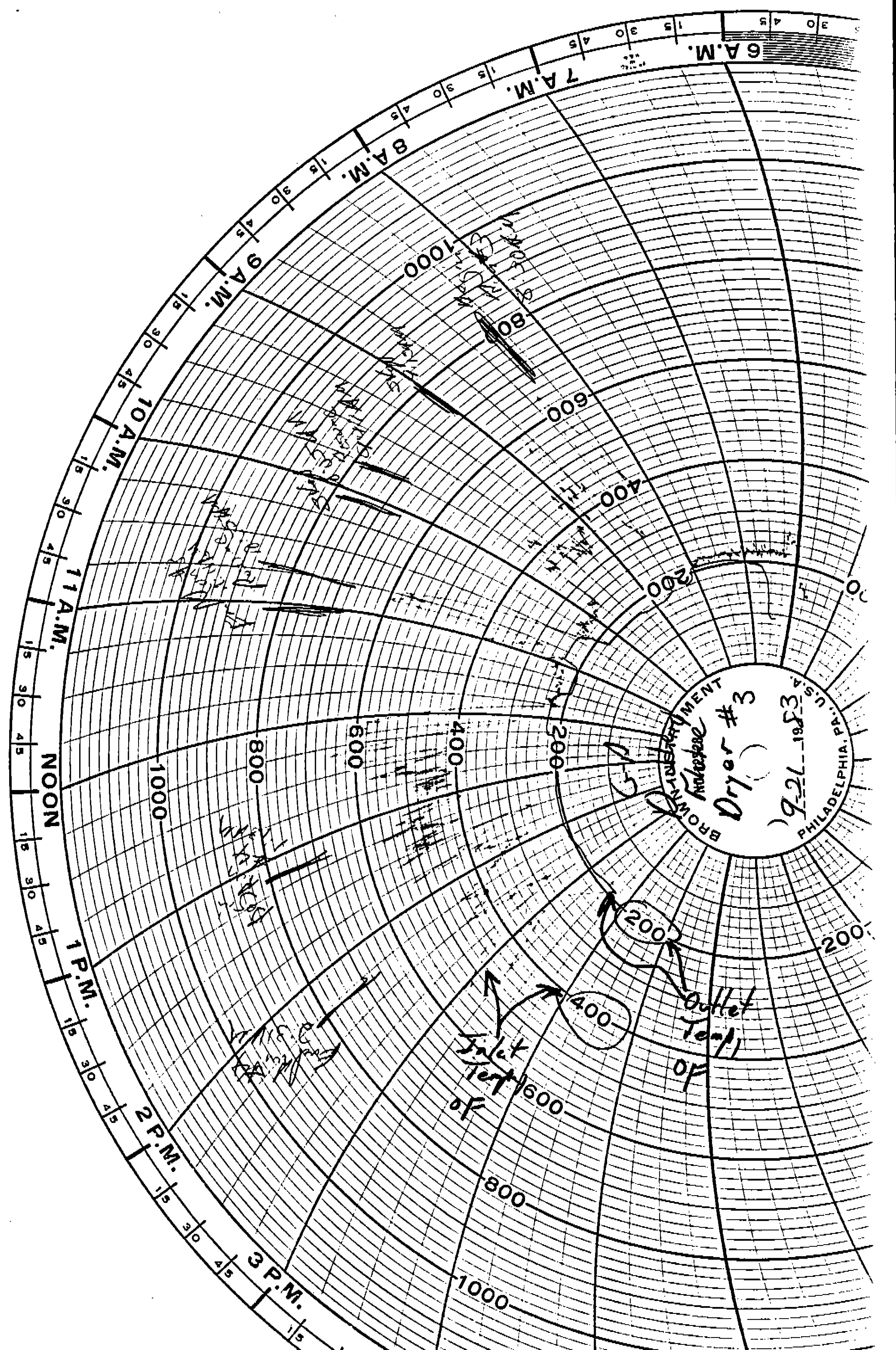
8 AM
9 AM
10 AM
11 AM
NOON
1 PM
2 PM
3 PM
4 PM
0 TO 600 °F PT BULB
0 TO 1500 °F PT BULB
HONEYWELL
680015 — 192
FT. WASHINGTON, PA. U.S.A.
19
Pg 6
Outlet Temp °F
Inlet Temp °F
100
200
300
400
500
600
800
1000
1200
1400



BROWN INSTRUMENT
NO. 12528
PHILADELPHIA, PA., U.S.A.
9-28 1983
Dryer #2
Outlet Temp °F
Inlet Temp °F
8 A.M.
9 A.M.
10 A.M.
11 A.M.
NOON
1 P.M.
2 P.M.
3 P.M.
4 P.M.
15
30
45
200
400
600
800
1000


5 AM
6 AM
7 AM
8 AM
9 AM
10 AM
11 AM
NOON
1 PM
2 PM
3 PM
0 TO 1500 °F PT BULB
0 TO 600 °F PT BULB
HONEYWELL
MINNEAPOLIS
FT. WASHINGTON, PA. U.S.A.
19
Outlet temp °F
200
Inlet temp °F
800


4 AM
5 AM
6 AM
7 AM
8 AM
9 AM
10 AM
11 AM
NOON
1 PM
2 PM
0 TO 600 °F PT BULB
0 TO 1500 °F PT BULB
HONEYWELL
60001-192
FT. WASHINGTON PA. U.S.A.
19 83
G-21
2#
G-10 Outlet filter #2
Outlet Temp °F
Inlet Temp °F
200
800

6 A.M.
7 A.M.
8 A.M.
9 A.M.
10 A.M.
11 A.M.
NOON
1 P.M.
2 P.M.
3 P.M.
15
30
45
200
400
600
800
1000
BROWN INSTRUMENT
PHILADELPHIA, PA. U.S.A.
Dryer #3
9-21-1983
Inlet Temp °F
Outlet Temp, °F

Georgia·Pacific

intracompany memo

to	Gerald Tice	location	Atlanta
from	Dave Atkins	location	Dudley
subject	Wood Flow During EP Test 9-20-83	date	9-22-83

Prior to the test (7am-9/20/83), the Dry Flake Bin was full, the Blender Metering Bin was empty. At the end of the second shift, the Dry Flake Bin was again full and the Blender Metering Bin was full.

During the 2 shifts, 213.6 tons of wood was recorded across the weighbelts. Approximately 7 tons was in the Blender Metering Bin.

Ave. Green M.C.	=	46.8%		
Ave. Dry M.C.	=	5.49%		
Ave. feed rate #3	=	8.16 ton/hr	(10.63 during test)
#2	=	76%	(80%during test)
#1	=	64%	(80% during test)

Minus 8 mesh screen fines was 16.55%.
Total dryer run time was 44.19 hours (ave 14.73/Dryer)
#1 & #2 Dryers - 75% = 12 Green tons/hr.
213.6 + 7 x 1.1655 = 257.11 tons x (100-5.49%) = $\boxed{\text{243 OD tons.}}$ 243

$$\frac{\text{243 OD tons}}{1.00-.468} = \text{456.8 Green Tons}$$

$\frac{243}{456.8}$ 53%

$$\frac{\text{456 Green Tons}}{\text{14.73 Run Hrs}} = \text{31.01 Green tons/hr.}$$

#3	31.01 8.16 22.85		Act. Meas.	10.63	Tons/Hr
#2	12.16	x	$\frac{80}{76}$ =	12.80	Tons/Hr
#1	10.69	x	$\frac{80}{64}$ x .8333 * =	11.14	Tons/Hr
				34.57	Tons/Hr

*Outfeed rate of #1 Dryer Metering Bin is reduced by one-sixth because of dead screw in the bin.

Dave Atkins

DA/ld

TEST PARTICIPANTS

James S. McCormack, PE	President ENVIRONMENTAL TESTING, INC.
Paul R. Jenkins, Jr.	Laboratory Director ENVIRONMENTAL TESTING, INC.
W. Keith O'Neal	Environmental Scientist ENVIRONMENTAL TESTING, INC.
Rodney H. Lang	Environmental Scientist ENVIRONMENTAL TESTING, INC.

federal register

THURSDAY, AUGUST 18, 1977
PART II

THE NATIONAL ARCHIVES OF THE UNITED STATES • 1934 •

ENVIRONMENTAL PROTECTION AGENCY

■

STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES

Revision to Reference Method 1-8

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

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

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

MISCELLANEOUS

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

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

(Secs. 111, 114 and 301(a) of the Clean Air Act, sec. 4(a) of Pub. L. No. 91-604, 84 Stat. 1683; sec. 4(a) of Pub. L. No. 91-604, 84 Stat. 1687; sec. 2 of Pub. L. No. 90-148, 81 Stat. 504 [42 U.S.C. 1857c-6, 1857c-9, 1857g(a)].)

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

Dated: August 10, 1977.

DOUGLAS M. COSTLE,
Administrator.

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

APPENDIX A—REFERENCE METHODS

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

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

Inclusion of methods in this appendix is not intended as an endorsement or denial of their applicability to sources that are not subject to standards of performance. The methods are potentially applicable to other sources; however, applicability should be confirmed by careful and appropriate evaluation of the conditions prevalent at such sources.

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

Minor changes in the reference methods should not necessarily affect the validity of the results and it is recognized that alternative and equivalent methods exist. Section 60.8 provides authority for the Administrator to specify or approve (1) equivalent methods, (2) alternative methods, and (3) minor changes in the methodology of the reference methods. It should be clearly understood that unless otherwise identified all such methods and changes must have prior approval of the Administrator. An owner employing such methods or deviations from the reference methods without obtaining prior approval does so at the risk of subsequent disapproval and retesting with approved methods.

Within the reference methods, certain specific equipment or procedures are recognized as being acceptable or potentially acceptable and are specifically identified in the methods. The items identified as acceptable options may be used without approval but must be identified in the test report. The potentially approvable options are cited as "subject to the approval of the Administrator" or as "or equivalent." Such potentially approvable techniques or alternatives may be used at the discretion of the owner without prior approval. However, detailed descriptions for applying these potentially approvable techniques or alternatives are not provided in the reference methods. Also, the potentially approvable options are not necessarily acceptable in all applications. Therefore, an owner electing to use such potentially approvable techniques or alternatives is responsible for: (1) assuring that the techniques or alternatives are in fact applicable and are properly executed; (2) including a written description of the alternative method in the test report (the written method must be clear and must be capable of being performed without additional instruction, and the degree of detail should be similar to the detail contained in the reference methods); and (3) providing any rationale or supporting data necessary to show the validity of the alternative in the particular application. Failure to meet these requirements can result in the Administrator's disapproval of the alternative.

METHOD 1—SAMPLE AND VELOCITY TRAVERSES FOR STATIONARY SOURCES

1. *Principle and Applicability*

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

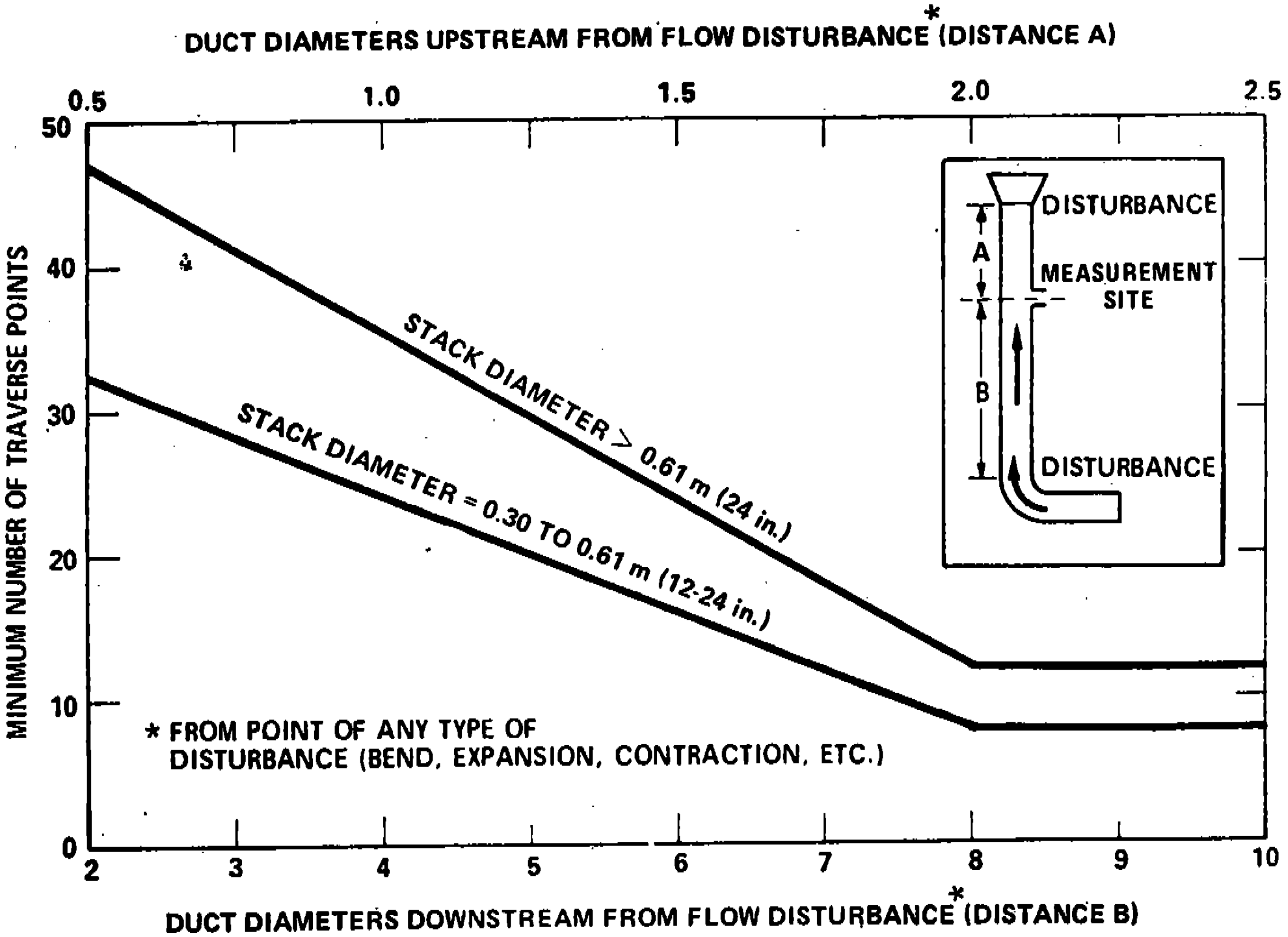
1.2 Applicability. This method is applicable to flowing gas streams in ducts, stacks, and flues. The method cannot be used when: (1) flow is cyclonic or swirling (see Section 2.4), (2) a stack is smaller than about 0.30 meter (12 in.) in diameter, or 0.071 m^2 (113 $in.^2$) in cross-sectional area, or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

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

2. *Procedure*

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

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



* FROM POINT OF ANY TYPE OF DISTURBANCE (BEND, EXPANSION, CONTRACTION, ETC.)

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

where L=length and W=width.

2.2 Determining the Number of Traverse Points.

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

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

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

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

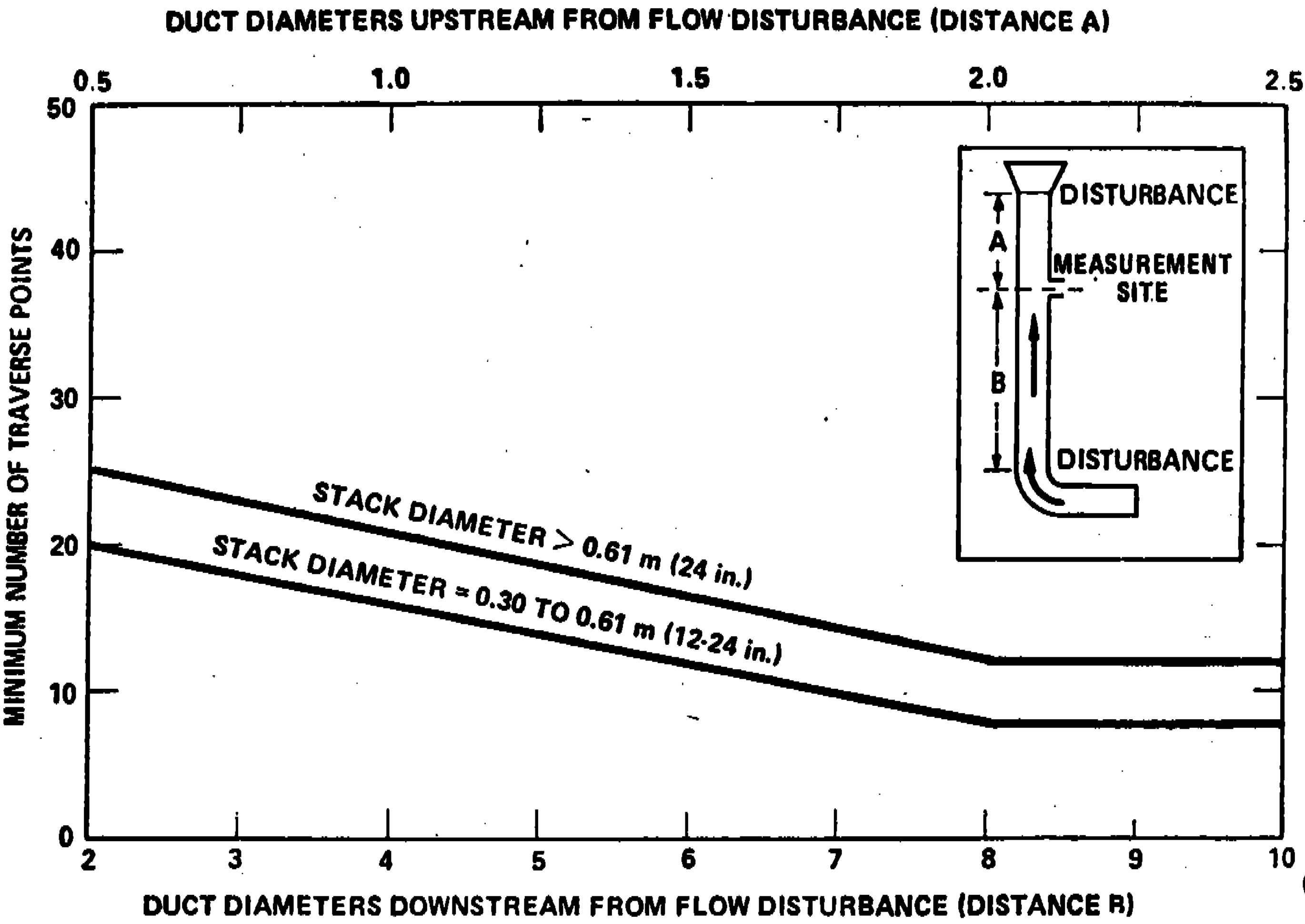


Figure 1-2. Minimum number of traverse points for velocity (nonparticulate) traverses.

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

2.3 Cross-Sectional Layout and Location of Traverse Points.

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

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

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

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

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

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

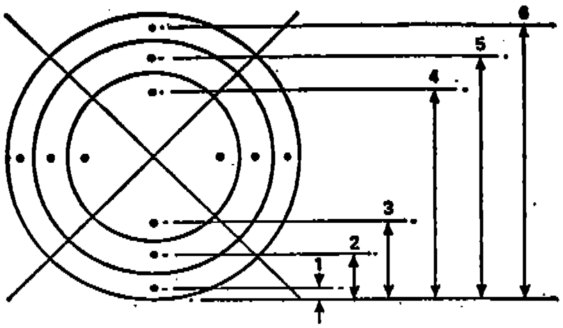


Figure 1-3. Example showing circular stack cross section divided into 12 equal areas, with location of traverse points indicated.

Table 1-2. LOCATION OF TRAVERSE POINTS IN CIRCULAR STACKS
(Percent of stack diameter from inside wall to traverse point)

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

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

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

The 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.

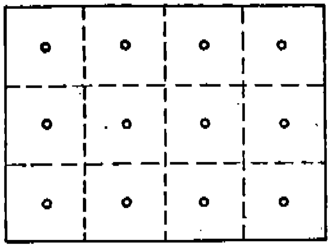


Figure 1-4. Example showing rectangular stack cross section divided into 12 equal areas, with a traverse point at centroid of each area.

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 travrse point, calculate the average of the absolute values of α; assign α values of 0° to those points for which no rotation was required, and include these in the overall average. If the average value of α is greater than 10°, the overall flow condition in the stack is unacceptable and alternative methodology, subject to the approval of the Administrator, must be used to perform accurate sample and velocity traverses.

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

1. *Principle and Applicability*

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

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

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

2. *Apparatus*

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

3.6 Determine the stack gas dry molecular weight. For combustion processes or processes that emit essentially CO_2, O_2, CO, and N_2, use Method 3. For processes emitting essentially air, an analysis need not be conducted; use a dry molecular weight of 29.0. For other processes, other methods, subject to the approval of the Administrator, must be used.

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

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

4. *Calibration*

4.1 Type S Pitot Tube. Before its initial use, carefully examine the Type S pitot tube in top, side, and end views to verify that the face openings of the tube are aligned within the specifications illustrated in Figure 2-2 or 2-3. The pitot tube shall not be used if it fails to meet these alignment specifications.

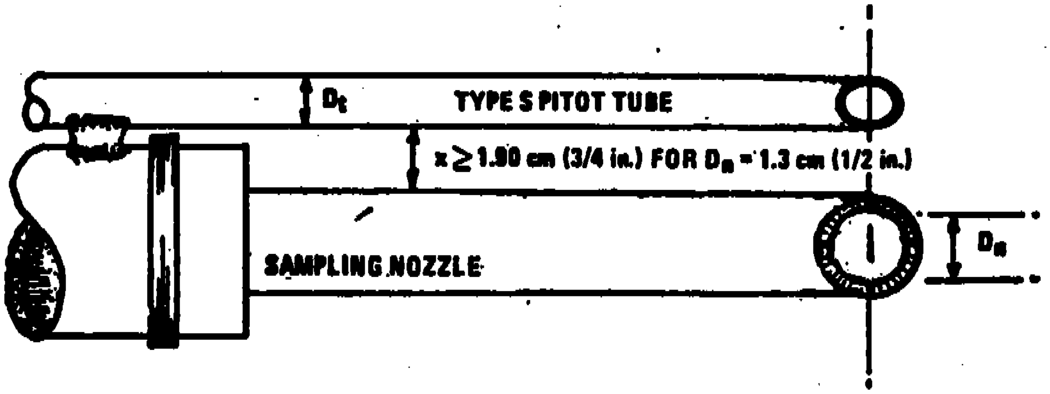
After verifying the face opening alignment, measure and record the following dimensions of the pitot tube: (a) the external tubing diameter (dimension D_t, Figure 2-2b); and (b) the base-to-opening plane distances (dimensions P_A and P_B, Figure 2-2b). If D_t is between 0.48 and 0.95 cm (3/16 and 3/8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

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

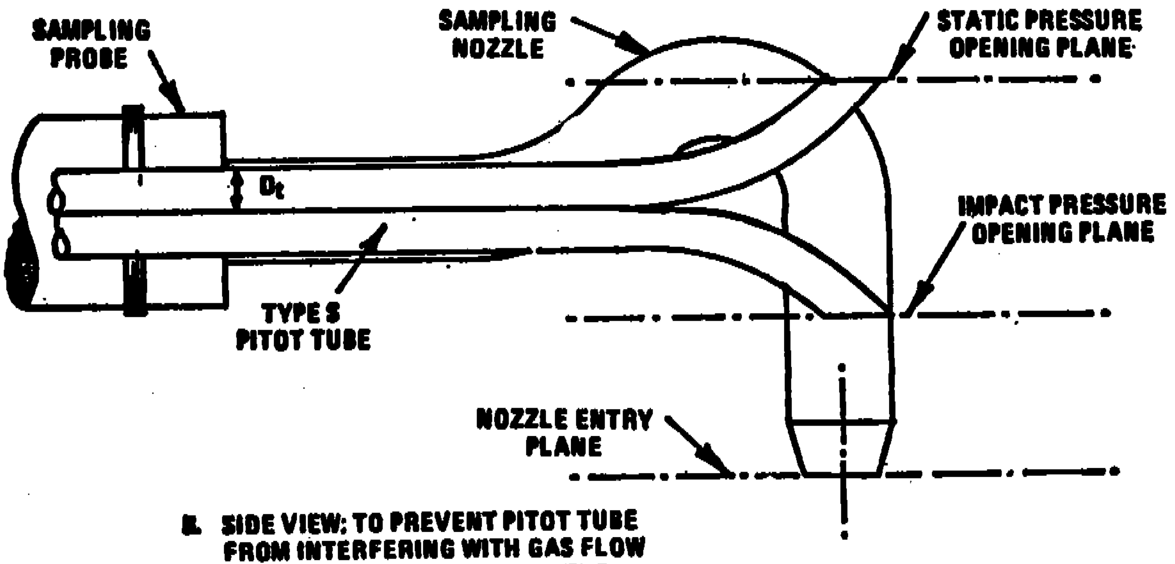
4.1.1 Type S Pitot Tube Assemblies. During sample and velocity traverses, the isolated Type S pitot tube is not always used; in many instances, the pitot tube is used in combination with other source-sampling components (thermocouple, sampling probe, nozzle) as part of an "assembly." The presence of other sampling components can sometimes affect the baseline value of the Type S pitot tube coefficient (Citation 9 in Section 6); therefore an assigned (or otherwise known) baseline coefficient value may or may not be valid for a given assembly. The baseline and assembly coefficient values will be identical only when the relative placement of the components in the assembly is such that aerodynamic interference effects are eliminated. Figures 2-6 through 2-8 illustrate interference-free component arrangements for Type S pitot tubes having external tubing diameters between 0.48 and 0.95 cm (3/16 and 3/8 in.). Type S pitot tube assemblies that fail to meet any or all of the specifications of Figures 2-6 through 2-8 shall be calibrated according to the procedure outlined in Sections 4.1.2 through 4.1.5 below, and prior to calibration, the values of the intercomponent spacings (pitot-nozzle, pitot-thermocouple, pitot-probe sheath) shall be measured and recorded.

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

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



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



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

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

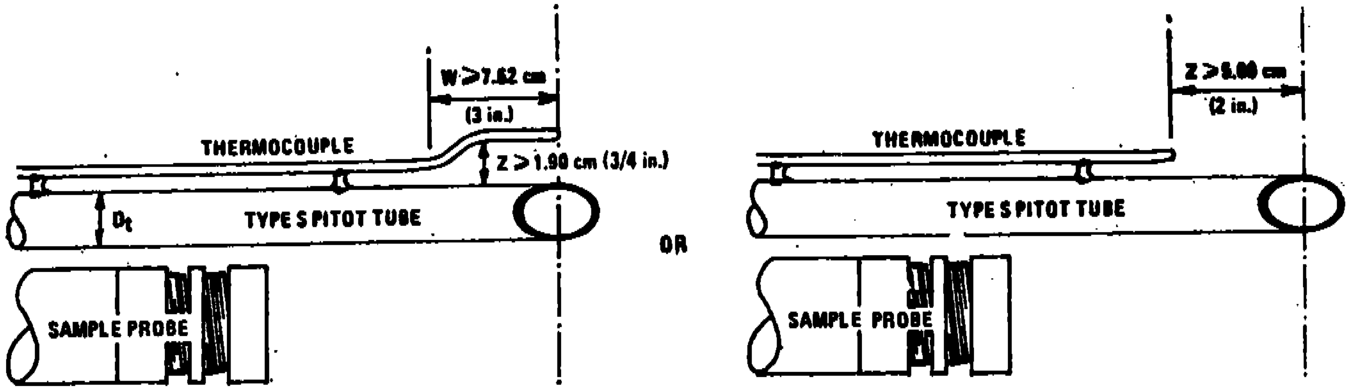


Figure 2-7. Proper thermocouple placement to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

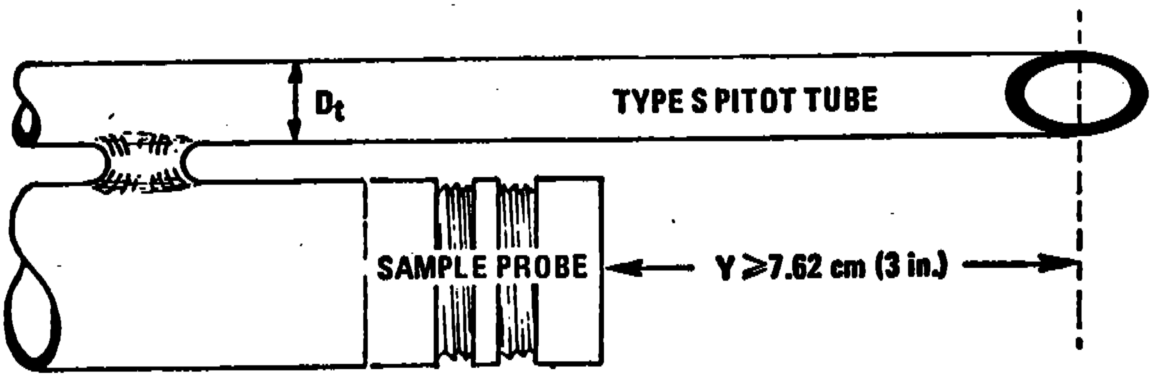


Figure 2-8. Minimum pitot-sample probe separation needed to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

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

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

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

Equation 2-1

where:

D_e = Equivalent diameter
L = Length
W = Width

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

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

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

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

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

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

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

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

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

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

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

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

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

4.1.3.9 Perform calculations, as described in Section 4.1.4 below.

4.1.4 Calculations.

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

PITOT TUBE IDENTIFICATION NUMBER: ______________ **DATE:** ______________

CALIBRATED BY: ______________________________

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

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

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

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

Figure 2-9. Pitot tube calibration data.

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

Equation 2-2

where:

$C_{p(s)}$ = Type S pitot tube coefficient

$C_{p(std)}$ = Standard pitot tube coefficient; use 0.99 if the coefficient is unknown and the tube is designed according to the criteria of Sections 2.7.1 to 2.7.5 of this method.

Δp_{std} = Velocity head measured by the standard pitot tube, cm H_2O (in. H_2O)

Δp_s = Velocity head measured by the Type S pitot tube, cm H_2O (in. H_2O)

4.1.4.2 Calculate $\bar{C}_p$ (side A), the mean A-side coefficient, and $\bar{C}_p$ (side B), the mean B-side coefficient; calculate the difference between these two average values.

4.1.4.3 Calculate the deviation of each of the three A-side values of $C_{p(s)}$ from $\bar{C}_p$ (side A), and the deviation of each B-side value of $C_{p(s)}$ from $\bar{C}_p$ (side B). Use the following equation:

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

Equation 2-3

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

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

Equation 2-4

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

4.1.5 Special considerations.

4.1.5.1 Selection of calibration point.

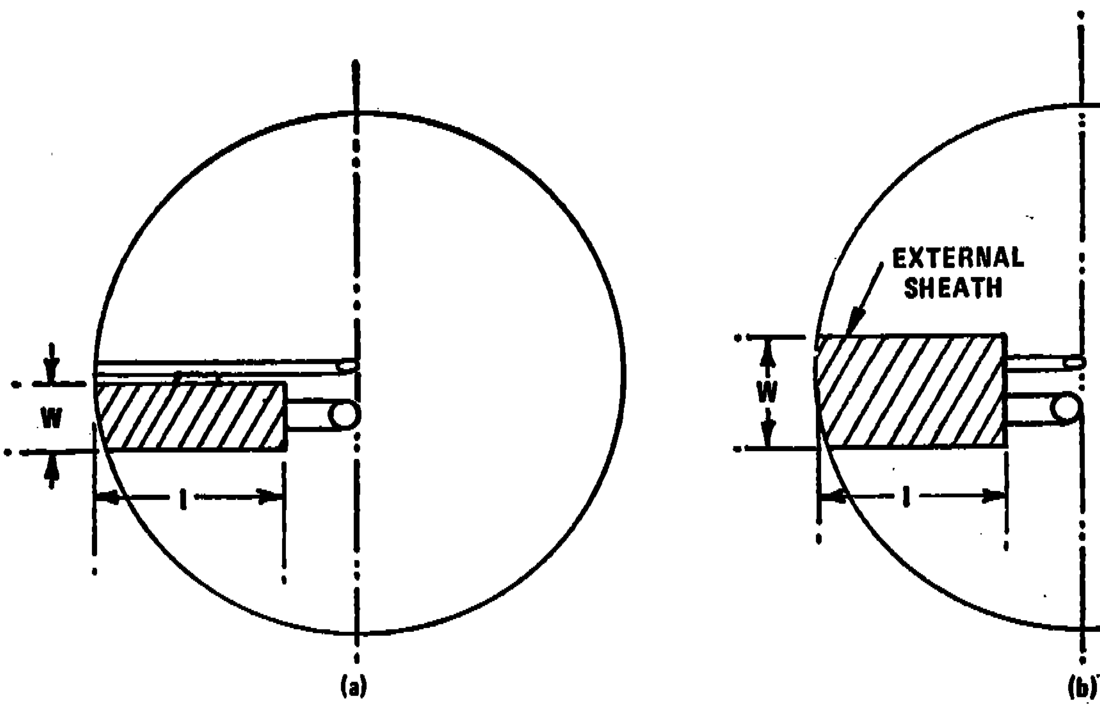
4.1.5.1.1 When an isolated Type S pitot tube is calibrated, select a calibration point at or near the center of the duct, and follow the procedures outlined in Sections 4.1.3 and 4.1.4 above. The Type S pitot coefficients so obtained, i.e., $\bar{C}_p$ (side A) and $\bar{C}_p$ (side B), will be valid,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

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

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

4.1.5.2 For those probe assemblies in which pitot tube-nozzle interference is a factor (i.e., those in which the pitot-nozzel separation distance fails to meet the specification illustrated in Figure 2-6a), the value of $C_{p(s)}$ depends upon the amount of free-space between the tube and nozzle, and therefore is a function of nozzle size. In these instances, separate calibrations shall be performed with each of the commonly used nozzle sizes in place. Note that the single-velocity calibration technique is acceptable for this purpose, even though the larger nozzle sizes (>0.635 cm or ¼ in.) are not ordinarily used for isokinetic sampling at velocities around 915 m/min (3,000 ft/min), which is the calibration velocity; note also that it is not necessary to draw an isokinetic sample during calibration (see Citation 19 in Section 6).

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



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

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

4.1.6 Field Use and Recalibration.

4.1.6.1 Field Use.

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

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

4.1.6.2 Recalibration.

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

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

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

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

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

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

5. *Calculations*

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

5.1 Nomenclature.

A = Cross-sectional area of stack, m² (ft²).

B_{ws} = Water vapor in the gas stream (from Method 5 or Reference Method 4), proportion by volume.

C_p = Pitot tube coefficient, dimensionless.

K_p = Pitot tube constant,

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

for the metric system and

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

for the English system.

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

M_s = Molecular weight of stack gas, wet basis, g/g-mole (lb/lb-mole).

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

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

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

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

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

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

Q_{sd} = Dry volumetric stack gas flow rate corrected to standard conditions, dscm/hr (dscf/hr).

t_s = Stack temperature, °C (°F).

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

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

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

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

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

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

3,600 = Conversion factor, sec/hr.

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

5.2 Average stack gas velocity.

$$v_s = K_p C_p (\sqrt{\Delta p})_{avg} \sqrt{\frac{T_{s(avg)}}{P_s M_s}}$$

Equation 2-9

5.3 Average stack gas dry volumetric flow rate.

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

Equation 2-10

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

1. *Principle and Applicability*

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

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

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

2. *Apparatus*

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

2.1 Grab Sampling (Figure 3-1).

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

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

2.2 Integrated Sampling (Figure 3-2).

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

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

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

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

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

2.2.5 Rate Meter. The rotameter, or equivalent rate meter, used should be capable of measuring flow rate to within ±2 percent of the selected flow rate. A flow rate range of 500 to 1000 cm^3/min is suggested.

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

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

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

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

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

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

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

3. *Dry Molecular Weight Determination*

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

3.1 Single-Point, Grab Sampling and Analytical Procedure.

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

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

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

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

3.2 Single-Point, Integrated Sampling and Analytical Procedure.

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

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

3.2.3 Sample at a constant rate. The sampling run should be simultaneous with, and for the same total length of time as, the pollutant emission rate determination. Collection of at least 30 liters (1.00 ft^3) of sample gas is recommended; however, smaller volumes may be collected, if desired.

3.2.4 Obtain one integrated flue gas sample during each pollutant emission rate determination. Within 8 hours after the sample is taken, analyze it for percent CO_2 and percent O_2 using either an Orsat analyzer or a Fyrite-type combustion gas analyzer. If an Orsat analyzer is used, it is recommended that the Orsat leak-check described in Section 5 be performed before this determination; however, the check is optional. Determine the percentage of the gas that is N_2 and CO by subtracting the sum of the percent CO and percent O_2 from 100 percent. Calculate the dry molecular weight as indicated in Section 6.3.

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

3.3 Multi-Point, Integrated Sampling and Analytical Procedure.

3.3.1 Unless otherwise specified by the Administrator, a minimum of eight traverse points shall be used for circular stacks having diameters less then 0.61 m (24 in.), a minimum of nine shall be used for rectangular stacks having equivalent diameters less than 0.61 m (24 in.), and a minimum of twelve traverse points shall be used for all other cases. The traverse points shall be located according to Method 1. The use of fewer points is subject to approval of the Administrator.

3.3.2 Follow the procedures outlined in Sections 3.2.2 through 3.2.5, except for the following: traverse all sampling points and sample at each point for an equal length of time. Record sampling data as shown in Figure 3-3.

4. *Emission Rate Correction Factor or Excess Air Determination*

NOTE.—A Fyrite-type combustion gas analyzer is not acceptable for excess air or emission rate correction factor determination, unless approved by the Administrator. If both percent CO_2 and percent O_2 are measured, the analytical results of any of the three procedures given below may also be used for calculating the dry molecular weight.

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

4.1 Single-Point, Grab Sampling and Analytical Procedure.

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

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

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

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

Figure 3-3. Sampling rate data.

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

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

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

4.2 Single-Point, Integrated Sampling and Analytical Procedure.

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

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

4.2.3 Sample at a constant rate, or as specified by the Administrator. The sampling run must be simultaneous with, and for the same total length of time as, the pollutant emission rate determination. Collect at least 30 liters (1.00 ft^3) of sample gas. Smaller volumes may be collected, subject to approval of the Administrator.

4.2.4 Obtain one integrated flue gas sample during each pollutant emission rate determination. For emission rate correction factor determination, analyze the sample within 4 hours after it is taken for percent CO_2 or percent O_2 (as outlined in Sections 4.2.5 through 4.2.7). The Orsat analyzer must be leak-checked (see Section 5) before the analysis. If excess air is desired, proceed as follows: (1) within 4 hours after the sample is taken, analyze it (as in Sections 4.2.5 through 4.2.7) for percent CO_2, O_2, and CO; (2) determine the percentage of the gas that is N_2 by subtracting the sum of the percent CO_2, percent O_2, and percent CO from 100 percent; (3) calculate percent excess air, as outlined in Section 6.2.

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

4.2.6 Repeat the analysis until the following criteria are met:

4.2.6.1 For percent CO_2, repeat the analytical procedure until the results of any three analyses differ by no more than (a) 0.3 percent by volume when CO_2 is greater than 4.0 percent or (b) 0.2 percent by volume when CO_2 is less than or equal to 4.0 percent. Average the three acceptable values of percent CO_2 and report the results to the nearest 0.1 percent.

4.2.6.2 For percent O_2, repeat the analytical procedure until the results of any three analyses differ by no more than (a) 0.3 percent by volume when O_2 is less than 15.0 percent or (b) 0.2 percent by volume when O_2 is greater than 15.0 percent. Average the three acceptable values of percent O_2 and report the results to the nearest 0.1 percent.

4.2.6.3 For percent CO, repeat the analytical procedure until the results of any three analyses differ by no more than 0.3 percent. Average the three acceptable values of percent CO and report the results to the nearest 0.1 percent.

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

4.3 Multi-Point, Integrated Sampling and Analytical Procedure.

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

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

5. *Leak-Check Procedure for Orsat Analyzers*

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

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

5.1.2 Raise the leveling bulb sufficiently to bring the confining liquid meniscus onto the graduated portion of the burette and then close the manifold stopcock.

5.1.3 Record the meniscus position.

5.1.4 Observe the meniscus in the burette and the liquid level in the pipette for movement over the next 4 minutes.

5.1.5 For the Orsat analyzer to pass the leak-check, two conditions must be met.

5.1.5.1 The liquid level in each pipette must not fall below the bottom of the capillary tubing during this 4-minute interval.

5.1.5.2 The meniscus in the burette must not change by more than 0.2 ml during this 4-minute interval.

5.1.6 If the analyzer fails the leak-check procedure, all rubber connections and stopcocks should be checked until the cause of the leak is identified. Leaking stopcocks must be disassembled, cleaned, and regreased. Leaking rubber connections must be replaced. After the analyzer is reassembled, the leak-check procedure must be repeated.

6. *Calculations*

6.1 Nomenclature.

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

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

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

Equation 3-1

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

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

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

Equation 3-2

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

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METHOD 4—DETERMINATION OF MOISTURE CONTENT IN STACK GASES

1. *Principle and Applicability*

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

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

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

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

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

2. *Reference Method*

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

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

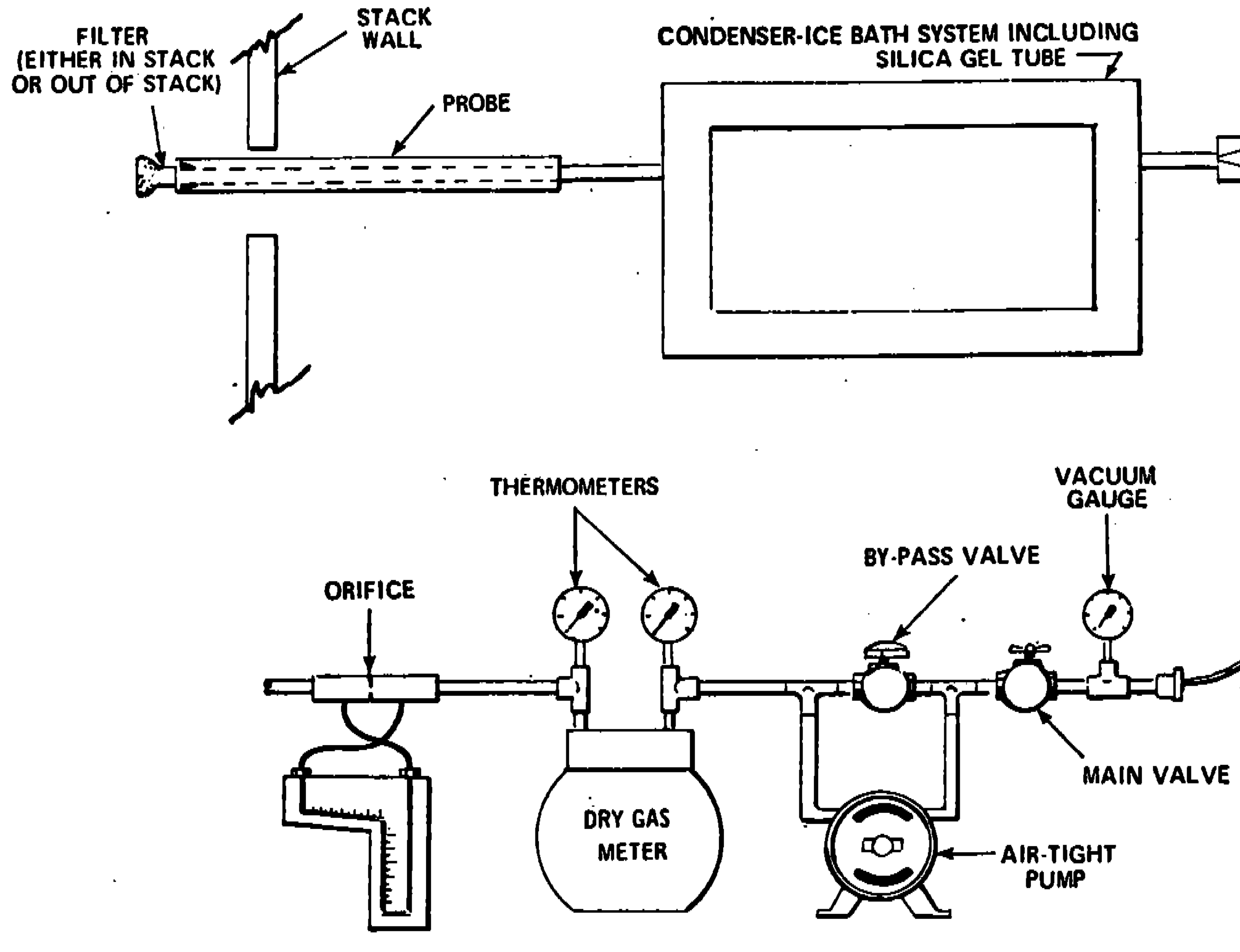

Figure 4-1. Moisture sampling train-reference method.

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

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

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

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

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

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

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

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

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

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

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

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

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

2.2.3 Set up the sampling train as shown in Figure 4-1. Turn on the probe heater and (if applicable) the filter heating system to temperatures of about 120° C (248° F), to prevent water condensation ahead of the condenser; allow time for the temperatures to stabilize. Place crushed ice in the ice bath container. It is recommended, but not required, that a leak check be done, as follows: Disconnect the probe from the first impinger or (if applicable) from the filter holder. Plug the inlet to the first impinger (or filter holder) and pull a 380 mm (15 in.) Hg vacuum; a lower vacuum may be used, provided that it is not exceeded during the test. A leakage rate in excess of 4 percent of the average sampling rate or 0.00057 m^3/min (0.02 cfm), whichever is less, is unacceptable. Following the leak check, reconnect the probe to the sampling train.

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

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

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

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

PLANT____________________

LOCATION____________________

OPERATOR____________________

DATE____________________

RUN NO.____________________

AMBIENT TEMPERATURE____________________

BAROMETRIC PRESSURE____________________

PROBE LENGTH m(ft)____________________

SCHEMATIC OF STACK CROSS SECTION

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

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

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

Figure 4 3. Analytical data - reference method.

2.3.1 Nomenclature.

B_{ws} = Proportion of water vapor, by volume, in the gas stream.
M_w = Molecular weight of water, 18.0 g/g-mole (18.0 lb/lb-mole).
P_m = Absolute pressure (for this method, same as barometric pressure) at the dry gas meter, mm Hg (in. Hg).
P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).
R = Ideal gas constant, 0.06236 (mm Hg) (m^3)/(g-mole) (°K) for metric units and 21.85 (in. Hg) (ft^3)/(lb-mole) (°R) for English units.
T_m = Absolute temperature at meter, °K (°R).
T_{std} = Standard absolute temperature, 293° K (528° R).
V_m = Dry gas volume measured by dry gas meter, dcm (dcf).
ΔV_m = Incremental dry gas volume measured by dry gas meter at each traverse point, dcm (dcf).
$V_{m(std)}$ = Dry gas volume measured by the dry gas meter, corrected to standard conditions, dscm (dscf).
$V_{wc(std)}$ = Volume of water vapor condensed corrected to standard conditions, scm (scf).
$V_{wsg(std)}$ = Volume of water vapor collected in silica gel corrected to standard conditions, scm (scf).
V_f = Final volume of condenser water, ml.
V_i = Initial volume, if any, of condenser water, ml.
W_f = Final weight of silica gel or silica gel plus impinger, g.
W_i = Initial weight of silica gel or silica gel plus impinger, g.
Y = Dry gas meter calibration factor.
ρ_w = Density of water, 0.9982 g/ml (0.002201 lb/ml).

2.3.2 Volume of water vapor condensed.

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

Equation 4-1

where:
K_1=0.001333 m^3/ml for metric units
=0.04707 ft^3/ml for English units

2.3.3 Volume of water vapor collected in silica gel.

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

Equation 4-2

where:
K_2=0.001335 m^3/g for metric units
=0.04715 ft^3/g for English units

2.3.4 Sample gas volume.

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

Equation 4-3

where:
K_1=0.3858 °K/mm Hg for metric units
=17.64 °R/in. Hg for English units

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

2.3.5 Moisture Content.

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

Equation 4-4

NOTE.—In saturated or moisture droplet-laden gas streams, two calculations of the moisture content of the stack gas shall be made, one using a value based upon the saturated conditions (see Section 1.2), and another based upon the results of the impinger analysis. The lower of these two values of B_{ws} shall be considered correct.

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

3. *Approximation Method*

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

3.1 Apparatus.

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

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

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

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

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

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

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

3.1.8 Rate Meter. Rotameter, to measure the flow range from 0 to 3 lpm (0 to 0.11 cfm).

3.1.9 Graduated Cylinder. 25 ml.

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

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

3.2 Procedure.

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

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

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

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

3.3.1 Nomenclature.

B_{wm}=Approximate proportion, by volume, of water vapor in the gas stream leaving the second impinger, 0.025.
B_{ws}=Water vapor in the gas stream, proportion by volume.
M_w=Molecular weight of water, 18.0 g/g-mole (18.0 lb/lb-mole)
P_m=Absolute pressure (for this method, same as barometric pressure) at the dry gas meter.
P_{std}=Standard absolute pressure, 760 mm Hg (29.92 in. Hg).
R=Ideal gas constant, 0.06236 (mm Hg) (m³)/(g-mole) (°K) for metric units and 21.85 (in. Hg) (ft³)/lb-mole) (°R) for English units.
T_m=Absolute temperature at meter, °K (°R)
T_{std}=Standard absolute temperature, 293° K (528° R)
V_f=Final volume of impinger contents, ml.
V_i=Initial volume of impinger contents, ml.
V_m=Dry gas volume measured by dry gas meter, dcm (dcf).
$V_{m(std)}$=Dry gas volume measured by dry gas meter, corrected to standard conditions, dscm (dscf).
$V_{wc(std)}$=Volume of water vapor condensed, corrected to standard conditions, scm (scf).
ρ_w=Density of water, 0.9982 g/ml (0.002201 lb/ml).

3.3.2 Volume of water vapor collected.

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

Equation 4–5

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

3.3.3 Gas volume.

$$V_{m(std)}=V_m\left(\frac{P_m}{P_{std}}\right)\left(\frac{T_{std}}{T_m}\right)$$
$$=K_2\frac{V_m P_m}{T_m}$$

Equation 4–6

where:
K_2=0.3858 °K/mm Hg for metric units
=17.64 °R/in. Hg for English units

3.3.4 Approximate moisture content.

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

Equation 4–7

4. *Calibration*

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

5. *Bibliography*

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

3. Methods for Determination of Velocity, Volume, Dust and Mist Content of Gases. Western Precipitation Division of Joy Manufacturing Co., Los Angeles, Calif. Bulletin WP-50. 1968.

METHOD 5—DETERMINATION OF PARTICULATE EMISSIONS FROM STATIONARY SOURCES

1. *Principle and Applicability*

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

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

2. *Apparatus*

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

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

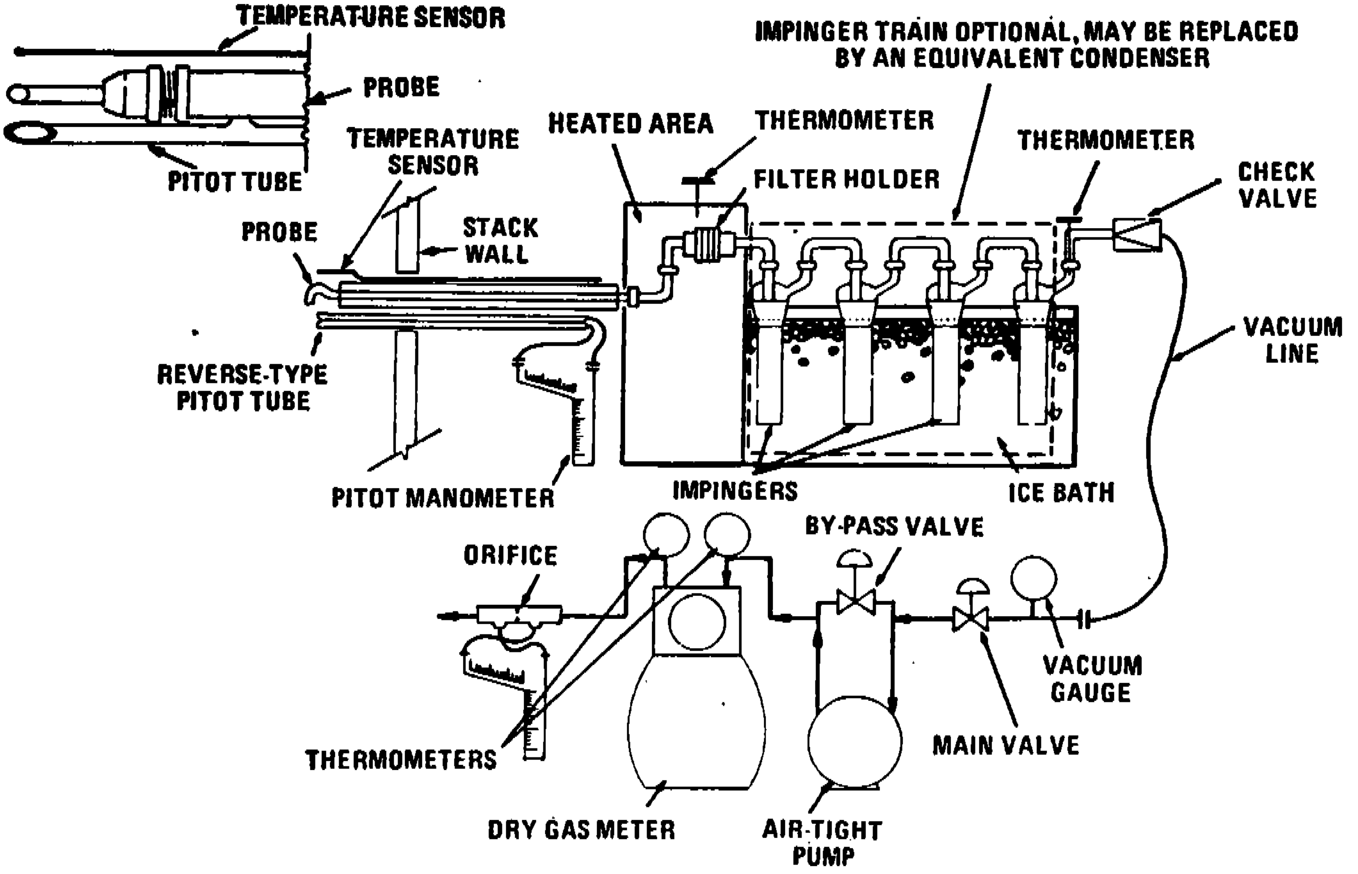

Figure 5 1. Particulate-sampling train.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

2.2 Sample Recovery. The following items are needed:

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

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

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

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

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

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

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

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

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

2.3.1 Glass Weighing Dishes.

2.3.2 Desiccator.

2.3.3 Analytical Balance. To measure to within 0.1 mg.

2.3.4 Balance. To measure to within 0.5 g.

2.3.5 Beakers. 250 ml.

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

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

3. *Reagents*

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

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

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

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

3.1.4 Crushed Ice.

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

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

3.3 Analysis. Two reagents are required for the analysis:

3.3.1 Acetone. Same as 3.2.

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

4. *Procedure*

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Place crushed ice around the impingers.

4.1.4 Leak-Check Procedures.

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

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

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

If an asbestos string is used, do not connect the probe to the train during the leak-check. Instead, leak-check the train by first plugging the inlet to the filter holder (cyclone, if applicable) and pulling a 380 mm Hg (15 in. Hg) vacuum (see Note immediately above). Then connect the probe to the train and leak-check at about 25 mm Hg (1 in. Hg) vacuum; alternatively, the probe may be leak-checked with the rest of the sampling train, in one step, at 380 mm Hg (15 in. Hg) vacuum. Leakage rates in excess of 4 percent of the average sampling rate or 0.00057 m^3/min (0.02 cfm), whichever is less, are unacceptable.

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

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

4.1.4.2 Leak-Checks During Sample Run. If, during the sampling run, a component (e.g., filter assembly or impinger) change becomes necessary, a leak-check shall be conducted immediately before the change is made. The leak-check shall be done according to the procedure outlined in Section 4.1.4.1 above, except that it shall be done at a vacuum equal to or greater than the maximum value recorded up to that point in the test. If the leakage rate is found to be no greater than 0.00057 m^3/min (0.02 cfm) or 4 percent of the average sampling rate (whichever is less), the results are acceptable, and no correction will need to be applied to the total volume of dry gas metered; if, however, a higher leakage rate is obtained, the tester shall either record the leakage rate and plan to correct the sample volume as shown in Section 6.3 of this method, or shall void the sampling run.

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

4.1.4.3 Post-test Leak-Check. A leak-check is mandatory at the conclusion of each sampling run. The leak-check shall be done in accordance with the procedures outlined in Section 4.1.4.1, except that it shall be conducted at a vacuum equal to or greater than the maximum value reached during the sampling run. If the leakage rate is found to be no greater than 0.00057 m^3/min (0.02 cfm) or 4 percent of the average sampling rate (whichever is less), the results are acceptable, and no correction need be applied to the total volume of dry gas metered. If, however, a higher leakage rate is obtained, the tester shall either record the leakage rate and correct the sample volume as shown in Section 6.3 of this method, or shall void the sampling run.

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

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

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

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

PLANT ____________
LOCATION ____________
OPERATOR ____________
DATE ____________
RUN NO. ____________
SAMPLE BOX NO. ____________
METER BOX NO. ____________
METER $\Delta H_@$ ____________
C FACTOR ____________
PITOT TUBE COEFFICIENT, C_p ____________

SCHEMATIC OF STACK CROSS SECTION

AMBIENT TEMPERATURE ____________
BAROMETRIC PRESSURE ____________
ASSUMED MOISTURE, % ____________
PROBE LENGTH, m (ft) ____________
NOZZLE IDENTIFICATION NO. ____________
AVERAGE CALIBRATED NOZZLE DIAMETER, cm (in.) ____________
PROBE HEATER SETTING ____________
LEAK RATE, m^3/min.(cfm) ____________
PROBE LINER MATERIAL ____________
STATIC PRESSURE, mm Hg (in. Hg) ____________
FILTER NO. ____________

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

Figure 5-2. Particulate field data.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Container No. 2. Taking care to see that dust on the outside of the probe or other exterior surfaces does not get into the sample, quantitatively recover particulate matter or any condensate from the probe nozzle, probe fitting, probe liner, and front half of the filter holder by washing these components with acetone and placing the wash in a glass container. Distilled water may be used instead of acetone when approved by the Administrator and shall be used when specified by the Administrator; in these cases, save a water blank and follow the Administrator's directions on analysis. Perform the acetone rinses as follows:

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

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

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

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

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

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

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

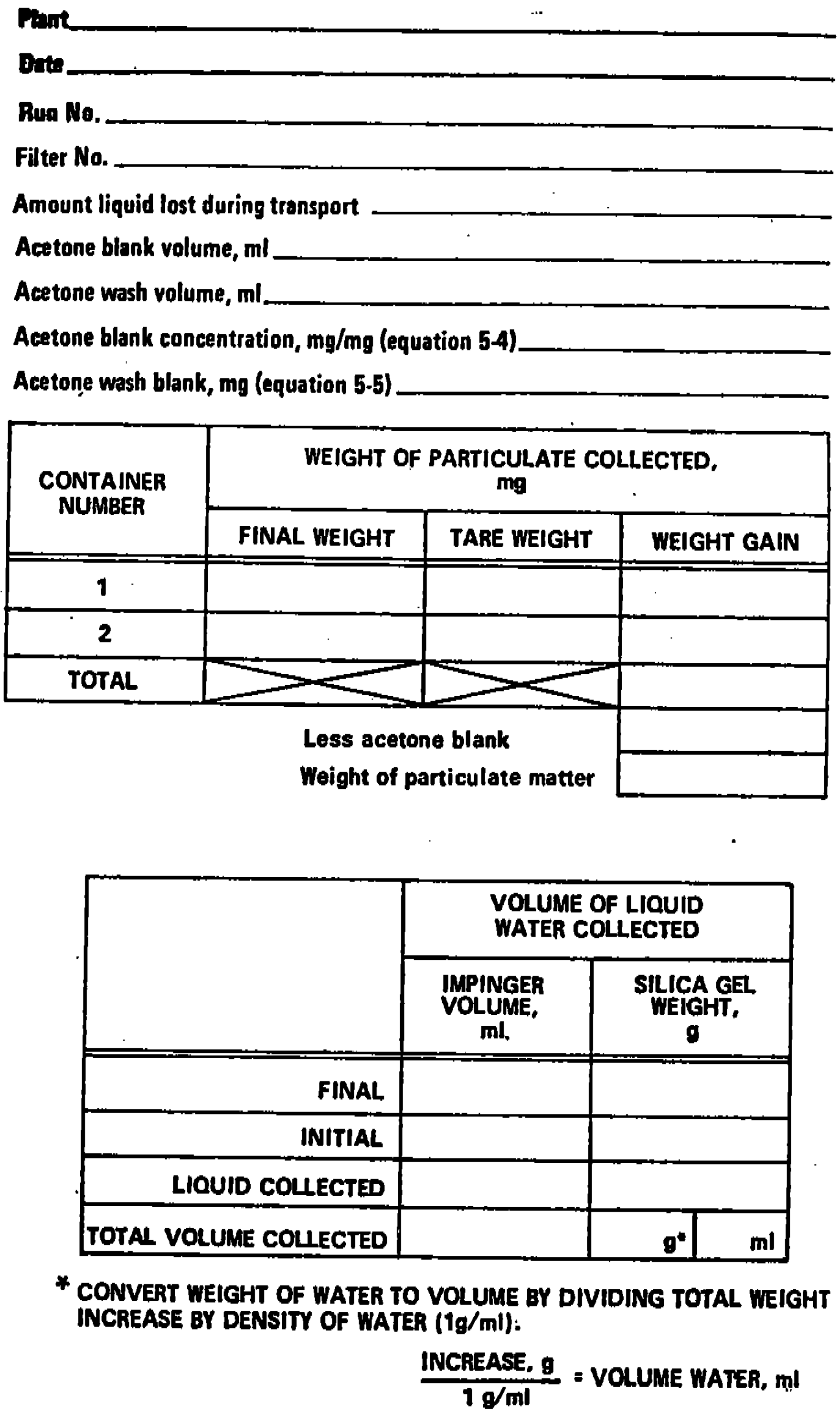
Discard the liquid after measuring and recording the volume or weight, unless analysis of the impinger catch is required (see Note, Section 2.1.7).

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

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

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

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



Plant ______________________

Date ______________________

Run No. ______________________

Filter No. ______________________

Amount liquid lost during transport ______________________

Acetone blank volume, ml ______________________

Acetone wash volume, ml ______________________

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

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

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED, mg		
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
1			
2			
TOTAL	☒	☒	

Less acetone blank ______

Weight of particulate matter ______

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

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

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

Figure 5-3. Analytical data.

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

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

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

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

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

5. *Calibration*

Maintain a laboratory log of all calibrations.

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

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

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

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

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

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

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

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

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

5.7 Barometer. Calibrate against a mercury barometer.

6. *Calculations*

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

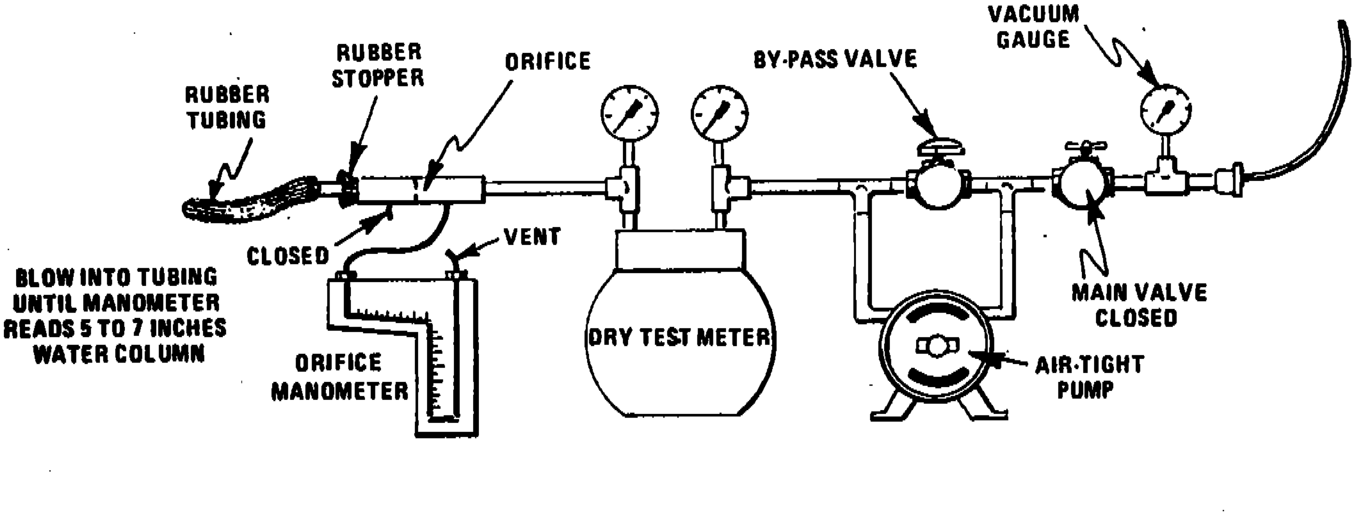


Figure 5-4. Leak check of meter box.

6.1 Nomenclature

A_n = Cross-sectional area of nozzle, m² (ft²).

B_{ws} = Water vapor in the gas stream, proportion by volume.

C_a = Acetone blank residue concentrations, mg/g.

c_s = Concentration of particulate matter in stack gas, dry basis, corrected to standard conditions, g/dscm (g/dscf).

I = Percent of isokinetic sampling.

L_a = Maximum acceptable leakage rate for either a pretest leak check or for a leak check following a component change; equal to 0.00057 m³/min (0.02 cfm) or 4 percent of the average sampling rate, whichever is less.

L_i = Individual leakage rate observed during the leak check conducted prior to the "i^{th}" component change (i=1, 2, 3 . . . . n), m³/min (cfm).

L_p = Leakage rate observed during the post-test leak check, m³/min (cfm).

m_n = Total amount of particulate matter collected, mg.

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

m_a = Mass of residue of acetone after evaporation, mg.

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

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

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

R = Ideal gas constant, 0.06236 mm Hg-m³/°K-g-mole (21.85 in. Hg-ft³/°R-lb-mole).

T_m = Absolute average dry gas meter temperature (see Figure 5–2), °K (°R).

T_s = Absolute average stack gas temperature (see Figure 5-2), °K (°R).

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

V_a = Volume of acetone blank, ml.

V_{aw} = Volume of acetone used in wash, ml.

V_{lc} = Total volume of liquid collected in impingers and silica gel (see Figure 5–3), ml.

V_m = Volume of gas sample as measured by dry gas meter, dcm (dcf).

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

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

v_s = Stack gas velocity, calculated by Method 2, Equation 2–9, using data obtained from Method 5, m/sec (ft/sec).

W_a = Weight of residue in acetone wash, mg.

Y = Dry gas meter calibration factor.

ΔH = Average pressure differential across the orifice meter (see Figure 5–2), mm H₂O (in. H₂O).

ρ_a = Density of acetone, mg/ml (see label on bottle).

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

θ = Total sampling time, min.

θ_1 = Sampling time interval, from the beginning of a run until the first component change, min.

θ_i = Sampling time interval, between two successive component changes, beginning with the interval between the first and second changes, min.

θ_p = Sampling time interval, from the final (n^{th}) component change until the end of the sampling run, min.

13.6 = Specific gravity of mercury.

60 = Sec/min.

100 = Conversion to percent.

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

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

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

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

Equation 5-1

where;
$m_1 = 0.3858$ °K/mm Hg for metric units
$= 17.64$ °R/in. Hg for English units

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

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

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

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

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

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

6.4 Volume of water vapor.

Equation 5-2

$$V_{w(std)} = V_{1c}\left(\frac{\rho_w}{M_w}\right)\left(\frac{RT_{std}}{P_{std}}\right) = K_2 V_{1c}$$

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

6.5 Moisture Content.

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

Equation 5-3

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

6.6 Acetone Blank Concentration.

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

Equation 5-4

6.7 Acetone Wash Blank.

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

Equation 5-5

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

6.9 Particulate Concentration.

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

Equation 5-6

6.10 Conversion Factors:

From	To	Multiply by
scf	m³	0.02832
g/ft³	gr/ft³	15.43
g/ft³	lb/ft³	2.205×10⁻³
g/ft³	g/m³	35.31

6.11 Isokinetic Variation.

6.11.1 Calculation From Raw Data.

$$I = \frac{100\, T_s [K_3 V_{1c} + (V_m/T_m)(P_{bar} + \Delta H/13.6)]}{60\, \theta v_s P_s A_n}$$

Equation 5-7

where:
$K_3 = 0.003454$ mm Hg−m³/ml−°K for metric units.
$= 0.002669$ in. Hg−ft³/ml−°R for English units.

6.11.2 Calculation From Intermediate Values.

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

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

Equation 5-8

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

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

7. *Bibliography*

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METHOD 6—DETERMINATION OF SULFUR DIOXIDE EMISSIONS FROM STATIONARY SOURCES

1. *Principle and Applicability*

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

1.2 Applicability. This method is applicable for the determination of sulfur dioxide emissions from stationary sources. The minimum detectable limit of the method has been determined to be 3.4 milligrams (mg) of SO_2/m³ (2.12×10^{-7} lb/ft³). Although no upper limit has been established, tests have shown that concentrations as high as 80,000 mg/m³ of SO_2 can be collected efficiently in two midget impingers, each containing 15 milliliters of 3 percent hydrogen peroxide, at a rate of 1.0 lpm for 20 minutes. Based on theoretical calculations, the upper concentration limit in a 20-liter sample is about 93,300 mg/m³.

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

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

2. *Apparatus*

CALIBRATION INFORMATION

NOZZLES

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

PITOT TUBES

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

DRY GAS METER AND ORIFICE METER

Meter box calibrations are checked periodically according to their usage. If a large difference is noted between calibrations, the meter box is sent back to the manufacturer to be rechecked.

THERMOMETERS, FYRITES, ORSAT, ORSAT BAGS

Each new thermometer, pyrometer and thermocouple purchased by ETI is checked and calibrated before being put into field use. Periodically and according to each piece of equipments use it is again checked and recalibrated.

Fyrites and orsats are checked after each source test. If they do not function properly, each is refilled with fresh solutions and rechecked. Orsat gas sampling bags are leak tested and evacuated after each source test.

Calibration data and test dates are posted on each individual piece of equipment.

PRETEST -POSTTEST CALIBRATION CHECKS

(Method 5, Figure 5.1)

Plant GP Dudley – Precip Outlet Calibrated by JSM-KO

Meter box number RAC 1348 Date 9/22/83

Dry Gas Meter

Pretest calibration factor, Y = 0.99 (within ±2%)
Posttest check, Y* = 1.026 (within ±5% of pretest)
Recalibration required? ✓ yes ______ no
If yes, recalibration factor, Y ______ (within ±2%)
Lower calibration factor, Y = 0.99 for calculations (pretest or posttest)

Dry Gas Meter Thermometers

Was a pretest temperature correction used? ______ yes ✓ no
If yes, temperature correction ______ (within ±3°C (5.4°F) over range)
Posttest comparison with mercury-in-glass thermometer?* (within ±6°C (10.8°F) at ambient temperature)
Recalibration required? ______ yes ✓ no
Recalibration temperature correction? ______ (within ±3°C (5.4°F) over range)*
If yes, no correction necessary for calculations if meter thermometer temperature is higher; if calibration temperature is higher, add correction to average meter temperature for calculations

Stack Temperature Sensor

Was a pretest temperature correction used? ______ yes ______ no
If yes, temperature correction ______ °C (°F) (within ±1.5% of readings in K (°R) over range)
Average stack temperature of compliance test, T_s ______ K (°R)
Temperature of reference thermometer or solution for recalibration 667.5 ~~K~~ (°R)* (within ±10% of T_s)
Temperature of stack thermometer for recalibration 666 ~~K~~ (°R)
Difference between reference and stack thermometer temperatures, ΔT_s 0.5 ~~K~~ (°R)
Do values agree within ±1.5%?* ✓ yes ______ no
If yes, no correction necessary for calculations
If no, calculations must be done twice--once with the recorded values and once with the average stack temperature corrected to correspond to the reference temperature differential (ΔT_s); both final result values must be reported since there is no way to determine which is correct

(continued)

(continued)

Barometer

Was the pretest field barometer reading correct? ___ yes _✓_ no
Posttest comparison?* Δ = .04 ~~mm~~ (in.) Hg (±2.5 mm (0.1 in.) Hg)
Was calibration required? ___ yes _✓_ no
If yes, no correction necessary for calculations when the field barometer has a lower reading; if the mercury-in-glass reading is lower, subtract the difference from the field data readings for the calculation

Nozzle*

Was the nozzle calibrated to the nearest 0.025 mm (0.001 in.)?
_✓_ yes ___ no

Impinger Thermometer

Was a pretest temperature correction used? ___ yes _✓_ no
If yes, temperature correction ___ (within ±3°C (5.4°F) over range)

*Most significant items/parameters to be checked.

POSTTEST DRY GAS METER CALIBRATION DATA FORM (English units)

Test number Precip Outlet P-4 Date 9/22/83 Meter box number RAC 1347 Plant GP-Dudley

Barometric pressure, P_b = 29.29 in. Hg Dry gas meter number 1 Pretest Y ______

Orifice manometer setting, (ΔH), in. H_2O	Gas volume		Temperature				Time (θ), min	Vacuum setting, in. Hg	Y_i	Y_i
	Wet test meter (V_w), ft^3	Dry gas meter (V_d), ft^3	Wet test meter (t_w), °F	Dry gas meter						$\frac{V_w P_b (t_d + 460)}{V_d \left(P_b + \frac{\Delta H}{13.6}\right)(t_w +}$
				Inlet (t_{d_i}), °F	Outlet (t_{d_o}), °F	Average[a] (t_d), °F				
3.85	10	10.53	75.25	146.5	105	125.75	9.71	20.0	1.029	$\frac{10(29.29)(125.75+460)}{10.53(29.29+\frac{3.85}{13.6})(75.25+46}$
3.85	10	10.56	75.75	148.5	107	127.75	9.78	20.0	1.028	$\frac{10(29.29)(127.75+460)}{10.56(29.29+\frac{3.85}{13.6})(75.75}$
3.85	10	10.67	76.25	149.5	109	129.25	9.79	20.0	1.020	$\frac{10(29.29)(129.25+460)}{10.67(29.29+\frac{3.85}{13.6})(76.25+4}$
									Y = 1.026	

[a] If there is only one thermometer on the dry gas meter, record the temperature under t_d

where

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

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

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

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

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

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

ΔH = Pressure differential across orifice, in. H_2O.

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

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

P_b = Barometric pressure, in. Hg.

θ = Time of calibration run, min.

PRETEST -POSTTEST CALIBRATION CHECKS
(Method 5, Figure 5.1)

Plant GP Dudley Precip Inlet Calibrated by JSM-KO

Meter box number RAC 1965 Date 9/22/83

Dry Gas Meter

Pretest calibration factor, Y = [illegible] [illegible] 0.99 (within ±2%)
Posttest check, Y* 0.99 (within ±5% of pretest)
Recalibration required? ______ yes ✓ no
If yes, recalibration factor, Y ______ (within ±2%)
Lower calibration factor, Y ______ for calculations (pretest or posttest)

Dry Gas Meter Thermometers

Was a pretest temperature correction used? ______ yes ✓ no
If yes, temperature correction ______ (within ±3°C (5.4°F) over range)
Posttest comparison with mercury-in-glass thermometer?* (within ±6°C (10.8°F) at ambient temperature)
Recalibration required? ______ yes ✓ no
Recalibration temperature correction? ______ (within ±3°C (5.4°F) over range)*
If yes, no correction necessary for calculations if meter thermometer temperature is higher; if calibration temperature is higher, add correction to average meter temperature for calculations

Stack Temperature Sensor

Was a pretest temperature correction used? ______ yes ______ no
If yes, temperature correction ______ °C (°F) (within ±1.5% of readings in K (°R) over range)
Average stack temperature of compliance test, T_s ______ K (°R)
Temperature of reference thermometer or solution for recalibration 667.5 ~~K~~ (°R)* (within ±10% of T_s)
Temperature of stack thermometer for recalibration 669.0 ~~K~~ (°R)
Difference between reference and stack thermometer temperatures, ΔT_s 1.5 ~~K~~ (°R)
Do values agree within ±1.5%?* ✓ yes ______ no
If yes, no correction necessary for calculations
If no, calculations must be done twice--once with the recorded values and once with the average stack temperature corrected to correspond to the reference temperature differential (ΔT_s); both final result values must be reported since there is no way to determine which is correct

(continued)

(continued)

Barometer

Was the pretest field barometer reading correct? ✓ yes ____ no
Posttest comparison?* Δ=.03 ~~mm~~ (in.) Hg (±2.5 mm (0.1 in.) Hg)
Was calibration required? ____________ yes ______✓______ no

If yes, no correction necessary for calculations when the field barometer has a lower reading; if the mercury-in-glass reading is lower, subtract the difference from the field data readings for the calculation

Nozzle*

Was the nozzle calibrated to the nearest 0.025 mm (0.001 in.)?
___✓___ yes _______ no

Impinger Thermometer

Was a pretest temperature correction used? _______ yes ___✓___ no

If yes, temperature correction __________ (within ±3°C (5.4°F) over range)

*Most significant items/parameters to be checked.

POSTTEST DRY GAS METER CALIBRATION DATA FORM (English units)

Test number Precip Inlet 1-4 Date 2/22/83 Meter box number RAC. ~~1348~~ 1965 Plant GP Dudley

Barometric pressure, P_b = 29.29 in. Hg Dry gas meter number 1 Pretest Y = 0.99

Orifice manometer setting, (ΔH), in. H_2O	Gas volume		Temperature				Time (θ), min	Vacuum setting, in. Hg	Y_i	Y_i
	Wet test meter (V_w), ft^3	Dry gas meter (V_d), ft^3	Wet test meter (t_w), °F	Dry gas meter						$\frac{V_w P_b (t_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6})(t_w + 4}$
				Inlet (t_{d_i}), °F	Outlet (t_{d_o}), °F	Average[a] (t_d), °F				
0.58	~~10~~ 11.1	11.43	69	91	79	85	26.81	9.0	1.00	$\frac{11.1(29.29)(85+460)}{11.43(29.29+\frac{.58}{13.6})(69+460)}$
0.58	10	10.57	71	98	88.5	93.25	24.12	9.0	0.98	$\frac{10(29.29)(93.25+460)}{10.57(29.29+\frac{.58}{13.6})(88.5+460)}$
0.58	10	10.66	73	101	93	97	24.11	9.0	0.98	$\frac{10(29.29)(97+460)}{10.66(29.29+\frac{.58}{13.6})(97+46}$
									Y = 0.99	

[a] If there is only one thermometer on the dry gas meter, record the temperature under t_d

where

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

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

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

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

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

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

ΔH = Pressure differential across orifice, in. H_2O.

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

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

P_b = Barometric pressure, in. Hg.

θ = Time of calibration run, min.

STAKSAMPLR CALIBRATION SHEET

ENVIRONMENTAL TESTING, INC.

Date 2/15/83

Pump Vanes oiled, Pressure checked

Pump Oil Changed

Clean Quick Connects cleaned & lubricated

Manometers fluids & levels checked

Dry Test Meter adjusted 7/13/83

Thermometers OK

Lights OK

Electrical Check--Amphenol OK

Variac OK

Vacuum Gauge OK

Leak Check at 27" Hg.--Leakage ≤.007

Valves OK

Remarks:

New calibration on 9/19/83

Calibration--Orifice and Meter

Date 9/19/83 Box No. RAC 1965 P_b 29.33

Man. Orifice	CF_w	CF_d	T_w	IT_d	OT_d	T_d avg.	Time t
0.5	5	5.23	79.0	95.0	86.0	90.5	12.84 1281
1.0	5	5.21	80.0	101.0	90.5	95.8	9.14
1.5	10	10.45	81.0	107.0	95.0	101.0	15.23
2.0	10	10.49	82.3	112.0	99.0	105.5	13.30
3.0	10	10.47	82.8	114.5	101.0	107.8	10.98
4.0	10	10.45	83.3	116.5	102.5	109.5	9.55

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

$$Y = \frac{CF_w \, P_b \, (T_d \text{ avg.} + 460)}{CF_d \left(P_b + \frac{\Delta H}{13.6}\right)(T_w + 460)}$$

0.99

$$\Delta H_@ = \frac{0.0317 \, \Delta H}{P_b \, (T_d + 460)} \left[\frac{(T_w + 460)\, t}{CF_w} \right]^2$$

1.96

Tolerances

$Y = 0.90 - \underline{1.00} - 1.10$ $Y \pm 0.02Y$

$\Delta H_@ = 1.6 - \underline{1.84} - 2.1$ $\Delta H_{@i} \pm 0.15$ in.

Date Box

$\frac{0.0317\ (\text{Man. orifice})}{P_b\ (T_d + 460)}$	$\left[\frac{(T_w + 460)\ t}{CF_w}\right]^2$	Man.	$\Delta H_@$	$\frac{CF_w\ P_b\ (T_d\ \text{avg.} + 460)}{CF_d\left(P_b + \frac{\text{Man. orifice}}{13.6}\right)(T_w + 460)}$	Man.	Y
$\frac{0.01585}{20.33\ (90.5 + 460)}$	$\left[\frac{(79 + 460)\ 12.81}{5\ \cancel{10}}\right]^2$	.5	1.872	$\frac{5 \times 20.33\ (90.5 + 460)}{5.23\ (20.33 + 0.0368)\ (79 + 460)}$	.5	.9
$\frac{0.0317}{20.33\ (95.8 + 460)}$	$\left[\frac{(80 + 460)\ 9.14}{5}\right]^2$	1.0	1.890	$\frac{5 \times 20.33\ (95.8 + 460)}{5.21\ (20.33 + 0.0737)\ (80 + 460)}$	1.0	.96
$\frac{0.04755}{20.33\ (101.0 + 460)}$	$\left[\frac{(81 + 460)\ 15.23}{10}\right]^2$	1.5	1.962	$\frac{10 \times 20.33\ (101.0 + 460)}{10.45\ (20.33 + 0.1103)\ (81 + 460)}$	1.5	.96
$\frac{0.06340}{20.33\ (105.5 + 460)}$	$\left[\frac{(82.3 + 460)\ 13.30}{10}\right]^2$	2.0	1.989	$\frac{10 \times 20.33\ (105.5 + 460)}{10.49\ (20.33 + 0.1471)\ (82.3 + 460)}$	2.0	.96
$\frac{0.09510}{20.33\ (107.8 + 460)}$	$\left[\frac{(82.8 + 460)\ 10.98}{10}\right]^2$	3.0	2.028	$\frac{10 \times 20.33\ (107.8 + 460)}{10.47\ (20.33 + 0.2206)\ (82.8 + 460)}$	3.0	.9
$\frac{0.12680}{20.33\ (109.5 + 460)}$	$\left[\frac{(83.3 + 460)\ 9.55}{10}\right]^2$	4.0	2.044	$\frac{10 \times 20.33\ (109.5 + 460)}{10.45\ (20.33 + 0.2941)\ (83.3 + 460)}$	4.0	.9

METER BOX TEMPERATURE SENSOR CALIBRATION DATA FORM
TOLERANCE: ± 5.4 F

Date MAY 31, 1983 Thermocouple number Bimetallic

Ambient temperature 74.0 °F Barometric pressure 28.84 in. Hg

Calibrator K.O'Neal Reference: mercury-in-glass #15-0008/#ETI23

other NA

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
METER BOX NUMBER				
RAC 1965				
1965 A	OIL BATH	122.9	123	+0.02
	"	135.9	140	-0.69
	"	101.8	108	-1.10
1965 B	OIL BATH	122.9	123	+0.02
	"	135.9	139	-0.69
	"	101.8	108	-1.10

A = INLET THERMOMETER, B = OUTLET THERMOMETER

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $$\left[\frac{(\text{ref temp, }^\circ\text{F} + 460) - (\text{test thermom temp, }^\circ\text{F} + 460)}{\text{ref temp, }^\circ\text{F} + 460}\right] 100 \leq 1.5\%.$$

STAKSAMPLR CALIBRATION SHEET

ENVIRONMENTAL TESTING, INC.

Date 3/22/83

Pump RAC 1348

Pump Oil changed

Clean Quick Connects cleaned & lubricated

Manometers fluild and levels checked

Dry Test Meter adjusted on 7/14/83

Thermometers see calibration form

Lights ok

Electrical Check--Amphenol ok

Variac ok

Vacuum Gauge ok

Leak Check at 27" Hg.--Leakage <.001 CFM

Valves ok

Remarks: New calibration to establish ΔH@ and Y perfor
on 7/14/83.

Calibration--Orifice and Meter

Date Box No. RAC 1348 P_b

Man. Orifice	CF_w	CF_d	T_w	IT_d	OT_d	T_d avg.	Time t
0.5	5.00	5.35	73.8	106.5	86.5	96.5	13.03
1.0	5.10	5.46	74.3	116.0	93.0	104.5	9.62
1.5	10.00	10.69	75.3	122.5	97.0	109.8	15.54
2.0	10.00	10.87	75.8	126.0	100.5	113.3	13.57
3.0	10.00	10.62	76.5	130.0	102.5	116.3	11.08
4.0	10.00	10.80	77.3	133.0	104.5	118.8	9.87

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

$$Y = \frac{CF_w \, P_b \, (T_d \text{ avg.} + 460)}{CF_d \left(P_b + \frac{\Delta H}{13.6}\right)(T_w + 460)} = 0.99$$

$$\Delta H_@ = \frac{0.0317 \, \Delta H}{P_b \, (T_d + 460)} \left[\frac{(T_w + 460)\, t}{CF_w} \right]^2 = 1.98$$

Tolerances

$Y = 0.90 - \underline{1.00} - 1.10 \quad Y \pm 0.02Y$

$\Delta H_@ = 1.6 - \underline{1.84} - 2.1 \quad \Delta H_{@i} \pm 0.15$ in.

CALIBRATION CALCULATIONS METER AND PUMP BOX Date Box No. RAC-1398

$\frac{0.0317\,(\text{Man. orifice})}{P_b\,(T_d + 460)}$	$\left[\frac{(T_w + 460)\,t}{CF_w}\right]^2$	Man.	$\Delta H_@$	$\frac{CF_w\,P_b\,(T_d\text{ avg.} + 460)}{CF_d\left(P_b + \frac{\text{Man. orifice}}{13.6}\right)(T_w + 460)}$	Man.	Y
$\frac{0.01585}{29.30\,(96.5 + 460)}$	$\left[\frac{(73.8 + 460)\,13.03}{5.00}\right]^2$	.5	1.88	$\frac{5.00 \times 29.30\,(96.5 + 460)}{5.35\,(29.30 + 0.0368)\,(73.8 + 460)}$	.5	.9
$\frac{0.0317}{29.30\,(104.5 + 460)}$	$\left[\frac{(74.3 + 460)\,9.62}{5.10}\right]^2$	1.0	1.95	$\frac{5.10 \times 29.30\,(104.5 + 460)}{5.46\,(29.30 + 0.0737)\,(74.3 + 460)}$	1.0	.9
$\frac{0.04755}{29.30\,(109.8 + 460)}$	$\left[\frac{(75.3 + 460)\,\_\_\_\_}{10.00}\right]^2$	1.5	1.97	$\frac{10.00 \times 29.30\,(75.3 + 460)}{10.69\,(29.30 + 0.1103)\,(109.8 + 460)}$	1.5	.9
$\frac{0.06340}{29.31\,(113.3 + 460)}$	$\left[\frac{(75.8 + 460)\,13.57}{10.00}\right]^2$	2.0	2.00	$\frac{10.00 \times 29.31\,(113.3 + 460)}{10.07\,(29.31 + 0.1471)\,(75.8 + 460)}$	2.0	.9
$\frac{0.09510}{29.31\,(116.3 + 460)}$	$\left[\frac{(76.5 + 460)\,11.08}{10.00}\right]^2$	3.0	1.99	$\frac{10.00 \times 29.31\,(116.3 + 460)}{10.62\,(29.31 + 0.2206)\,(76.5 + 460)}$	3.0	1.0
$\frac{0.12680}{29.31\,(104.5 + 460)}$	$\left[\frac{(77.3 + 460)\,9.87}{10.80}\right]^2$	4.0	2.10	$\frac{10.00 \times 29.31\,(104.5 + 460)}{[illegible]\,(29.31 + 0.2941)\,(77.3 + 460)}$	4.0	1.0

METER BOX TEMPERATURE SENSOR CALIBRATION DATA FORM

TOLERANCE: ± 5.4 F

Date MAY 31, 1983 Thermocouple number Bimetallic

Ambient temperature 74.0 °F Barometric pressure 28.84 in. Hg

Calibrator K. O'Neal Reference: mercury-in-glass #15-0008/#ETI 23

other NA

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
METER BOX NUMBER				
RAC 1348				
1348 A	OIL BATH	122.9	124	-0.19
	"	137.3	143.5	-1.04
	"	101.8	109	-1.10
1348B	OIL BATH	122.9	125	-0.19
	"	137.3	143	-1.04
	"	101.9	109	-1.10

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $$\left[\frac{(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)}{\text{ref temp, °F} + 460}\right] 100 \leq 1.5\%.$$

3/16"

NOZZLE CALIBRATION

SET NO. 1

Date 5/24/83 Calibrated by K. O'Neal

Nozzle identification number	D_1, in.	D_2, in.	D_3, in.	ΔD, in.	D_{avg}
3/16"-1	.174	.175	.178	.004	.176
3/16"-2	.176	.177	.180	.004	.178
3/16"-3	.178	.180	.179	.002	.179

where:

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

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

D_{avg} = average of D_1, D_2, and D_3.

Figure E-1. Nozzle calibration data.

1/4"

NOZZLE CALIBRATION

SET NO. 1

Date 5/24/83 Calibrated by K. O'Neal

Nozzle identification number	D_1, in.	D_2, in.	D_3, in.	ΔD, in.	D_{avg}
1/4" - 1	.256	.254	.254	.002	.255
1/4" - 2	.259	.257	.259	.002	.258
1/4" - 3	.253	.250	.250	.003	.251

where:

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

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

D_{avg} = average of D_1, D_2, and D_3.

Figure E-1. Nozzle calibration data.

8' Thermocouples

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 5/13/83 Thermocouple number 8'#1, 8'#2, 8'#3

Ambient temperature 75.0 °F Barometric pressure 29.31 in. Hg

Calibrator K.O'Neal Reference: mercury-in-glass #20T0500/ETI#5

other NA

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
Thermometer NO.				
8'#1 a.	OIL BATH	223	224	-0.15
b.	"	260	261	-0.14
c.	"	335	332	+0.38
8'#2 a.	OIL BATH	223	224	-0.15
b.	"	260	261	-0.14
c.	"	335	333	+0.38
8'#3 a.	OIL BATH	224	226	-0.29
b.	"	260	261	-0.14
c.	"	335	334	+0.13

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $$\left[\frac{(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)}{\text{ref temp, °F} + 460}\right] 100 \leq 1.5\%.$$

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 9/17/83 Thermocouple number 9'7"

Ambient temperature 76 °F Barometric pressure 29.32 in. Hg

Calibrator JSM Reference: mercury-in-glass ✓

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
100°F	Hg in glass	106°F	105°F	-0.18%
200°F	Hg in glass	193°F	193°F	0.00%
300°F	Hg in glass	330°F	328°F	0.25% ~~0.70~~

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $$\left[\frac{(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)}{\text{ref temp, °F} + 460}\right] 100 \le 1.5\%.$$

8' unattached Pitot tube

TYPE S PITOT TUBE INSPECTION DATA FORM

Pitot tube assembly level? ✓ yes ______ no

Pitot tube openings damaged? ______ yes (explain below) ✓ no

α_1 = 1.0 ° (<10°), α_2 = 1.0 ° (<10°), β_1 = 2.0 ° (<5°),
β_2 = 2.0 ° (<5°)

γ = 2.0 °, θ = 3.0 °, A = .982 ~~cm~~ (in.)

$z = A \sin \gamma$ = .034 ~~cm~~ (in.); <0.32 cm (<1/8 in.),
$w = A \sin \theta$ = .051 ~~cm~~ (in.); <.08 cm (<1/32 in.)

P_A .491 ~~cm~~ (in.) P_b .491 ~~cm~~ (in.)

D_t = .378 ~~cm~~ (in.)

Comments: calibrated on 5/13/83

Calibration required? ______ yes ✓ no

PRETEST CHECK FOR SAMPLE HEAD

Date 5/10/83 Sample Head No. 1 Job to be used on - PN

Thermometer ±2 F of mercury thermometer See "Impinger Temp. Sensor Calibration

Quick connect Cleaned and lubricated

Leak check @ 5" Hg <.01 cfm - @ 15" Hg <.01 cfm

General remarks Check value cleaned, lubricated and checked for smooth operation.

Checked by W.K. O'neal
Signature

PRETEST CHECK FOR SAMPLE HEAD

Date 5/10/83 Sample Head No. 2 Job to be used on - PN

Thermometer ±2 F of mercury thermometer See "Impinger Temp. Sensor Data Calib. For.

Quick connect Cleaned & lubricated

Leak check @ 5" Hg <.01 cfm - @ 15" Hg <.01 cfm

General remarks Check value cleaned, lubricated and checked for smooth operation

Checked by W. K. O'Neal
Signature

PRETEST CHECK FOR SAMPLE HEAD

Date 5/10/83 Sample Head No. 3 Job to be used on - PN____

Thermometer ±2 F of mercury thermometer See "Impinger Temp Sensor Calib. F

Quick connect cleaned & Lubricated

Leak check @ 5" Hg <.01 cfm - @ 15" Hg <.01 cfm

General remarks check value cleaned, lubricated and checked for smooth operation

Checked by W. K. O'neal
Signature

PRETEST CHECK FOR SAMPLE HEAD

Date 5/10/83 Sample Head No. 4 Job to be used on - PN

Thermometer ±2 F of mercury thermometer See "Impinger Temp Sensor Calib.

Quick connect Cleaned & Lubricated

Leak check @ 5" Hg <.01 cfm - @ 15" Hg <.01 cfm

General remarks check value cleaned, lubricated ack echeck for smooth operation.

Checked by W. K. O'Neel
Signature

IMPINGER TEMPERATURE SENSOR CALIBRATION DATA FORM
TOLERANCE: ± 2.0 F.

Date 5/10/83 Thermocouple number Bimetallic

Ambient temperature 72.1 °F Barometric pressure 29.40 in. Hg

Calibrator K. O'Neal Reference: mercury-in-glass #15-0008/ETI #24

other NA

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
Thermometer NO.				
# 1 a.	ICE * BATH	33.8	36.0	-0.44
b.	"	46.0	44.8	+0.24
c.	"	59.5	58.0	+0.29
# 2 a.	ICE * BATH	33.8	33.8	+0.00
b.	"	46.0	45.2	+0.16
c.	"	59.5	59.0	+0.01

---

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)}{\text{ref temp, °F} + 460}\right] 100 \leq 1.5\%.$

IMPINGER TEMPERATURE SENSOR CALIBRATION DATA FORM
TOLERANCE: ± 2.0 F.

Date 5/10/83 Thermocouple number Bimetallic

Ambient temperature 72.1 °F Barometric pressure 29.40 in. Hg

Calibrator K. ONeal Reference: mercury-in-glass #15-000B/ETI #24

other NA

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
Thermometer No.				
#3 a.	ICE BATH *	33.8	33.0	+0.16
b.	"	46.9	45.9	+0.20
c.	"	59.7	58.9	+0.15
#4 a.	ICE BATH *	33.8	32.5	+0.26
b.	"	47.8	47.0	+0.20
c.	"	59.7	58.5	+0.23

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)}{\text{ref temp, °F} + 460}\right] 100 \leq 1.5\%.$

BOX TEMPERATURE SENSOR CALIBRATION DATA FORM

TOLERANCE: ±5.4 F

Date 5/10/83 Thermocouple number Bimetallic

Ambient temperature 72.1 °F Barometric pressure 29.40 in. Hg

Calibrator K. O'Neal Reference: mercury-in-glass #2070500/ETZ #5

other NA

Reference point number[a]		Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
Thermometer No.					
# 1	a.	OIL BATH	238	230	+1.14
	b.	"	250	238	+1.69
	c.	"	269	260	+1.23
# 2	a.	OIL BATH	243	241	+0.28
	b.	"	250	251	-0.14
	c.	"	270	267	+0.41
# 3	a.	OIL BATH	244	249	-0.71
	b.	"	252	250	+0.28
	c.	"	270	266	-0.71
# 4	a.	OIL BATH	244	232	+1.70
	b.	"	252	240	+1.69
	c.	"	268	250	+2.47

---

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)}{\text{ref temp, °F} + 460}\right] 100 \leq 1.5\%$.

BOX TEMPERATURE SENSOR CALIBRATION DATA FORM

TOLERANCE: ±5.4 F

Date 5/10/83 Thermocouple number Bimetallic

Ambient temperature 72.1 °F Barometric pressure 29.40 in. Hg

Calibrator K. O'Neal Reference: mercury-in-glass #2070500/ETZ #5

other NA

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
#5 a.	OIL BATH	245	245	+0.00
b.	"	252	252	+0.00
c.	"	270	265	+0.68
#6 a.	OIL BATH	245	243	+0.28
b.	"	253	250	+0.42
c.	"	270	268	+0.27
#7 a.	OIL BATH	243	245	-0.28
b.	"	254	255	-0.14
c.	"	270	271	-0.14
#8 a.	OIL BATH	244	239	+0.71
b.	"	254	251	+0.42
c.	"	269	263	+0.82

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $$\left[\frac{(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)}{\text{ref temp, °F} + 460}\right] 100 \leq 1.5\%.$$

WET-BULB & DRY-BULB
TEMPERATURE SENSOR CALIBRATION DATA FORM
TOLERANCE: ± 3 C. (±5.4 F.)

OMEGA ENGINEERING THERMOMETER

Date 5/13/83 Thermocouple number W_b-D_b

Ambient temperature 75.0 F Barometric pressure 29.31 in. Hg

Calibrator K.O'Neal Reference: mercury-in-glass # 2070500/ETI#5

other SN 11756 & 14403

Reference point number[a]		Source[b] (specify)	Reference thermometer temperature, F	Thermocouple potentiometer temperature, F	Temperature difference,[c] %
Thermometer NO.					
Wb_1	a.	OIL BATH	226	225	+0.15
	b.	"	259	260	-0.14
	c.	"	334	334	0.00
Db_1	a.	OIL BATH	226	226	0.00
	b.	"	262	265	-0.42
	c.	"	337	338	-0.13
Wb_2	a.	OIL BATH	228	228	0.00
	b.	"	261	262	-0.14
	c.	"	336	335	+0.13
Db_2	a.	OIL BATH	229	235	-0.87
	b.	"	262	263	-0.14
	c.	"	337	335	+0.25

[a] Every 30°C (50°F) for each reference point.

[b] Type of calibration system used.

[c] $$\left[\frac{(\text{ref temp, F} + 460) - (\text{test thermom temp, F} + 460)}{\text{ref temp, F} + 460}\right] 100 \leq 1.5\%.$$

9'7" Probe Sheath No. 1

TYPE S PITOT TUBE INSPECTION DATA FORM

Pitot tube assembly level? ✓ yes ______ no

Pitot tube openings damaged? ______ yes (explain below) ✓ no

α_1 = 0.0 ° (<10°), α_2 = 0.0 ° (<10°), β_1 = 2.5 ° (<5°),
β_2 = 0.5 ° (<5°)

γ = 1.5 °, θ = 1.5 °, A = .925 ~~cm~~ (in.)

$z = A \sin \gamma$ = 0.0242 ~~cm~~ (in.); <0.32 cm (<1/8 in.),
$w = A \sin \theta$ = 0.0242 ~~cm~~ (in.); <.08 cm (<1/32 in.) .03125

P_A .463 ~~cm~~ (in.) P_b .462 ~~cm~~ (in.)

D_t = .380 ~~cm~~ (in.)

Comments: calibrated on 9/12/83

Calibration required? ______ yes ✓ no

9'7" Probe Sheath No.2

TYPE S PITOT TUBE INSPECTION DATA FORM

Pitot tube assembly level? ✓ yes ______ no

Pitot tube openings damaged? ______ yes (explain below) ✓ no

α_1 = 2.5 ° (<10°), α_2 = 1.5 ° (<10°), β_1 = 4.0 ° (<5°),

β_2 = 2.5 ° (<5°)

γ = 1.5 °, θ = 1.5 °, A = .975 ~~cm~~ (in.)

$z = A \sin \gamma$ = 0.0255 cm (in.); <0.32 cm (<1/8 in.),

$w = A \sin \theta$ = 0.0255 cm (in.); <.08 cm (<1/32 in.)

P_A .487 ~~cm~~ (in.) P_b .488 ~~cm~~ (in.)

D_t = .379 ~~cm~~ (in.)

Comments: Calibrated on 9/12/83

Calibration required? ______ yes ✓ no

8' PROBE SHEATH NO. 4

TYPE S PITOT TUBE INSPECTION DATA FORM

Pitot tube assembly level? ✓ yes ______ no

Pitot tube openings damaged? ______ yes (explain below) ✓ no

α_1 = 0.5 ° (<10°), α_2 = 2.5 ° (<10°), β_1 = 0.0 ° (<5°),
β_2 = 0.5 ° (<5°)

γ = 0.5 °, θ = 1.5 °, A = 1.000 cm (in.)

z = A sin γ = 0.009 cm (in.); <0.32 cm (<1/8 in.),
w = A sin θ = 0.026 cm (in.); <.08 cm (<1/32 in.)

P_A 0.500 ~~cm~~ (in.) P_b 0.500 ~~cm~~ (in.)

D_t = 0.378 ~~cm~~ (in.)

Comments: Calibrated on 9/12/83

Calibration required? ______ yes ✓ no

8' PROBE SHEATH No. 5

TYPE S PITOT TUBE INSPECTION DATA FORM

Pitot tube assembly level? ✓ yes ______ no

Pitot tube openings damaged? ______ yes (explain below) ✓ no

α_1 = 0.5 ° (<10°), α_2 = 0.5 ° (<10°), β_1 = 0.0 ° (<5°),
β_2 = 0.5 ° (<5°)

γ = 3.5 °, θ = 1.5 °, A = 1.009 cm (in.)

$z = A \sin \gamma$ = 0.062 cm (in.); <0.32 cm (<1/8 in.),
$w = A \sin \theta$ = 0.026 cm (in.); <.08 cm (<1/32 in.)

P_A 0.505 cm (in.) P_b 0.504 cm (in.)

D_t = 0.378 cm (in.)

Comments: Calibrated on 9/12/83

Calibration required? ______ yes ✓ no

8' PROBE SHEATH NO. 6

TYPE S PITOT TUBE INSPECTION DATA FORM

Pitot tube assembly level? [✓ yes] ______ no

Pitot tube openings damaged? ______ yes (explain below) [✓ no]

α_1 = 0.5 ° (<10°), α_2 = 0.5 ° (<10°), β_1 = 0.0 ° (<5°),

β_2 = 0.5 ° (<5°)

γ = 0.5 °, θ = 1.0 °, A = .955 ~~cm~~ (in.)

$z = A \sin \gamma$ = 0.008 ~~cm~~ (in.); <0.32 cm (<1/8 in.),

$w = A \sin \theta$ = 0.017 ~~cm~~ (in.); <.08 cm (<1/32 in.)

P_A .478 ~~cm~~ (in.) P_b .477 ~~cm~~ (in.)

D_t = .379 ~~cm~~ (in.)

Comments: calibrated on 9/12/83 KO, PRI

Calibration required? ______ yes [✓ no]