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

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

AP-42 Section 12.2
Reference
Report Sect. 4
Reference 152

ENTROPY ENVIRONMENTALISTS, INC.

SPECIALISTS IN AIR POLLUTION MEASUREMENT & MANAGEMENT

STATIONARY SOURCE SAMPLING REPORT

17.9 tons of coal charge
Aug - Oct, 1978
my 114

WEIRTON STEEL

WEIRTON, WEST VIRGINIA

PARTICULATE EMISSIONS TESTING

COKE QUENCH TOWER STACK-BATTERY #8

SEPTEMBER 1980

P.O. Box 12291, Research Triangle Park, North Carolina 27709
Phone 919-781-3550

REPORT CERTIFICATION

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

Date September 17, 1980 Signature David W. Finley

David W. Finley

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

Date September 17, 1980 Signature D James Grove

D. James Grove, P. E.

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INTRODUCTION

Stationary source sampling was performed for Weirton Steel at their Weirton, West Virginia facilities on September 3-6, 1980. Testing was performed to determine the particulate emissions from the quench tower stack when just-pushed coke is quenched and when coke, partially quenched by the PECT hood, is quenched. Each day two simultaneous modified EPA Method 5 tests were performed. Plume color readings were also taken during each test. Mr. Steve Kraynak of Weirton Steel was present to coordinate the testing program.

Immediately following is the "Summary of Results" section which presents, in condensed form, the results from the runs. For a more detailed account, see Appendix A. A description of the source and an air flow schematic appears in the "Process Description and Operation" section. The last section, "Sampling and Analytical Procedures", briefly describes the sampling strategy used. For a detailed description of the equipment and procedures, refer to Appendix E. Pertinent calibration data is presented in Appendix F.

SUMMARY OF RESULTS

Table 1 summarizes the results of all particulate runs. The total stack emission rate was calculated by adding east-side and west-side emission rates together. Since each quench lasted two minutes, the emission rates as pounds per quench were calculated by dividing the pounds per hour by thirty quenches per hour. Individual runs are summarized in Tables 2, 3, 4 and 5.

The run numbers represent the day date of the test and the side of the quench tower which was tested.

The color of the plume for all quenches was white.

decree 5/80
11.58 lb/mesh

TABLE 1

CATCH WEIGHTS AND EMISSION RATES

WITH PECT HOOD	SEPTEMBER 3 MILLIGRAMS 3W	3E	POUNDS PER QUENCH 3W	3E	TOTAL	SEPTEMBER 5 MILLIGRAMS 5W	5E	POUNDS PER QUENCH 5W	5E	TOTAL
Probe plus filter rinsings	25.4	9.7	1.72	0.63	2.35	19.4	14.2	1.44	1.09	2.53
Cyclone	11.3	14.6	0.77	0.95	1.72	7.3	4.5	0.54	0.34	0.88
Filter	2.0	2.7	0.13	0.17	0.30	7.9	3.3	0.58	0.25	0.83
TOTAL RUN 4.31 ave	38.7	27.0	2.62	1.75	4.37	34.6	22.0	2.56	1.68	4.24

WITHOUT PECT HOOD	SEPTEMBER 4 MILLIGRAMS 4W	4E	POUNDS PER QUENCH 4W	4E	TOTAL	SEPTEMBER 6 MILLIGRAMS 6W	6E	POUNDS PER QUENCH 6W	6E	TOTAL
Probe plus filter rinsings	27.9	35.5	2.11	2.68	4.79	35.2	45.6	2.32	3.02	5.34
Cyclone	25.1	13.7	1.90	1.04	2.94	5.1	4.1	0.33	0.27	[illegible]
Filter	10.3	9.3	0.78	0.70	1.48	8.2	18.6	0.54	1.23	1.77
TOTAL RUN 8.46 ave	63.3	58.5	4.79	4.42	9.21	48.5	68.3	3.19	4.52	7.71

8.46 − 4.31 = 4.15 lb/quench difference

TABLE 2

PARTICULATE TESTS SUMMARY OF RESULTS

Quench Tower Stack

	3-W	3-E
DATE	9/ 3/80	9/ 3/80
STACK TEMPERATURE, DEG. F	132.	134.
STACK FLOW RATE SCFM* DRY	157719.	148020.
STACK FLOW RATE ACFM, WET	270762.	244127.
VOLUME OF GAS SAMPLED SCF* DRY	10.29	10.06
PERCENT ISOKINETIC	100.8	109.1
MODIFIED METHOD 5 RESULTS:		
MILLIGRAMS CATCH	38.7	27.0
GRAINS PER DSCF*	.0581	.0414
POUNDS PER QUENCH	2.62	1.75

* 68 DEG F, 29.92 IN. HG

TABLE 3

PARTICULATE TESTS SUMMARY OF RESULTS

Quench Tower Stack

	4-W	4-E
DATE	9/ 4/80	9/ 4/80
STACK TEMPERATURE, DEG. F	144.	136.
STACK FLOW RATE SCFM* DRY	161886.	162680.
STACK FLOW RATE ACFM, WET	284106.	275483.
VOLUME OF GAS SAMPLED SCF* DRY	9.433	9.496
PERCENT ISOKINETIC	101.3	105.4
MODIFIED METHOD 5 RESULTS:		
MILLIGRAMS CATCH	63.3	58.5
GRAINS PER DSCF*	.1036	.0951
POUNDS PER QUENCH	4.79	4.42

* 68 DEG F, 29.92 IN. HG

TABLE 4

PARTICULATE TESTS SUMMARY OF RESULTS

Quench Tower Stack

	5-W	5-E
DATE	9/ 5/80	9/ 5/80
STACK TEMPERATURE, DEG. F	144.	140.
STACK FLOW RATE SCFM* DRY	167695.	158718.
STACK FLOW RATE ACFM, WET	307942.	281820.
VOLUME OF GAS SAMPLED SCF* DRY	10.00	9.160
PERCENT ISOKINETIC	103.7	104.2
MODIFIED METHOD 5 RESULTS:		
MILLIGRAMS CATCH	34.6	22.0
GRAINS PER DSCF*	.0534	.0371
POUNDS PER QUENCH	2.56	1.68

* 68 DEG F, 29.92 IN. HG

TABLE 5

PARTICULATE TESTS SUMMARY OF RESULTS

Quench Tower Stack

	6-W	6-E
DATE	9/ 6/80	9/ 6/80
STACK TEMPERATURE, DEG. F	159.	139.
STACK FLOW RATE SCFM* DRY	164872.	176726.
STACK FLOW RATE ACFM, WET	295721.	299034.
VOLUME OF GAS SAMPLED SCF* DRY	11.06	11.77
PERCENT ISOKINETIC	103.6	106.9
MODIFIED METHOD 5 RESULTS:		
MILLIGRAMS CATCH	48.5	68.3
GRAINS PER DSCF*	.0677	.0896
POUNDS PER QUENCH	3.19	4.52

* 68 DEG F, 29.92 IN. HG

PROCESS DESCRIPTION AND OPERATION

At their Weirton, West Virginia plant, Weirton Steel produces coke for use in steel manufacturing. The coke is produced by heating coal in an air-tight oven. After the volatile compounds have been driven off the coal, the door machine moves into place and removes the oven door. Next, the door machine moves aside and aligns the coke guide with the coke oven. Hot coke is then pushed out of the oven and into the hot car for transport to the quench tower.

To control emissions during the pushing process, Weirton Steel has installed a PECT Hood on the door machine. When the door machine has aligned the coke guide, the PECT Hood is properly aligned over the hot car. As hot coke is pushed into the hot car, water is sprayed from the PECT Hood onto the coke to partially quench the coke.

Following pushing, whether the coke has been partially quenched or not quenched, the hot car moves to the quench tower and the coke is quenched with excess water. The steam rising from the hot car naturally drafts up the quench tower and out the stack. Each quench at the tower takes approximately two minutes.

All the coke quenched during testing was pushed from Number 8 battery.

SAMPLING AND ANALYTICAL PROCEDURES

When possible, the sampling and analytical procedures used were those generally recommended by the United States Environmental Protection Agency. Details of the equipment and procedures used are described in Appendix E, which is extracted from the Federal Register, August 18, 1977.

The stack cross section was divided into thirty-six equal areas with six sampling points on each of six traverse axes, as shown in Figures 1 and 2. To test all thirty-six sampling points in one day, two EPA Method 5 trains were run simultaneously. One train tested the eighteen points accessed from the east side of the stack, while the other train tested the eighteen points accessed from the west side of the stack. For each train, each of the eighteen points were sampled for two minutes for a total test time of thirty-six minutes. Since each quench lasted for approximately two minutes, one quench was sampled at each point. During the two minutes of sampling at each point, velocity readings with corresponding flow rate adjustments were made every thirty seconds. A complete test run is the combination of the two trains, covering the entire thirty-six points and eighteen separate quenches.

Due to process problems, only sixteen quenches were sampled on September 4 and 5 which resulted in thirty-two minute runs.

Velocity measurements were taken in accord with Method 2 criteria. The stack gas composition and dry molecular weight was assumed to be that of ambient air. Method 5, with the modification

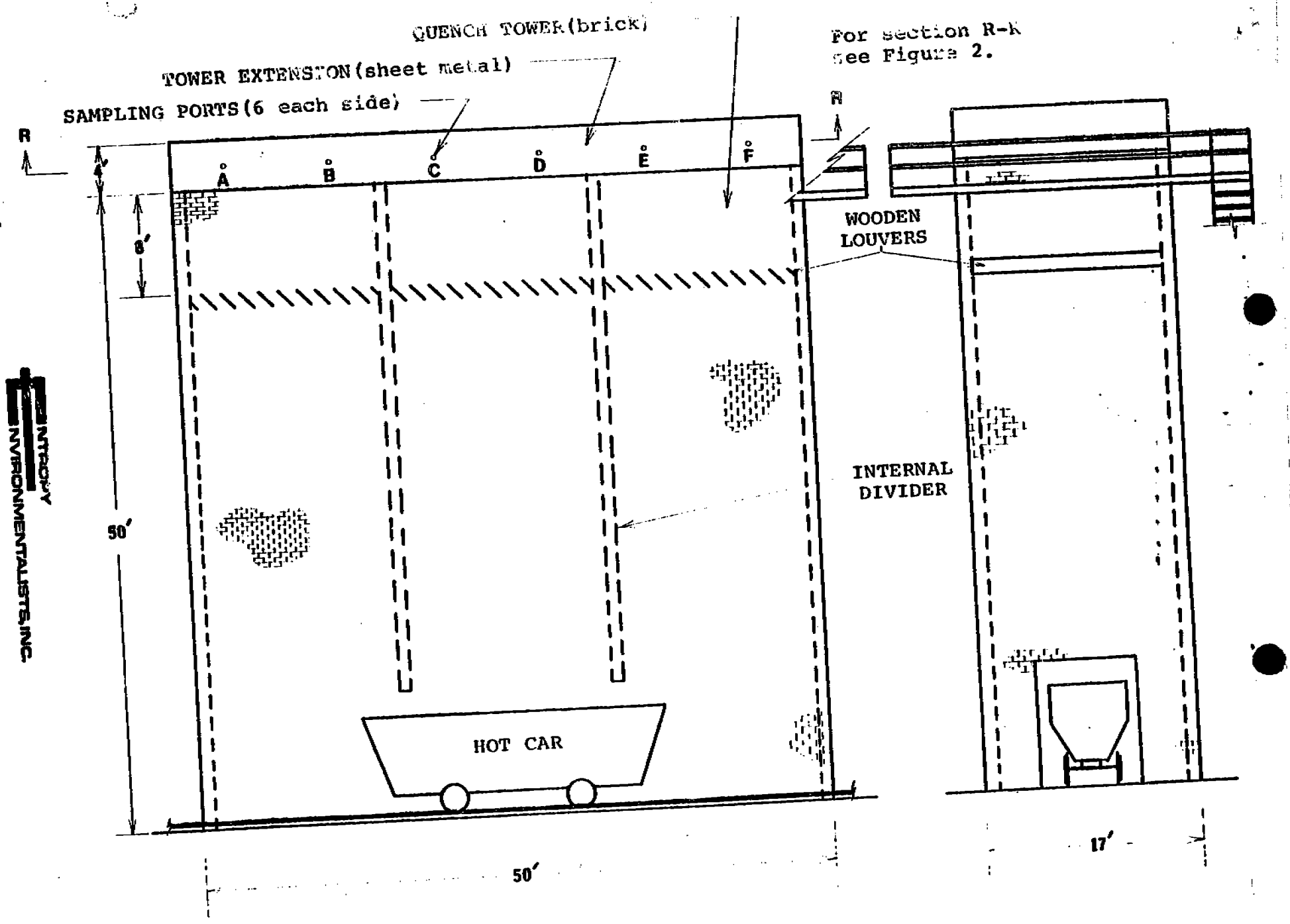

FIGURE 1. QUENCH TOWER DIMENSIONS AND SAMPLING PORT LOCATIONS

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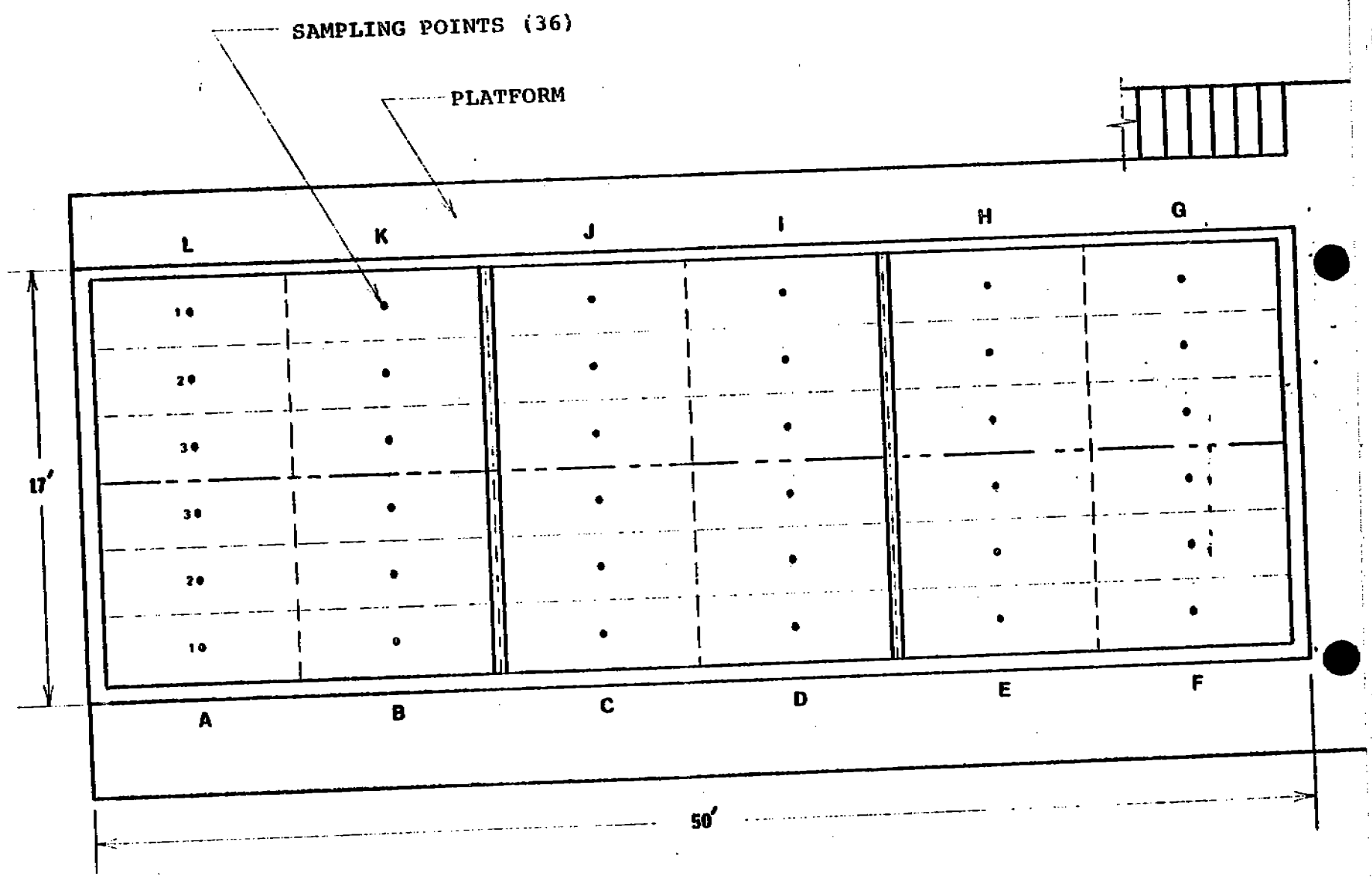

SECTION R-R

FIGURE 2. QUENCH TOWER CROSS-SECTION SHOWING EQUAL AREAS & SAMPLING POINT LOCATIONS

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discussed below, was used for particulate emission determinations. To separate the liquid water in the stack gases from the water vapor, the probe and filter holder were kept at the stack temperature, and a cyclone was placed immediately upstream of the filter.

All sampling equipment was manufactured by either Nutech Corporation or Entropy Environmentalists, Inc.

APPENDICES

APPENDIX A

(COMPUTER PRINTED)

PARTICULATE TESTS RESULTS

WITH EXAMPLE CALCULATIONS

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT: Weirton Steel, Weirton, West Virginia

TEST TEAM LEADER: Neill M. Harden & David W. Finley

RUN 3-W Quench Tower Stack, West-side

RUN 3-E Quench Tower Stack, East-side

		3-W	3-E
	RUN DATE	9/ 3/80	9/ 3/80
	RUN START TIME	1035	1035
	RUN FINISH TIME	1750	1750
	NET SAMPLING POINTS	18.	18.
TT	NET TIME OF RUN, MIN.	36.00	36.00
DN	SAMPLING NOZZLE DIA., IN.	.374	.367
CP	PITOT TUBE COEFFICIENT	.84	.84
Y	DRY GAS METER CAL. FACTOR	1.014	1.001
PB	BAROMETRIC PRESSURE, IN. HG.	29.30	29.30
PM	AVERAGE ORIFICE PRESSURE DROP, IN. H2O	.29	.25
VM	VOLUME OF DRY GAS SAMPLED CU. FT. @ METER COND.	10.904	10.767
TM	AVERAGE GAS METER TEMP. DEGREES F	96.	94.
VMSTD	VOLUME OF DRY GAS SAMPLED SCF *	10.286	10.061
VW	TOTAL H2O COLLECTED IN IMPINGERS & SIL. GEL, ML.	109.0	93.0
VWV	VOLUME OF WATER VAPOR, SCF *	5.13	4.38
PMV	PERCENT MOISTURE BY VOL.	33.3	30.3
MD	MOLE FRACTION DRY GAS	.667	.697

(continued next page)

		3-W	3-E
MWD	MOLECULAR WT-DRY STACK GAS	28.84	28.84
MW	MOLECULAR WT-STACK GAS	25.23	25.55
PSI	STATIC PRES OF STACK GAS IN. H2O	0.0	0.0
PS	STACK PRES, ABS., IN. HG.	29.30	29.30
TS	AVERAGE STACK TEMP. DEG F	132.	134.
DPS	AVERAGE VELOCITY HEAD OF STACK GAS, IN. H2O	.027	.022
VS	AVE STACK GAS VELOCITY, FPS	10.6	9.60
AS	STACK AREA, SQUARE INCHES	61200.	61200.
QS	STACK FLOW RATE, DRY SCFM*	157719.	148020.
QA	ACTUAL STACK FLOW RATE, ACFM	270762.	244127.
PERI	PERCENT ISOKINETIC	100.8	109.1
	MODIFIED METHOD 5 RESULTS:		
MGM	MILLIGRAMS CATCH	38.7	27.0
CAN	GRAINS PER DSCF*	.0581	.0414
CAW	POUNDS PER HOUR	78.50	52.54
CAWQ	POUNDS PER QUENCH	2.62	1.75

* 68 DEG F, 29.92 IN. HG

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50x17x144

ENTROPY ENVIRONMENTALISTS, INC.

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT: Weirton Steel, Weirton, West Virginia

TEST TEAM LEADER: Neill M. Harden & David W. Finley

RUN 4-W Quench Tower Stack, West-side

RUN 4-E Quench Tower Stack, East-side

		4-W	4-E
	RUN DATE	9/ 4/80	9/ 4/80
	RUN START TIME	1036	1036
	RUN FINISH TIME	1515	1515
	NET SAMPLING POINTS	16.	16.
TT	NET TIME OF RUN, MIN.	32.00	32.00
DN	SAMPLING NOZZLE DIA., IN.	.374	.367
CP	PITOT TUBE COEFFICIENT	.84	.84
Y	DRY GAS METER CAL. FACTOR	1.014	1.001
PB	BAROMETRIC PRESSURE, IN. HG.	29.10	29.10
PM	AVERAGE ORIFICE PRESSURE DROP, IN. H2O	.31	.30
VM	VOLUME OF DRY GAS SAMPLED CU. FT. @ METER COND.	10.032	10.360
TM	AVERAGE GAS METER TEMP. DEGREES F	94.	101.
VMSTD	VOLUME OF DRY GAS SAMPLED SCF *	9.433	9.496
VW	TOTAL H2O COLLECTED IN IMPINGERS & SIL. GEL, ML.	98.5	92.5
VWV	VOLUME OF WATER VAPOR, SCF *	4.64	4.35
PMV	PERCENT MOISTURE BY VOL.	33.0	31.4
MD	MOLE FRACTION DRY GAS	.670	.686

(continued next page)

		4-W	4-E
MWD	MOLECULAR WT-DRY STACK GAS	28.84	28.84
MW	MOLECULAR WT-STACK GAS	25.27	25.43
PSI	STATIC PRES OF STACK GAS IN. H2O	0.0	0.0
PS	STACK PRES, ABS., IN. HG.	29.10	29.10
TS	AVERAGE STACK TEMP. DEG F	144.	136.
DPS	AVERAGE VELOCITY HEAD OF STACK GAS, IN. H2O	.029	.028
VS	AVE STACK GAS VELOCITY, FPS	11.1	10.8
AS	STACK AREA, SQUARE INCHES	61200.	61200.
QS	STACK FLOW RATE, DRY SCFM*	161884.	162680.
QA	ACTUAL STACK FLOW RATE, ACFM	284106.	275483.
PERI	PERCENT ISOKINETIC	101.3	105.4
	MODIFIED METHOD 5 RESULTS:		
MGM	MILLIGRAMS CATCH	63.3	58.5
CAN	GRAINS PER DSCF*	.1036	.0951
CAW	POUNDS PER HOUR	143.70	132.56
CANQ	POUNDS PER QUENCH	4.79	4.42

* 68 DEG F, 29.92 IN. HG

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT: Weirton Steel, Weirton, West Virginia

TEST TEAM LEADER: Neill M. Harden & David W. Finley

RUN 5-W Quench Tower Stack, West-side

RUN 5-E Quench Tower Stack, East-side

		5-W	5-E
	RUN DATE	9/ 5/80	9/ 5/80
	RUN START TIME	1105	1105
	RUN FINISH TIME	1515	1515
	NET SAMPLING POINTS	16.	16.
TT	NET TIME OF RUN, MIN.	32.00	32.00
DN	SAMPLING NOZZLE DIA., IN.	.374	.367
CP	PITOT TUBE COEFFICIENT	.84	.84
Y	DRY GAS METER CAL. FACTOR	1.014	1.001
PB	BAROMETRIC PRESSURE, IN. HG.	29.00	29.00
PM	AVERAGE ORIFICE PRESSURE DROP, IN. H2O	.34	.26
VM	VOLUME OF DRY GAS SAMPLED CU. FT. @ METER COND.	10.693	9.939
TM	AVERAGE GAS METER TEMP. DEGREES F	95.	96.
VMSTD	VOLUME OF DRY GAS SAMPLED SCF *	10.003	9.160
VW	TOTAL H2O COLLECTED IN IMPINGERS & SIL. GEL, ML.	118.0	100.0
VWV	VOLUME OF WATER VAPOR, SCF *	5.55	4.71
PMV	PERCENT MOISTURE BY VOL.	35.7	33.9
MD	MOLE FRACTION DRY GAS	.643	.661

(continued next page)

		5-W	5-E
MWD	MOLECULAR WT-DRY STACK GAS	28.84	28.84
MW	MOLECULAR WT-STACK GAS	24.97	25.16
PSI	STATIC PRES OF STACK GAS IN. H2O	0.0	0.0
PS	STACK PRES, ABS., IN. HG.	29.00	29.00
TS	AVERAGE STACK TEMP. DEG F	144.	140.
DPS	AVERAGE VELOCITY HEAD OF STACK GAS, IN. H2O	.034	.029
VS	AVE STACK GAS VELOCITY, FPS	12.1	11.1
AS	STACK AREA, SQUARE INCHES	61200.	61200.
QS	STACK FLOW RATE, DRY SCFM*	167695.	158718.
QA	ACTUAL STACK FLOW RATE, ACFM	307942.	281820.
PERI	PERCENT ISOKINETIC	103.7	104.2
	MODIFIED METHOD 5 RESULTS:		
MGM	MILLIGRAMS CATCH	34.6	22.0
CAN	GRAINS PER DSCF*	.0534	.0371
CAW	POUNDS PER HOUR	76.73	50.43
CAWQ	POUNDS PER QUENCH	2.56	1.68

* 68 DEG F, 29.92 IN. HG

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT: Weirton Steel, Weirton, West Virginia

TEST TEAM LEADER: Neill M. Harden & David W. Finley

RUN 6-W Quench Tower Stack, West-side

RUN 6-E Quench Tower Stack, East-side

		6-W	6-E
	RUN DATE	9/ 6/80	9/ 6/80
	RUN START TIME	0835	0835
	RUN FINISH TIME	1512	1512
	NET SAMPLING POINTS	18.	18.
TT	NET TIME OF RUN, MIN.	36.00	36.00
DN	SAMPLING NOZZLE DIA., IN.	.374	.367
CP	PITOT TUBE COEFFICIENT	.84	.84
Y	DRY GAS METER CAL. FACTOR	1.014	1.001
PB	BAROMETRIC PRESSURE, IN. HG.	29.10	29.10
PM	AVERAGE ORIFICE PRESSURE DROP, IN. H2O	.47	.37
VM	VOLUME OF DRY GAS SAMPLED CU. FT. @ METER COND.	11.797	12.651
TM	AVERAGE GAS METER TEMP. DEGREES F	96.	93.
VMSTD	VOLUME OF DRY GAS SAMPLED SCF *	11.057	11.766
VW	TOTAL H2O COLLECTED IN IMPINGERS & SIL. GEL, ML.	114.5	112.5
VWV	VOLUME OF WATER VAPOR, SCF *	5.39	5.30
PMV	PERCENT MOISTURE BY VOL.	32.8	31.0
MD	MOLE FRACTION DRY GAS	.672	.690

(continued next page)

		6-W	6-E
MWD	MOLECULAR WT-DRY STACK GAS	28.84	28.84
MW	MOLECULAR WT-STACK GAS	25.29	25.47
PSI	STATIC PRES OF STACK GAS IN. H2O	0.0	0.0
PS	STACK PRES, ABS., IN. HG.	29.10	29.10
TS	AVERAGE STACK TEMP. DEG F	159.	139.
DPS	AVERAGE VELOCITY HEAD OF STACK GAS, IN. H2O	.031	.033
VS	AVE STACK GAS VELOCITY, FPS	11.6	11.7
AS	STACK AREA, SQUARE INCHES	61200.	61200.
QS	STACK FLOW RATE, DRY SCFM*	164872.	176726.
QA	ACTUAL STACK FLOW RATE, ACFM	295721.	299034.
PERI	PERCENT ISOKINETIC	103.6	106.9
	MODIFIED METHOD 5 RESULTS:		
MGM	MILLIGRAMS CATCH	48.5	68.3
CAN	GRAINS PER DSCF*	.0677	.0896
CAW	POUNDS PER HOUR	95.66	135.70
CAWQ	POUNDS PER QUENCH	3.19	4.52

* 68 DEG F, 29.92 IN. HG

EXAMPLE PARTICULATE CALCULATIONS TEST NO. 3-W

Quench Tower Stack

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

$$VMSTD = 17.64 * VM * Y * (PB+PM/13.6) / (TM+460)$$

$$VMSTD = \frac{17.64 * 10.904 * 1.014 * (29.30 + .290/13.6)}{556.0} = 10.286 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

$$VWV = .04707 * VW$$

$$VWV = .04707 * 109.0 = 5.130 \text{ SCF}$$

PERCENT MOISTURE IN STACK GAS

$$PMV = (100 * VWV)/(VMSTD+VWV)$$

$$PMV = \frac{100. * 5.13}{10.286 + 5.13} = 33.3 \text{ PERCENT}$$

MOLE FRACTION OF DRY STACK GAS

$$MD = (100.-PMV)/100.$$

$$MD = \frac{100.- 33.3}{100.} = .667$$

MOLECULAR WEIGHT OF STACK GAS

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

$$MW = 28.84 * .667 + 18 * (1- .667) = 25.23 \text{ LB/LB MOLE}$$

STACK GAS VELOCITY AT STACK CONDITIONS

$$VS = 85.49 * CP * SQRT[(DPS * (TS+460))/(PS * MW)]$$

$$VS = 85.49*.84 * SQRT[(.027 * 592.)/(29.30 * 25.23)] = 10.6 \text{ FPS}$$

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STACK GAS VOLUMETRIC FLOW AT STACK CONDITION

$$QA = VS * AS * 60 / 144$$

$$QA = 10.6 * 61200. * 60 / 144 = 270762. \text{ ACFM}$$

STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS

$$QS = (17.64 * QA * PS * MD) / (TS+460)$$

$$QS = \frac{17.64 * 270762. * 29.30 * .667}{592.0} = 157719. \text{ SCFM}$$

PERCENT ISOKINETIC

$$PERI = (17.3 * (TS+460) * VMSTD)/(VS * TT * PS * MD * DN * DN)$$

$$PERI = \frac{17.3 * 592. * 10.286}{10.6 * 36.0 * 29.30 * .667 * .374 * .374} = 100.8 \text{ PERCENT}$$

GRAINS PER DRY STANDARD CUBIC FOOT

$$CAN = 0.01543 * MGM/VMSTD$$

$$CAN = 0.01543 * (38.7 / 10.286) = .0581 \text{ GR/DSCF}$$

POUNDS PER HOUR

$$CAW = 60. * CAN * QS / 7000.$$

$$CAW = 60. * .0581 * 157719. / 7000. = 78.50 \text{ LBS/HR}$$

POUNDS PER QUENCH

$$CAWQ = CAW / 30.$$

$$CAWQ = 78.50 / 30. = 2.62$$

Preliminary Field Data

PLANT NAME Wauton steel

LOCATION Wauton WV

SAMPLING LOCATION

DUCT DEPTH
FROM INSIDE FAR WALL TO OUTSIDE OF PORT

NIPPLE LENGTH

DEPTH OF DUCT 102

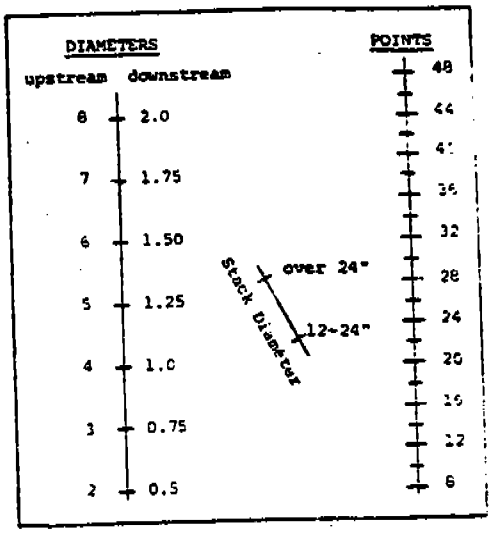
WIDTH (RECTANGULAR DUCT) ~~102~~

EQUIVALENT DIAMETER:

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

DISTANCE TO NEAREST FLOW DISTURBANCE:	UPSTREAM	DOWNSTREAM
FEET		
STACK DIAMETERS		

STACK AREA = (102)(600) = 61200 IN^2



Point	% OF DIAMETER	DISTANCE FROM INSIDE WALL	DISTANCE FROM OUTSIDE OF PORT
1	16.7	17 9/8	17 3/8
2	50.0	51.0	51.0
3	83.3	85.0	85.0
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			

LOCATION OF TRAVERSE POINTS IN CIRCULAR STACKS

	4	6	8	10	12	14	16	18	20	22	24
1	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3	75.0	29.6	19.4	14.6	11.9	9.9	8.5	7.5	6.7	6.0	5.5
4	93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5		85.4	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6		95.6	80.6	65.8	35.6	26.9	22.0	18.8	16.5	14.6	13.2
7			89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1
8			96.8	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9				91.8	82.3	73.1	62.5	38.2	30.6	26.2	23.0
10				97.4	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11					93.3	85.4	78.0	70.4	61.2	39.3	32.3
12					97.9	90.1	83.1	76.4	69.4	60.7	39.8
13						94.3	87.5	81.2	75.0	68.5	60.2
14						98.2	91.5	85.4	79.6	73.8	67.7
15							95.1	89.1	83.5	78.2	72.8
16							98.4	92.5	87.1	82.0	77.0
17								95.6	90.3	85.4	80.6
18								98.6	93.3	88.4	83.9
19									96.1	91.3	86.8
20									98.7	94.0	89.5
21										96.5	92.1
22										98.9	94.5
23											96.8
24											98.9

LOCATION OF TRAVERSE POINTS IN RECTANGULAR STACKS

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

[redacted]NTROPY
[redacted]NVIRONMENTALISTS, INC

Run # 3-W1

WEIRTON STEEL
WEIRTON, W. VA.
on QUENCH TOWER-WEST SIDE
30 Team Leader MF Technicians
sure, in. Hg 29.3 Static Pressure, in. H_2O
Leak Test Vacuum, in. Hg 15 4
Leak Rate, cu. ft./min. 0.007 0.013

Time Start 1035
Time Finish 1750

CHECKS
test
test
g System
@ 32 °F

IDENTIFICATION NUMBERS

Reagent Box 200 Nozzle 311 Diameter .374
Meter Box N-2 T/C Readout 03
Umbilical T/C Probe
Sample Box Orsat Pump
Probe S-5 Tedlar Bag

Tare
4504

NOMOGRAPH SET-UP Nomograph #

$\Delta H_@$ 1.61 C Factor .52
Meter Temp 97 Stack Temp 200
% Moisture 35 Ref. ΔP .20

POINTS
48
44
40
36
32
28
24
20
16
12
8
over 24"
12-24"
1/2 diameter

TANCE INSIDE WALL	DISTANCE FROM OUTSIDE OF PORT
3/8	17 3/8
1.0	51.0
30	85.0

Gas ter ing, Ft.	Pitot Reading (Δp), In. H_2O	Orifice Setting (ΔH), In. H_2O Ideal	Orifice Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F
.631	.015	.13	.13	89	1	130	65	93
	.01	.10	.10	90	1	130	65	90
	.01	.10	.10	90	1	130	65	88
	.01	.10	.10	90	1	130	65	87
537	.02	.175	.175	90	1	130	65	123
	.015	.13	.13	91	1	130	65	102
	.01	.10	.10	92	1	130	65	95
	.01	.10	.10	92	1	130	65	88
32	.026	.30	.30	94	2	130	65	125
	.015	.13	.13	96	1	130	65	106
	.015	.13	.13	96	1	130	65	88
	.01	.10	.10	96	1	130	65	87
62	.01	.10	.10	93	1	130	65	97
	.01	.10	.10	94	1	130	65	87
	.01	.10	.10	94	1	130	65	81
	.01	.10	.10	94	1	130	65	87
15	.02	.175	.175	94	1	130	65	108
	.025	.22	.22	94	1	130	65	97
	.01	.10	.10	94	1	130	65	92
	.01	.10	.10	94	1	130	65	88
86	.025	.22	.22	93	2	130	65	122
	.015	.13	.13	93	1	130	65	103
	.01	.10	.10	93	1	130	65	93
	.01	.10	.10	93	1	130	65	92

$\overline{(\sqrt{\Delta p})^2}$ $\overline{\Delta H}$ $\overline{T_m}$ $\overline{T_s}$

ENTROPY ENVIRONMENTALISTS, INC

Company Name WEIRTON STEEL Run # B 39-54

Sampling Location QUENCH TOWER-WEST SIDE Date 9-3-80

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice-Setting (ΔH), In. H_2O Ideal	Orifice-Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F
C 1	12/0	702.203	.026	.22	.22	93	2	150	65	158
	1/2		.02	.175	.175	93	2	150	65	145
	1		.025	.22	.22	93	2	150	65	129
	1 1/2		.025	.22	.22	93	2	150	65	124
2	17/0	703.260	.12	1.10	1.10	93	4	160	65	197
	1/2		.09	.81	.81	93	4	160	65	184
	1		.085	.76	.76	93	4	160	65	166
	1 1/2		.06	.54	.54	93	3	160	65	135
3	16/0	704.346	.10	.90	.90	93	4	170	65	197
	1/2		.075	.67	.67	94	4	170	65	188
	1		.065	.58	.58	94	4	170	65	156
	1 1/2		.04	.36	.36	94	3	170	65	135
D 1	18/0	705.256	.045	.40	.40	94	3	170	65	172
	1/2		.035	.30	.30	95	3	170	65	158
	1		.035	.30	.30	96	3	170	65	147
	1 1/2		.025	.22	.22	96	2	170	65	136
2	20/0	706.074	.13	1.18	1.18	92	4	170	65	195
	1/2		.10	.90	.90	92	3	170	65	182
	1		.07	.63	.63	92	3	170	65	154
	1 1/2		.055	.48	.48	92	2	170	65	135
3	12/0	707.112	.09	.81	.81	95	4	170	70	190
	1/2		.08	.72	.72	95	4	170	70	178
	1		.06	.54	.54	95	3	170	70	156
	1 1/2		.03	.265	.265	96	3	170	70	128
F 1	24/0	707.696	.025	.22	.22	96	2	170	70	116
	1/2		.02	.175	.175	96	2	170	70	103
	1		.015	.13	.13	96	1	170	70	97
	1 1/2		.01	.10	.10	96	1	170	70	94
2	26/0	708.425	.025	.22	.22	96	2	160	70	173
	1/2		.02	.175	.175	96	1	160	70	165
	1		.02	.175	.175	96	1	160	70	159
	1 1/2		.02	.175	.175	96	1	160	70	124
3	28/0	709.022	.04	.36	.36	99	2	160	65	169
	1/2		.035	.30	.30	100	2	160	65	160
	1		.03	.265	.265	101	2	160	65	148
	1 1/2		.025	.22	.22	102	2	160	65	130
F 1	30/0	709.669	.02	.175	.175	103	2	150	65	169
	1/2		.015	.13	.13	103	1	150	65	153
	1		.015	.13	.13	104	1	150	65	125
	1 1/2		.01	.10	.10	104	1	150	65	116

V_m $(\sqrt{\Delta p})^2$ $\overline{\Delta H}$ $\overline{T_m}$ $\overline{T_s}$

ENTROPY ENVIRONMENTALISTS, INC

Company Name WEIRTON STEEL Run # 82 39-54

Sampling Location QUENCH TOWER-WEST SIDE Date 9-3-80

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice Setting (ΔH), In. H_2O Ideal	Orifice Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F
2	32/0	710.108	.02	.175	.175	103	2	150	65	158
	½		.015	.13	.13	103	1	150	65	162
	1		.015	.13	.13	103	1	150	65	157
	1½		.01	.10	.10	103	1	150	65	126
3	34/0	710.563	.02	.175	.175	102	1	145	65	863
	½		.015	.13	.13	102	1	145	65	135
	1		.015	.13	.13	102	1	145	65	137
	1½		.02	.175	.175	102	1	145	65	125
	36/FINAL	711.035								

10.904 / V_m .02726 / $(\sqrt{\Delta p})^2$ .2866 / $\overline{\Delta H}$ 96 / $\overline{T_m}$ 132 / $\overline{T_s}$

ENTROPY ENVIRONMENTALISTS, INC

Run # 3-E

Company Name Western Steel — Time Start ____
Address Western WV — Time Finish ____
Sampling Location Quench Tower
Date 9/3/80 — Team Leader DE. — Technicians ____
Barometric Pressure, in. Hg 29.0 — Static Pressure, in. H_2O ____
Sampling Train Leak Test Vacuum, in. Hg 15
Sampling Train Leak Rate, cu. ft./min. .000

EQUIPMENT CHECKS

- Pitots, pre-test
- Pitots, post-test
- Orsat Sampling System
- Tedlar Bag
- Thermocouple @ ____ °F

IDENTIFICATION NUMBERS

Reagent Box —
Meter Box W-4
Umbilical ____
Sample Box 16
Probe 7-1
Nozzle 310 Diameter .367
T/C Readout 3
T/C Probe ____
Orsat Pump ____
Tedlar Bag ____

Filter #	Tare
7037	.4355

NOMOGRAPH SET-UP Nomograph # ____

$\Delta H_@$ 1.80 — C Factor .58
Meter Temp 110 — Stack Temp 200
% Moisture 35 — Ref. ΔP .19

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice Setting (ΔH), In. H_2O Ideal	Orifice Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F	
	0/0	484.130	.01	.10	.10	88	1	150	60	68	94
	30		.01	.10	.10	88	1	150	60	68	
	60		.01	.10	.10	88	1	150	60	68	
	90		.01	.10	.10	88	1	150	60	68	
	100/0	488.580	.01	.10	.10	92	1	150	60	70	96
	30		.01	.10	.10	96	1	150	60	70	
	60		.01	.10	.10	96	1	150	60	70	
	90		.01	.10	.10	96	1	150	60	70	
	200/0	492.974	.01	.10	.10	90	1	150	60	72	98
	30		.01	.10	.10	90	1	150	60	72	
	60		.01	.10	.10	90	1	150	60	72	
	90		.01	.10	.10	90	1	150	60	72	
	300/0	498.405	.01	.10	.10	92	1	150	60	74	109
	30		.01	.10	.10	92	1	150	60	74	
	60		.01	.10	.10	92	1	150	60	74	
	90		.01	.10	.10	92	1	150	60	74	
	400/0	503.884	.01	.10	.10	93	1	150	60	74	109
	30		.01	.10	.10	93	1	150	60	74	
	60		.01	.10	.10	93	1	150	60	74	
	90		.01	.10	.10	93	1	150	60	75	
	500/0	484.335	.01	.10	.10	95	1	150	60	75	106
	30		.01	.10	.10	94	1	150	60	75	
	60		.01	.10	.10	94	1	150	60	75	
	90		.01	.10	.10	94	1	150	60	75	

V_m — $\overline{(\sqrt{\Delta p})^2}$ — $\overline{\Delta H}$ — $\overline{T_m}$ — $\overline{T_s}$

ENTROPY ENVIRONMENTALISTS, INC

Company Name Winton Steel — Run # 55-72

Sampling Location _____ — Date 9/3/80

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice - Setting (ΔH), In. H_2O Ideal	Orifice - Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F	
	120/0	484.775	.01	.10	.10	94	1	150	60	75	
	30		.07	.10	.10	94	1	150	60	75	132
	60		.07	.10	.10	94	1	150	60	75	
	90		.01	.10	.10	94	1	150	60	76	
	120/0	485.200	.01	.10	.10	94	1	150	60	76	
	30		.01	.10	.10	94	1	150	60	76	155
	60		.01	.10	.10	94	1	150	60	76	
	90		.01	.10	.10	94	1	150	60	76	
	120/0	485.650	.01	.10	.10	94	1	150	60	76	
	30		.05	.46	.46	94	2	150	60	76	151
	60		.01	.10	.10	94	2	150	60	76	
	90		.01	.10	.10	94	2	150	60	76	
	120/0	496.241	.01	.10	.10	93	2	150	60	76	
	30		.03	.28	.28	93	2	150	60	76	137
	60		.01	.10	.10	93	2	150	60	76	
	90		.01	.10	.10	93	2	150	60	76	
	120/0	496.715	.01	.10	.10	93	2	150	60	77	
	30		.05	.46	.46	93	2	150	60	77	165
	60		.03	.28	.28	93	2	150	60	77	
	90		.01	.10	.10	93	2	150	60	77	
	120/0	497.330	.01	.10	.10	95	2	150	60	80	
	30		.06	.56	.56	95	2	150	60	80	168
	60		.04	.38	.38	95	2	150	60	80	
	90		.03	.28	.28	95	2	150	60	80	
	120/0	498.033	.01	.10	.10	97	2	150	60	80	
	30		.07	.68	.68	97	4	150	60	80	150
	60		.05	.46	.46	97	4	150	60	80	
	90		.04	.38	.38	97	4	150	60	80	
	120/0	498.729	.07	.68	.68	97	4	150	60	80	
	30		.06	.56	.56	97	4	150	60	80	146
	60		.05	.46	.46	97	4	150	60	80	
	90		.03	.28	.28	97	4	150	60	80	
	120/0	499.593	.04	.38	.38	97	4	150	60	80	
	30		.07	.68	.68	97	4	150	60	80	150
	60		.06	.56	.56	97	4	150	60	80	
	90		.04	.38	.38	97	4	150	60	80	
	120/0	500.136	.03	.28	.28	97	4	150	60	80	
	30		.07	.68	.68	97	4	150	60	80	150
	60		.05	.46	.46	97	4	150	60	80	
	90		.03	.28	.28	97	4	150	60	80	

V_m $(\sqrt{\Delta p})^2$ $\overline{\Delta H}$ $\overline{T_m}$ $\overline{T_s}$

ENTROPY ENVIRONMENTALISTS, INC

Company Name Weirton Steel Run # 55-72

Sampling Location _____ Date 9/3/80

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice - Setting (ΔH), In. H_2O Ideal	Orifice - Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F
	12/0	491.168	.03	.28	.28	96	2	150	60	81
	5	"	.07	.63	.68	96	2	150	60	81
P/A	10	"	.06	.56	.56	96	2	150	60	81
	40	"	.04	.35	.38	96	2	150	60	81
	12/0	492.028	.07	.60	.68	96	2	150	60	81
	30	"	.07	.68	.68	96	2	150	60	81
	40	"	.06	.56	.56	96	2	150	60	81
	50	"	.03	.28	.28	96	2	150	60	81
	12/100	492.897								

151

138

$\frac{10.767}{V_m}$ $\frac{.0242}{(\sqrt{\Delta p})^2}$ $\frac{.253}{\overline{\Delta H}}$ $\frac{94}{\overline{T_m}}$ $\frac{134}{\overline{T_s}}$

ENTROPY ENVIRONMENTALISTS, INC

Run # 4-W

Company Name WEIRTON STEEL — Time Start 1036
Address WEIRTON, W. VA. — Time Finish 1515
Sampling Location QUENCH TOWER-WEST SIDE
Date 9-4-80 — Team Leader - MT. — Technicians
Barometric Pressure, in. Hg 29.10 — Static Pressure, in H_2O 0
Sampling Train Leak Test Vacuum, in. Hg 15 — 6 (0) — 4 (F)
Sampling Train Leak Rate, cu. ft./min. 0.006 — 0.003 — 0.002

EQUIPMENT CHECKS

- ✓ Pitots, pre-test
- ___ Pitots, post-test
- ___ Orsat Sampling System
- ___ Tedlar Bag
- ✓ Thermocouple @ 32 °F

IDENTIFICATION NUMBERS

Reagent Box ___ — Nozzle .311 — Diameter .374
Meter Box N-2 — T/C Readout 03
Umbilical ___ — T/C Probe ___
Sample Box ___ — Orsat Pump ___
Probe S-5 — Tedlar Bag ___

Filter #	Tare
7040	.4490

NOMOGRAPH SET-UP — Nomograph # ___

$\Delta H_@$ 1.61 — C Factor .51
Meter Temp 95 — Stack Temp 175
% Moisture 35 — Ref. ΔP .20

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice Setting (ΔH), In. H_2O Ideal	Orifice Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F
A 1	0	711.395	.01	.10	.10	93	1	125	65	116
	½		.01	.10	.10	93	1	125	65	90
	1		.01	.10	.10	93	1	125	65	79
	1½		.01	.10	.10	93	1	125	65	75
2	2/0	711.785	.015	.13	.13	89	1	125	65	106
	½		.015	.13	.13	89	1	125	65	115
	1		.01	.10	.10	89	1	125	65	97
	1½		.01	.10	.10	89	1	125	65	94
3	4/0	712.187	.03	.265	.265	91	1	125	65	122
	½		.015	.13	.13	91	1	125	65	105
	1		.01	.10	.10	91	1	125	65	95
	1½		.01	.10	.10	91	1	125	65	93
B 1	6/0	712.657	.015	.13	.13	94	1	125	65	119
	½		.01	.10	.10	94	1	125	65	106
	1		.01	.10	.10	94	1	125	65	98
	1½		.01	.10	.10	94	1	125	65	98
2	8/0	713.070	.04	.36	.36	93	2	130	65	147
	½		.035	.30	.30	93	2	130	65	128
	1		.02	.175	.175	93	1	130	65	107
	1½		.015	.13	.13	93	1	130	65	101
3	10/0	713.650	.046	.40	.40	89	2	130	70	161
	½		.04	.36	.36	89	2	130	70	128
	1		.02	.175	.175	89	1	130	70	120
	1½		.02	.175	.175	89	1	130	70	99

V_m — $\overline{(\sqrt{\Delta p})^2}$ — $\overline{\Delta H}$ — $\overline{T_m}$ — $\overline{T_s}$

ENTROPY ENVIRONMENTALISTS, INC

Run # 75-90

Company Name WEIRTON STEEL

Date 9-4-80

Sampling Location QUENCH TOWER-WEST SIDE

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice Setting (ΔH), In. H_2O Ideal	Orifice Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F
C 1	12/0	714.287	.04	.36	.36	94	2	150	65	178
	½		.035	.30	.30	95	2	150	65	124
	1		.045	.40	.40	95	2	150	65	160
	1½		.03	.265	.265	96	2	150	65	142
2	14/0	715.000	.10	.90	.90	98	3	160	65	196
	½		.085	.76	.76	98	3	160	65	178
	1		.075	.67	.67	98	3	160	65	167
	1½		.05	.45	.45	98	2	160	65	148
3	16/0	715.961	.11	.98	.98	96	3	170	65	203
	½		.10	.90	.90	96	3	170	65	194
	1		.085	.76	.76	96	2	170	65	187
	1½		.06	.54	.54	96	2	170	65	162
D 1	18/0	717.000	.05	.45	.45	94	2	165	65	189
	½		.05	.45	.45	94	2	165	65	178
	1		.035	.30	.30	94	2	165	65	167
	1½		.035	.30	.30	94	2	165	65	152
2	20/0	717.256	.10	.90	.90	94	3	160	65	188
	½		.08	.72	.72	94	2	160	65	177
	1		.06	.54	.54	94	2	160	65	167
	1½		.05	.45	.45	94	2	160	65	137
3	22/0	718.709	.10	.90	.90	96	3	160	65	203
	½		.09	.81	.81	96	3	160	65	192
	1		.07	.63	.63	96	2	160	65	180
	1½		.05	.45	.45	96	2	160	65	154
E 1	24/0	719.674	.01	.10	.10	96	1	150	65	169
	½		.01	.10	.10	96	1	150	65	148
	1		.01	.10	.10	96	1	150	65	144
	1½		.01	.10	.10	96	1	150	65	139
2	26/0	720.150	.015	.13	.13	97	1	150	65	182
	½		.01	.10	.10	97	1	150	65	176
	1		.01	.10	.10	97	1	150	65	159
	1½		.01	.10	.10	97	1	150	65	141
3	28/0	720.573	.03	.265	.265	97	2	150	65	181
	½		.025	.22	.22	98	1	150	65	176
	1		.02	.175	.175	98	1	150	65	165
	1½		.01	.10	.10	98	1	150	65	130
F 1	30/0	721.100	.01	.10	.10	98	1	140	65	122
	½		.01	.10	.10	98	1	140	65	135
	1		.01	.10	.10	98	1	140	65	138
	1½		.01	.10	.10	98	1	140	65	112
	32/FINAL	721.485								

$\frac{10.032}{V_m}$ $\frac{.02933}{(\sqrt{\Delta p})^2}$ $\frac{.3146}{\overline{\Delta H}}$ $\frac{94}{\overline{T_m}}$ $\frac{144}{\overline{T_s}}$

ENTROPY ENVIRONMENTALISTS, INC

Run # 4-E

Company Name Weirton Steel — Time Start 1036
Address Weirton WV — Time Finish 1515
Sampling Location Queen Stack
Date 9/11/90 — Team Leader DE — Technicians
Barometric Pressure, in. Hg 29.10 — Static Pressure, in. H_2O 0
Sampling Train Leak Test Vacuum, in. Hg 15 6
Sampling Train Leak Rate, cu. ft./min. .000 .000

EQUIPMENT CHECKS

- ✓ Pitots, pre-test
- ~~Pitots~~, post-test
- Orsat Sampling System
- Tedlar Bag
- Thermocouple @ ____ °F

IDENTIFICATION NUMBERS

Reagent Box —
Meter Box N-4
Umbilical —
Sample Box 16
Probe 72
Nozzle 310 Diameter .367
T/C Readout 3
T/C Probe —
Orsat Pump —
Tedlar Bag —

Filter #	Tare
7041	4410

NOMOGRAPH SET-UP Nomograph # ____

$\Delta H_@$ 1.80 C Factor ~~.84~~ .62
Meter Temp ~~100~~ 100 Stack Temp 200
% Moisture ~~35~~ 30 Ref. ΔP ~~.44~~ .20

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice Setting (ΔH), In. H_2O Ideal	Orifice Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F	
	0/0	443.015	.01	.10	.10	94	1	150	60	70	
V	30		.01	.10	.10	94	1	150	60	70	72
P-1	60	P 0.84 SP 1.0	.01	.10	.10	94	1	150	60	70	
	90		.01	.10	.10	94	1	150	60	70	
	100/0	443.412	.01	.10	.10	94	1	150	60	71	
V	30	L	.01	.10	.10	94	1	150	60	71	12
P-4	60	P 0.84 SP 1.0	.01	.10	.10	94	1	150	60	71	
	90		.01	.10	.10	94	1	150	60	71	
	100/0	443.539	.01	.10	.10	96	1	150	60	75	
V	30	N	.01	.10	.10	96	1	150	60	75	12
P-3	60	P 0.84 SP 1.0	.01	.10	.10	96	1	150	60	75	
	90		.01	.10	.10	97	1	150	60	76	
	100/0	444.361	.01	.10	.10	97	1	150	60	76	
V	30	L	.01	.10	.10	97	1	150	60	76	12
P-2	60	P 0.84 SP 1.0	.01	.10	.10	97	1	150	60	76	
	90		.01	.10	.10	97	1	150	60	76	
	100/0	444.820	.01	.10	.10	98	1	150	60	78	
V	30	L	.01	.10	.10	98	1	150	60	74	13
P-5	60	P 0.84 SP 1.0	.01	.10	.10	98	1	150	60	78	
	90		.01	.10	.10	98	1	150	60	77	
	100/0	445.327	.03	.27	.27	98	1	150	60	80	
V	30	L	.01	.10	.10	98	1	150	60	80	14
P-6	60	P 0.84 SP 1.0	.01	.10	.10	98	1	150	60	80	
	90		.01	.10	.10	98	1	150	60	80	

V_m $\overline{(\sqrt{\Delta p})^2}$ $\overline{\Delta H}$ $\overline{T_m}$ $\overline{T_s}$

ENTROPY ENVIRONMENTALISTS, INC

Company Name Winton Steel Run # 91-108

Sampling Location Quartz tower Date 9/4/80

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice Setting (ΔH), In. H_2O Ideal	Orifice Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F	
Pt 9	120/0	495.790	.03	.26	.26	105	1	150	60	82	152
	30		.03	.26	.26	105	1	150	60	82	
	60	D002 1300	.02	.18	.18	105	1	150	60	82	
	90		.01	.10	.10	105	1	150	60	82	
Pt 10	120/0	496.881	.03	.26	.26	103	1	150	60	84	145
	30		.03	.26	.26	103	1	150	60	84	
	60	D002 1325	.02	.18	.18	103	1	150	60	84	
	90		.02	.18	.18	103	1	150	60	84	
Pt 11	120/0	496.990	.03	.26	.26	102	1	150	60	84	150
	30		.08	.72	.72	102	4	150	60	84	
	60	D002 1335	.08	.72	.72	102	4	150	60	84	
	90		.03	.26	.26	102	1	150	60	84	
Pt 12	120/0	497.700	.03	.26	.26	102	1	150	60	85	142
	30		.03	.26	.26	102	1	150	60	85	
	60	D002 1410	.03	.26	.26	102	1	150	60	85	
	90		.02	.26	.26	102	1	150	60	85	
Pt 13	120/0	498.353	.03	.26	.26	103	1	150	60	86	143
	30		.03	.26	.26	103	1	150	60	86	
	60	D002 1422	.02	.18	.18	103	1	150	60	86	
	90		.02	.18	.18	103	1	150	60	86	
Pt 14	120/0	498.930	.03	.26	.26	103	1	150	60	86	143
	30		.07	.62	.62	103	1	150	60	86	
	60	D002 1440	.07	.62	.62	103	1	150	60	86	
	90		.04	.36	.36	103	1	150	60	86	
Pt 15	120/0	499.700	.03	.26	.26	104	1	150	60	85	129
	30		.08	.72	.72	104	1	150	60	85	
	60	D002 1448	.08	.72	.72	104	1	150	60	85	
	90		.03	.26	.26	104	1	150	60	85	
Pt 16	120/0	500.589	.03	.26	.26	104	1	150	60	85	133
	30		.10	.90	.90	104	4	150	60	85	
	60	D002 1500	.10	.90	.90	104	4	150	60	85	
	90		.03	.26	.26	104	1	150	60	85	
Pt 17	120/0	501.496	.03	.26	.26	104	1	150	60	85	129
	30		.10	.90	.90	104	4	150	60	85	
	60	D002 1508	.10	.90	.90	104	4	150	60	85	
	90		.04	.36	.36	104	1	150	60	85	
Pt 18	120/0	502.400	.10	.90	.90	104	4	150	60	85	125
	30		.10	.90	.90	104	4	150	60	85	
	60	D002 1515	.05	.45	.45	104		150	60	85	
	90		.03	.26	.26	104		150	60	85	
		503.375									

10.360 V_m .02806 $(\overline{\sqrt{\Delta p}})^2$ .2997 $\overline{\Delta H}$ 101 $\overline{T_m}$ 136 $\overline{T_s}$

PARTICULATE FIELD DATA

Run # 5-W

Company Name WEIRTON STEEL — Time Start 1105
Address WEIRTON, W. VA. — Time Finish 1515
Sampling Location QUENCH TOWER-WEST SIDE
Date 9-5-80 — Team Leader MK — Technicians
Barometric Pressure, in. Hg 29.0 — Static Pressure, in. H_2O 0
Sampling Train Leak Test Vacuum, in. Hg 15 — 8 — 4
Sampling Train Leak Rate, cu. ft./min. 0.003 — 0.003 — 0.003

EQUIPMENT CHECKS

- ✓ Pitots, pre-test
- ___ Pitots, post-test
- ___ Orsat Sampling System
- ___ Tedlar Bag
- ✓ Thermocouple @ 32 °F

IDENTIFICATION NUMBERS

Reagent Box ___ — Nozzle .311 — Diameter .374
Meter Box N-2 — T/C Readout ___
Umbilical ___ — T/C Probe ___
Sample Box ___ — Orsat Pump ___
Probe S-S — Tedlar Bag ___

Filter #	Tare
7042	.4487

NOMOGRAPH SET-UP — Nomograph # ___

$\Delta H_@$ 1.61 — C Factor .51
Meter Temp 95 — Stack Temp 175
% Moisture 35 — Ref. ΔP .20

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice Setting (ΔH), In. H_2O Ideal	Orifice Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F
A 1	0	721.893	.01	.10	.10	96	1	130	70	115
	½		.01	.10	.10	96	1	130	70	100
	1		.01	.10	.10	96	1	130	70	86
	1½		.015	.13	.13	96	1	130	70	88
2	2/0	722.192	.04	.36	.36	96	1	130	70	125
	½		.02	.175	.175	96	1	130	70	114
	1		.015	.13	.13	96	1	130	70	106
	1½		.015	.13	.13	96	1	130	70	103
3	4/0	722.721	.05	.45	.45	96	2	130	70	135
	½		.025	.30	.30	95	1	130	70	114
	1		.025	.22	.22	95	1	130	70	112
	1½		.02	.175	.175	95	1	130	70	107
B 1	6/0	723.370	.015	.13	.13	94	1	130	70	98
	½		.02	.175	.175	94	1	130	70	119
	1		.015	.13	.13	94	1	130	70	119
	1½		.02	.175	.175	94	1	130	70	106
2	8/0	723.843	.04	.36	.36	95	2	130	70	146
	½		.03	.26	.26	95	1	130	70	126
	1		.02	.175	.175	95	1	130	70	118
	1½		.02	.175	.175	95	1	130	70	105
3	10/0	724.453	.045	.40	.40	94	2	130	70	144
	½		.025	.22	.22	94	1	130	70	124
	1		.02	.175	.175	94	1	130	70	102
	1½		.015	.13	.13	94	1	130	70	98

V_m — $(\sqrt{\Delta p})^2$ — $\overline{\Delta H}$ — $\overline{T_m}$ — $\overline{T_s}$

ARTICULATE FIELD DATA

page 2

Company Name WEIRTON STEEL Run # 109-126

Sampling Location QUENCH TOWER-WEST SIDE Date 9-5-80

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice Setting (ΔH), In. H_2O Ideal	Orifice Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F
C 1	12/0	725.026	.03	.265	.265	95	1	140	70	184
	½		.035	.30	.30	95	1	140	70	180
	1		.03	.265	.265	95	1	140	70	149
	1½		.03	.265	.265	95	1	140	70	124
2	14/0	725.638	.11	.98	.98	95	3	155	65	195
	½		.08	.72	.72	95	2	155	65	186
	1		.075	.67	.67	95	2	155	65	169
	1½		.035	.30	.30	95	1	155	65	138
3	16/0	726.668	.085	.76	.76	95	2	165	65	186
	½		.075	.67	.67	95	2	165	65	178
	1		.06	.54	.54	95	2	165	65	166
	1½		.04	.36	.36	95	1	165	65	143
D 1	18/0	727.589	.045	.40	.40	96	1	165	65	182
	½		.095	.40	.40	97	1	165	65	175
	1		.045	.40	.40	97	1	165	65	158
	1½		.025	.22	.22	97	1	165	65	135
2	20/0	728.303	.12	1.10	1.10	96	3	165	65	200
	½		.09	.81	.81	96	2	165	65	186
	1		.07	.63	.63	96	2	165	65	156
	1½		.07	.63	.63	96	2	165	65	155
3	22/0	729.342	.09	.81	.81	95	2	165	65	201
	½		.095	.85	.85	95	2	165	65	187
	1		.075	.67	.67	95	2	165	65	170
	1½		.04	.36	.36	95	1	165	65	142
E 1	24/0	730.323	.02	.175	.175	95	1	160	65	161
	½		.015	.13	.13	95	1	160	70	155
	1		.015	.13	.13	94	1	160	70	144
	1½		.01	.10	.10	94	1	160	70	123
2	26/0	730.834	.025	.22	.22	95	1	145	65	182
	½		.025	.22	.22	95	1	145	65	163
	1		.02	.175	.175	95	1	145	65	159
	1½		.025	.22	.22	96	1	145	65	128
3	28/0	731.382	.05	.45	.45	96	1	155	65	173
	½		.05	.45	.45	96	1	155	65	166
	1		.04	.36	.36	96	1	155	65	157
	1½		.03	.265	.265	96	1	155	65	130
F 1	30/0	732.126	.02	.175	.175	95	1	140	65	169
	½		.01	.10	.10	96	1	140	65	155
	1		.015	.13	.13	96	1	140	65	145
	1½		.015	.13	.13	96	1	140	65	132
	32/FWA	732.586								

LT. ① 730.373

V_m	$(\sqrt{\Delta p})^2$	$\overline{\Delta H}$	$\overline{T_m}$	$\overline{T_s}$
10.693	.03394	.3373	95	144

PARTICULATE FIELD DATA

Run # 5-E

Company Name Weirton Steel — Time Start 1105
Address Weirton WV — Time Finish 1515
Sampling Location Dutch tower
Date 9/5/80 — Team Leader DF — Technicians
Barometric Pressure, in. Hg 29.0 — Static Pressure, in. H_2O
Sampling Train Leak Test Vacuum, in. Hg 15 10
Sampling Train Leak Rate, cu. ft./min. .000 .000

EQUIPMENT CHECKS

- ✓ Pitots, pre-test
- ✓ Pitots, post-test
- ✓ Orsat Sampling System
- ✓ Tedlar Bag
- ✓ Thermocouple @ ____ °F

IDENTIFICATION NUMBERS

Reagent Box —
Meter Box W-4
Umbilical —
Sample Box 16
Probe 7-2
Nozzle 310 — Diameter .367
T/C Readout 3
T/C Probe —
Orsat Pump —
Tedlar Bag —

Filter #	Tare
7044	.4458

NOMOGRAPH SET-UP — Nomograph #

$\Delta H_@$ 1.80
Meter Temp 100
% Moisture 30
C Factor .62
Stack Temp 200
Ref. ΔP .20

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice Setting (ΔH), In. H_2O Ideal	Orifice Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F	
Pitot 1	0/0	503.516	.01	.10	.10	80	1	150	60	74	131
	30		.01	.10	.10	80	1	150	60	74	
	60	DOO 38 11:05	.01	.10	.10	80	1	150	60	74	
	90		.01	.10	.10	80	1	150	60	74	
	120/0	504.075	.01	.10	.10	85	1	150	60	76	133
Pitot 2	30		.01	.10	.10	85	1	150	60	76	
	60	DOO 1 11:18	.01	.10	.10	85	1	150	60	76	
	90		.01	.10	.10	85	1	150	60	76	
	120/0	504.505	.01	.10	.10	88	1	150	60	76	137
Pitot 3	30		.01	.10	.10	88	1	150	60	76	
	60	DOO 11 11:30	.01	.10	.10	88	1	150	60	76	
	90		.01	.10	.10	88	1	150	60	76	
	120/0	504.945	.01	.10	.10	90	1	150	60	77	134
Pitot 4	30		.01	.10	.10	90	1	150	60	77	
	60	DOO 21 11:40	.01	.10	.10	90	1	150	60	77	
	90		.01	.10	.10	90	1	150	60	77	
	120/0	505.379	.01	.10	.10	99	1	150	60	80	137
Pitot 5	30		.01	.10	.10	99	1	150	60	80	
	60	DOO 31 12:40	.01	.10	.10	99	1	150	60	80	
	90		.01	.10	.10	99	1	150	60	80	
	120/0	505.825	.01	.10	.10	94	1	150	60	80	(4)
Pitot 6	30		.01	.10	.10	94	1	150	60	80	
	60	DOO 41 12:50	.01	.10	.10	94	1	150	60	80	
	90		.01	.10	.10	94	1	150	60	80	

V_m — $(\overline{\sqrt{\Delta p}})^2$ — $\overline{\Delta H}$ — $\overline{T_m}$ — $\overline{T_s}$

ENTROPY ENVIRONMENTALISTS, INC

PARTICULATE FIELD DATA

Company Name Weston Shut Run # 127-140

Sampling Location Quick Town Date 9/5/90

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice Setting (ΔH), In. H_2O Ideal	Orifice Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F	
	120/0	506.290	.02	.18	.18	99	1	150	60	81	
	30	"	.02	.14	.14	99	1	150	60	81	
	60	"	.02	.18	.18	99	1	150	60	81	134
	90	"	.02	.18	.18	99	1	150	60	81	
	120/0	506.773	.02	.18	.18	99	1	150	60	82	
	30	"	.04	.35	.35	99	1	150	60	82	
	60	"	.03	.26	.26	99	1	150	60	82	152
	90	"	.02	.18	.18	99	1	150	60	82	
	120/0	507.400	.02	.18	.18	99	1	150	60	82	
	30	"	.04	.35	.35	99	1	150	60	82	
	60	"	.03	.26	.26	99	1	150	60	82	143
	90	"	.02	.18	.18	99	1	150	60	82	
	120/0	508.043	.03	.26	.26	99	1	150	60	83	
	30	"	.04	.35	.35	99	1	150	60	83	
	60	"	.03	.26	.26	99	1	150	60	83	149
	90	"	.02	.18	.18	99	1	150	60	83	
	120/0	508.674	.03	.26	.26	99	1	150	60	83	
	30	"	.05	.45	.45	99	1	150	60	83	
	60	"	.04	.35	.35	99	1	150	60	83	158
	90	"	.03	.26	.26	99	1	150	60	83	
	120/0	509.430	.03	.26	.26	99	1	150	60	83	
	30	"	.07	.62	.62	99	1	150	60	83	
	60	"	.05	.45	.45	99	1	150	60	83	149
	90	"	.02	.18	.18	99	1	150	60	83	
	120/0	510.163	.05	.45	.45	99	1	150	60	83	
	30	"	.06	.54	.54	99	1	150	60	83	
	60	"	.05	.45	.45	99	1	150	60	83	131
	90	"	.03	.26	.26	99	1	150	60	83	
	120/0	510.461	.05	.45	.45	100	1	150	60	84	
	30	"	.10	.92	.92	100	1	150	60	84	
	60	"	.07	.62	.62	100	1	150	60	84	145
	90	"	.03	.26	.26	100	1	150	60	84	
	120/0	511.835	.07	.62	.62	100	1	150	60	84	
	30	"	.05	.45	.45	100	1	150	60	84	
	60	"	.03	.26	.26	100	1	150	60	84	128
	90	"	.02	.18	.18	100	1	150	60	84	
	120/0	512.575	.07	.62	.62	100	1	150	60	83	
	30	"	.08	.72	.72	100	1	150	60	83	
	60	"	.07	.62	.62	100	1	150	60	83	140
	90	"	.03	.26	.26	100	1	150	60	83	
	120/0	513.455									

$\frac{9.939}{V_m}$ $\frac{.0285}{(\sqrt{\Delta p})^2}$ $\frac{.2597}{\overline{\Delta H}}$ $\frac{96}{\overline{T_m}}$ $\frac{140}{\overline{T_s}}$

PARTICULATE FIELD DATA

Run # 6-6U

Company Name WEIRTON STEEL — Time Start 0935
Address WEIRTON, W. VA. — Time Finish 1512
Sampling Location QUENCH TOWER-WEST SIDE — Technicians
Date 9-6-80 — Team Leader MM — Static Pressure, in H_2O 0
Barometric Pressure, in. Hg 29.16
Sampling Train Leak Test Vacuum, in. Hg 15 (8) (5)
Sampling Train Leak Rate, cu. ft./min. 0.017 0.007 0.004

EQUIPMENT CHECKS

- ✓ Pitots, pre-test
- — Pitots, post-test
- — Orsat Sampling System
- — Tedlar Bag
- ✓ Thermocouple @ 72 °F

IDENTIFICATION NUMBERS

Reagent Box —
Meter Box N-2
Umbilical —
Sample Box —
Probe S-5
Nozzle .311 Diameter .324
T/C Readout 03
T/C Probe —
Orsat Pump —
Tedlar Bag —

Filter #	Tare
7096	.4510

NOMOGRAPH SET-UP

Nomograph # —

$\Delta H_@$ 1.61
Meter Temp 95
% Moisture 35
C Factor .51
Stack Temp 175
Ref. ΔP .20

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice Setting (ΔH), In. H_2O Ideal	Orifice Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F
A 1	0	733.683	.02	.175	.175	78	6	125	70	117
	½		.015	.13	.13	78	6	125	70	98
	1		.01	.10	.10	78	6	125	70	86
	1½		.01	.10	.10	78	6	125	70	90
2	2/0	734.002	.015	.13	.13	79	6	125	70	109
	½		.01	.10	.10	79	6	125	70	94
	1		.01	.10	.10	80	6	125	70	85
	1½		.01	.10	.10	80	6	125	70	93
3	4/0	734.491	.03	.265	.265	96	6	125	70	135
	½		.01	.10	.10	96	6	125	70	112
	1		.01	.10	.10	96	6	125	70	96
	1½		.01	.10	.10	96	6	125	70	92
B 1	6/0	734.937	.02	.175	.175	95	6	130	70	120
	½		.04	.36	.36	95	6	130	70	145
	1		.025	.22	.22	95	6	130	70	126
	1½		.01	.10	.10	95	6	130	70	95
2	8/0	735.526	.025	.22	.22	96	6	135	70	144
	½		.025	.22	.22	96	6	135	70	157
	1		.03	.265	.265	96	6	135	70	145
	1½		.01	.10	.10	96	6	135	70	106
3	10/0	736.075	.04	.36	.36	100	6	150	70	156
	½		.025	.22	.22	100	6	150	70	139
	1		.02	.175	.175	100	6	150	70	115
	1½		.01	.10	.10	100	6	150	70	100

V_m — $\overline{(\sqrt{\Delta p})^2}$ — $\overline{\Delta H}$ — $\overline{T_m}$ — $\overline{T_s}$

ENTROPY ENVIRONMENTALISTS, INC

PARTICULATE FIELD DATA

page 2

145-163

Company Name WEIRTON STEEL Run # 5

Sampling Location QUENCH TOWER-WEST SIDE Date 9-6-80

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice Setting (ΔH), In. H_2O Ideal	Orifice Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F
C 1	12/0	736.620	.015	.13	.13	97	1	150	70	179
	1/2		.015	.13	.13	97	1	150	70	165
	1		.015	.13	.13	97	1	150	70	157
	1 1/2		.015	.13	.13	96	1	150	70	143
2	14/0	737.052	.11	.98	.98	96	2	160	70	192
	1/2		.095	.85	.85	96	2	160	70	186
	1		.09	.81	.81	96	2	160	70	172
	1 1/2		.06	.54	.54	97	2	160	70	135
3	16/0	738.153	.12	1.10	1.10	98	3	160	70	200
	1/2		.10	.90	.90	98	3	160	70	190
	1		.075	.67	.67	98	2	160	70	182
	1 1/2		.05	.45	.45	98	2	160	70	141
D 1	18/0	739.207	.06	.54	.54	94	2	160	70	185
	1/2		.05	.45	.45	94	1	160	70	178
	1		.05	.45	.45	94	1	160	70	169
	1 1/2		.04	.36	.36	94	1	160	70	151
2	20/0	740.108	.10	.90	.90	95	3	160	70	199
	1/2		.13	1.18	1.18	96	3	160	70	182
	1		.09	.81	.81	96	3	160	70	169
	1 1/2		.065	.58	.58	96	2	160	70	144
3	22/0	741.240	.12	1.10	1.10	105	3	160	70	202
	1/2		.11	.98	.98	105	3	160	70	195
	1		.095	.85	.85	105	2	160	70	187
	1 1/2		.06	.54	.54	105	2	160	70	156
E 1	24/0	742.407	.015	.13	.13	103	1	160	70	147
	1/2		.01	.10	.10	103	1	160	70	152
	1		.015	.13	.13	103	1	160	70	132
	1 1/2		.01	.10	.10	103	1	160	70	134
2	26/0	742.859	.025	.22	.22	100	1	145	70	172
	1/2		.02	.175	.175	100	1	145	70	166
	1		.015	.13	.13	100	1	145	70	173
	1 1/2		.01	.10	.10	100	1	145	70	144
3	28/0	743.337	.03	.265	.265	96	1	150	70	185
	1/2		.045	.40	.40	96	1	150	70	185
	1		.025	.22	.22	96	1	150	70	166
	1 1/2		.025	.22	.22	96	1	150	70	133
E 1	30/0	743.980	.02	.175	.175	95	1	145	70	162
	1/2		.015	.13	.13	95	1	145	70	143
	1		.015	.13	.13	95	1	145	70	185
	1 1/2		.01	.10	.10	95	1	145	70	124

L.T. @ 739.260

V_m	$(\sqrt{\Delta p})^2$	$\overline{\Delta H}$	$\overline{T_m}$	$\overline{T_s}$

ENTROPY ENVIRONMENTALISTS, INC

PARTICULATE FIELD DATA

page 2

145-162

Company Name WEIRTON STEEL Run # 5

Sampling Location QUENCH TOWER-WEST SIDE Date 9-6-80

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice Setting (ΔH), In. H_2O Ideal	Orifice Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F
2	22/0	744.425	.02	.175	.175	97	1	150	70	176
	1/2		.02	.175	.175	97	1	150	70	180
	1		.02	.175	.175	97	1	150	70	157
	1½		.015	.13	.13	97	1	150	70	198
3	34/0	744.903	.025	.22	.22	98	1	140	70	172
	1/2		.03	.265	.265	98	1	140	70	174
	1		.025	.22	.22	98	1	140	70	150
	1½		.02	.175	.175	98	1	140	70	143
	46/AVG	745.480								

11.797 / V_m ; .03077 / $(\sqrt{\Delta p})^2$; .4667 / $\overline{\Delta H}$; 96 / $\overline{T_m}$; 159 / $\overline{T_s}$

ENTROPY ENVIRONMENTALISTS, INC

PARTICULATE FIELD DATA

Run # 6-E

Company Name Winton Steel
Address Winton, WI
Sampling Location Quench tower
Date 9/6/80 Team Leader DE Technicians
Barometric Pressure, in. Hg 29.10 Static Pressure, in. H_2O 0
Sampling Train Leak Test Vacuum, in. Hg 15
Sampling Train Leak Rate, cu. ft./min. .000

Time Start 0835
Time Finish 1512

EQUIPMENT CHECKS

- ✓ Pitots, pre-test
- — Pitots, post-test
- — Orsat Sampling System
- — Tedlar Bag
- — Thermocouple @ ____ °F

IDENTIFICATION NUMBERS

Reagent Box —
Meter Box N-4
Umbilical —
Sample Box 16
Probe T-2

Nozzle .310 Diameter .367
T/C Readout 3
T/C Probe —
Orsat Pump —
Tedlar Bag —

Filter #	Tare
7045	.4474

NOMOGRAPH SET-UP

Nomograph # ____

$\Delta H_@$ 1.90
Meter Temp 120
% Moisture 30

C Factor .602
Stack Temp 200
Ref. ΔP .20

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice Setting (ΔH), In. H_2O Ideal	Orifice Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F	
	0/0	513.587	.01	.10	.10	75	1	150	60	65	
	30		.01	.10	.10	75	1	150	60	65	155
P1	60	0.96	.01	.10	.10	75	1	150	60	65	
	90		.01	.10	.10	75	1	150	60	65	
	120/0	514.031	.01	.10	.10	78	1	150	60	65	
	30		.01	.10	.10	78	1	150	60	65	131
	60	0.52	.01	.10	.10	78	1	150	60	65	
P2	90	0	.01	.10	.10	78	1	150	60	67	
	120/0	514.465	.03	.28	.28	85	1	150	60	67	142
	30		.01	.10	.10	85	1	150	60	67	
	60	0.43	.01	.10	.10	85	1	150	60	67	
P3	90		.01	.10	.10	87	1	150	60	70	
	120/0	515.034	.01	.10	.10	87	1	150	60	70	148
	30		.01	.10	.10	87	1	150	60	70	
	60	0.56	.01	.10	.10	87	1	150	60	71	
P4	90		.01	.10	.10	88	1	150	60	71	
	120/0	515.454	.01	.10	.10	88	1	150	60	71	141
	30		.02	.16	.18	88	1	150	60	71	
	60	0.36	.01	.10	.10	88	1	150	60	71	
P5	90		.01	.10	.10	95	1	150	60	75	
	120/0	515.905	.01	.10	.10	95	1	150	60	75	150
	30		.01	.10	.10	91	1	150	60	75	
	60	0.45	.01	.10	.10	93	1	150	60	75	
P6	90										

V_m $\overline{(\sqrt{\Delta p})^2}$ $\overline{\Delta H}$ $\overline{T_m}$ $\overline{T_s}$

PARTICULATE FIELD DATA

page 2

Company Name Winton Steel Run # 163-180

Sampling Location Quick Tower Date 9/6/80

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice Setting (ΔH), In. H_2O Ideal	Orifice Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F	
Point 7	120/0	516.339	.01	.10	.10	95	1	150	60	76	137
	30		.02	.18	.18	95	1	150	60	76	
	60	1137	.05	.46	.46	95	1	150	60	76	
	90		.02	.18	.18	95	1	150	60	77	
Point 8	120/0	516.887	.03	.28	.28	95	1	150	60	77	138
	30		.02	.18	.18	95	1	150	60	77	
	60	1140	.01	.10	.10	95	1	150	60	77	
	90		.01	.10	.10	95	1	150	60	77	
Point 9	120/0	517.422	.05	.48	.48	96	1	150	60	77	143
	30		.05	.48	.48	96	1	150	60	77	
	60	1148	.03	.28	.28	96	1	150	60	77	
	90		.01	.10	.10	96	1	150	60	79	
Point 10	120/0	518.128	.08	.70	.70	96	1	150	60	79	149
	30		.03	.28	.28	96	1	150	60	79	
	60	1147	.03	.28	.28	96	1	150	60	79	
	90		.02	.18	.18	96	1	150	60	80	
Point 11	120/0	518.839	.05	.48	.48	96	1	150	60	80	150
	30		.02	.18	.18	96	1	150	60	80	
	60	1155	.02	.18	.18	96	1	150	60	80	
	90		.01	.10	.10	96	1	150	60	81	
Point 12	120/0	519.425	.08	.70	.70	95	1	150	60	81	156
	30		.05	.48	.48	95	1	150	60	81	
	60	1352	.03	.28	.28	95	1	150	60	81	
	90		.02	.18	.18	95	1	150	60	81	
Point 13	120/0	520.213	.10	.90	.90	96	1	150	60	81	134
	30		.10	.90	.90	96	1	150	60	81	
	60	1405	.05	.48	.48	96	1	150	60	81	
	90		.03	.28	.28	96	1	150	60	81	
Point 14	120/0	521.212	.10	.90	.90	96	1	150	60	81	134
	30		.10	.90	.90	96	1	150	60	81	
	60	1417	.08	.70	.70	96	1	150	60	81	
	90		.05	.48	.48	96	1	150	60	81	
Point 15	120/0	522.311	.10	.90	.90	96	1	150	60	81	134
	30		.08	.70	.70	96	1	150	60	81	
	60	1457	.08	.70	.70	96	1	150	60	81	
	90		.04	.35	.35	96	1	150	60	82	
Point 16	120/0	523.355	.10	.90	.90	96	1	150	60	82	130
	30		.10	.90	.90	96	1	150	60	82	
	60	1450	.05	.48	.48	96	1	150	60	82	
	90		.03	.28	.28	96	1	150	60	82	

V_m $(\sqrt{\Delta p})^2$ $\overline{\Delta H}$ $\overline{T_m}$ $\overline{T_s}$

PARTICULATE FIELD DATA

page 2

Company Name Winton Steel

Sampling Location Quick lower

Run # 163-180

Date 9/6/80

Sample Point	Clock Time, Min.	Dry Gas Meter Reading, Cu. Ft.	Pitot Reading (Δp), In. H_2O	Orifice Setting (ΔH), In. H_2O Ideal	Orifice Setting (ΔH), In. H_2O Actual	Gas Meter Temp. °F	Pump Vacuum In. Hg Gauge	Filter Box Temp. °F	Imp. Exit Temp. °F	Stack Temp. °F
	120/0	524.279	.10	.90	.90	100	1	150	60	55
	30		.10	.90	.90	100	1	150	60	55
	60	15	.10	.90	.90	100	1	150	60	55
	90		.02	.18	.18	100	1	150	60	55
	125/0	525.245	.10	.90	.90	100	1	150	60	55
	30		.10	.90	.90	100	1	150	60	55
	60	15	.10	.90	.90	100	1	150	60	55
	90		.04	.35	.35	100	1	150	60	55
	120/Off	526.238								

129

133

12.651 V_m .03296 $(\sqrt{\Delta p})^2$ .3650 $\overline{\Delta H}$ 93 $\overline{T_m}$ 139 $\overline{T_s}$

ENTROPY ENVIRONMENTALISTS, INC

PARTICULATE SAMPLING CLEANUP SHEET

REAGENT BOX(ES) # 0206

Date Received 9/8/80

Plant WEIRTON STEEL

Date Analyzed 9/11/80

Sampling Location QUENCH TOWER

Run #	3-W	3-E	
Run Date	9/3	9/3	
ANALYSIS OF MOISTURE CATCH			
Final Water Volume, ml.	305	290	
Tared Volume, ml.	200	200	
CONDENSED WATER, ml.	105	90	
Final Silica Gel Wt., g.	204.0	203.0	
Tared Wt., g.	200.0	200.0	
ABSORBED WATER, g.	4.0	3.0	
TOTAL WATER COLLECTED, ml.	109.0	93.0	
ANALYSIS OF CATCH FROM NOZZLE TO FILTER, INCLUSIVE			
Filter + Particulate, mg.	452.4	438.5	
Filter Tare, mg.	450.4	435.8	
Filter Catch, mg.	2.0	2.7	
Probe + Filter rinsings, mg.	26.6	11.1	
Cyclone rinsings, mg.	11.3	14.6	
FILTER CATCH + RINSINGS, mg.	39.9	28.4	
Acetone Volume, ml.	175	200	
Acetone Residue, mg.	1.2	1.4	
TOTAL PARTICULATE CATCH, mg.	38.7	27.0	
ANALYSIS OF IMPINGER WATER			
Extraction wt., mg.			
Boildown wt., mg.			
Impinger Rinse wt., mg.			
Acetone Volume, ml.			
Acetone Residue, mg.			
Water Volume, ml.			
Water Residue, mg.			
TOTAL IMPINGER CATCH, mg.			
TOTAL TRAIN CATCH			

BLANK CALCULATION

	Acetone	Water
Volume, ml.	200	
Residue, mg.	1.4	
Concen., mg/ml	.007	

NOTES AND COMMENTS

Sampling Method 5 with cyclone, filter kept dry

ENTROPY ENVIRONMENTALISTS, INC

PARTICULATE SAMPLING CLEANUP SHEET

REAGENT BOX(ES) # 0214

Date Received 9/8/80

Plant WEIRTON STEEL

Date Analyzed 9/11/80

Sampling Location QUENCH TOWER

Run #	4-A	4-C	
Run Date	9/4	9/4	

ANALYSIS OF MOISTURE CATCH

Final Water Volume, ml.	295	289	
Tared Volume, ml.	200	200	
CONDENSED WATER, ml.	95	89	
Final Silica Gel Wt., g.	203.5	203.5	
Tared Wt., g.	200.0	200.0	
ABSORBED WATER, g.	3.5	3.5	
TOTAL WATER COLLECTED, ml.	98.5	92.5	

ANALYSIS OF CATCH FROM NOZZLE TO FILTER, INCLUSIVE

Filter + Particulate, mg.	459.3	450.3	
Filter Tare, mg.	449.0	441.0	
Filter Catch, mg.	10.3	9.3	
Probe + Filter rinsings, mg.	29.1	36.7	
Cyclone rinsings, mg.	25.1	13.7	
FILTER CATCH + RINSINGS, mg.	64.5	59.7	
Acetone Volume, ml.	175	175	
Acetone Residue, mg.	1.2	1.2	
TOTAL PARTICULATE CATCH, mg.	63.3	58.5	

ANALYSIS OF IMPINGER WATER

Extraction wt., mg.			
Boildown wt., mg.			
Impinger Rinse wt., mg.			
Acetone Volume, ml.			
Acetone Residue, mg.			
Water Volume, ml.			
Water Residue, mg.			
TOTAL IMPINGER CATCH, mg.			
TOTAL TRAIN CATCH			

BLANK CALCULATION

	Acetone	Water
Volume, ml.	200	
Residue, mg.	1.4	
Concen., mg/ml	.007	

NOTES AND COMMENTS

Sampling Method 5 with cyclone, filter kept dry.

ENTROPY ENVIRONMENTALISTS, INC

PARTICULATE-SAMPLING CLEANUP SHEET

REAGENT BOX(ES)# 0202

Date Received 9/8/80

Plant WERTON

Date Analyzed 9/11/80

Sampling Location QUENCH TOWER

	S-W	S-E	
Run #	9/5	9/5	
Run Date			

ANALYSIS OF MOISTURE CATCH

Final Water Volume, ml.	315	295	
Tared Volume, ml.	200	200	
CONDENSED WATER, ml.	115	95	
Final Silica Gel Wt., g.	203.0	205.0	
Tared Wt., g.	200.0	200.0	
ABSORBED WATER, g.	3.0	5.0	
TOTAL WATER COLLECTED, ml.	118.0	100.0	

ANALYSIS OF CATCH FROM NOZZLE TO FILTER, INCLUSIVE

Filter + Particulate, mg.	456.6	449.1	
Filter Tare, mg.	448.7	445.8	
Filter Catch, mg.	7.9	3.3	
Probe + Filter rinsings, mg.	21.2	15.4	
Cyclone Rinsings, mg.	7.3	4.5	
FILTER CATCH + RINSINGS, mg.	36.4	23.2	
Acetone Volume, ml.	250	175	
Acetone Residue, mg.	1.8	1.2	
TOTAL PARTICULATE CATCH, mg.	34.6	22.0	

ANALYSIS OF IMPINGER WATER

Extraction wt., mg.			
Boildown wt., mg.			
Impinger Rinse wt., mg.			
Acetone Volume, ml.			
Acetone Residue, mg.			
Water Volume, ml.			
Water Residue, mg.			
TOTAL IMPINGER CATCH, mg.			
TOTAL TRAIN CATCH			

BLANK CALCULATION

	Acetone	Water
Volume, ml.	200	
Residue, mg.	1.4	
Concen., mg/ml	.007	

NOTES AND COMMENTS

Sampling Method 5 with cyclone, filter kept dry

ENTROPY ENVIRONMENTALISTS, INC

PARTICULATE SAMPLING CLEANUP SHEET

REAGENT BOX(ES) # 0224

Date Received 9/8/80

Plant WEIRTON STEEL

Date Analyzed 9/11/80

Sampling Location QUENCH TOWER

	6-10	6-6	
Run #			
Run Date	9/6	9/6	

ANALYSIS OF MOISTURE CATCH

Final Water Volume, ml.	300	305	
Tared Volume, ml.	200	200	
CONDENSED WATER, ml.	100	105	
Final Silica Gel Wt., g.	204.5	207.5	
Tared Wt., g.	200.0	200.0	
ABSORBED WATER, g.	4.5	7.5	
TOTAL WATER COLLECTED, ml.	114.5	112.5	

ANALYSIS OF CATCH FROM NOZZLE TO FILTER, INCLUSIVE

Filter + Particulate, mg.	459.2	466.5	
Filter Tare, mg.	451.0	447.9	
Filter Catch, mg.	8.2	18.6	
Probe + Filter rinsings, mg.	37.3	47.4	
Cyclone rinsings, mg.	5.1	4.1	
FILTER CATCH + RINSINGS, mg.	50.6	70.1	
Acetone Volume, ml.	300	250	
Acetone Residue, mg.	2.1	1.8	
TOTAL PARTICULATE CATCH, mg.	48.5	68.3	

ANALYSIS OF IMPINGER WATER

Extraction wt., mg.			
Boildown wt., mg.			
Impinger Rinse wt., mg.			
Acetone Volume, ml.			
Acetone Residue, mg.			
Water Volume, ml.			
Water Residue, mg.			
TOTAL IMPINGER CATCH, mg.			
TOTAL TRAIN CATCH			

BLANK CALCULATION

	Acetone	Water
Volume, ml.	200	
Residue, mg.	1.4	
Concen., mg/ml	.007	

NOTES AND COMMENTS

Sampling Method 5 with cyclone, filter kept dry

ENTROPY ENVIRONMENTALISTS, INC

CUSTODY SHEET FOR REAGENT BOX # 0206

Date of Makeup 8/28/80 Initials BD Locked? ✓

Individual Tare of Reagent: 200 mls. of H_2O

Individual Tare of Reagent: _____ mls. of _____

Individual Silica Gel Tare Weight 200 gms.

PLANT NAME WEIRTON STEEL

SAMPLING LOCATION QUENCH TOWER - ~~WEST SIDE~~

Run Number	Date Used	Initials	Locked?	Date Cleanup	% S. Gel Spent	Initials	Locked?
(37-54) 2	9-3	MH	✓	9-3	85	MH	✓
(55-72) ~~2nd~~	9-3	MH	✓	9-3	85	MH	✓
~~2nd~~							

Received in Lab Date 9/8 Initials MS Locked? ✓

Sampling Method: M-5

Zero & Span Balance Initials MS

Filter #	Tare Weight (mgms)	Used on Test
7038	.4504	37-54
7039	.4358	55-72

Remarks:

ENTROPY ENVIRONMENTALISTS, INC.

CUSTODY SHEET FOR REAGENT BOX # 0214

Date of Makeup 8/28/80 Initials BD Locked? ✓

Individual Tare of Reagent: 200 mls. of H_2O

Individual Tare of Reagent: _____ mls. of _____

Individual Silica Gel Tare Weight 200 gms.

PLANT NAME WEIRTON STEEL

SAMPLING LOCATION QUENCH TOWER

Run Number	Date Used	Initials	Locked?	Date Cleanup	% S. Gel Spent	Initials	Locked?
(73-88) 3	9-4	MH	✓	9-4	60	MH	✓
91-106	9-4	MH	✓	"	"	"	"

Received in Lab Date 9/8 Initials MEO Locked? ✓

Sampling Method: M-5

Remarks: Dust clean up jars in this box LT.

Zero & Span Balance Initials MEO

Filter #	Tare Weight (mgms)	Used on Test
7040	449.0	73-88
7041	441.0	91-106

ENTROPY ENVIRONMENTALISTS, INC.

CUSTODY SHEET FOR REAGENT BOX # 0202

Date of Makeup 8/28/80 Initials BD Locked? —

Individual Tare of Reagent: 200 mls. of H2O

Individual Tare of Reagent: _____ mls. of _____

Individual Silica Gel Tare Weight 200 gms.

PLANT NAME Weirton Steel

SAMPLING LOCATION Quenching Tower

Run Number	Date Used	Initials	Locked?	Date Cleanup	% S. Gel Spent	Initials	Locked?
4 (109-12)	9-5	MH	—	9-5	20	MH	—
5 (12.-142)	9-5	MH	—	9-	20	MH	—

Received in Lab Date 9/8 Initials ME Locked? ✓

Sampling Method: M-5

Remarks:

Zero & Span Balance Initials ME

Filter #	Tare Weight (mgms)	Used on Test
7042	.4487	109-12
7044	.4458	127-142

ENTROPY ENVIRONMENTALISTS, INC.

CUSTODY SHEET FOR REAGENT BOX # 0224

Date of Makeup 8/28/80 Initials BD Locked? ✓

Individual Tare of Reagent: 200 mls. of H_2O

Individual Tare of Reagent: _____ mls. of _____

Individual Silica Gel Tare Weight 200 gms.

PLANT NAME WEIRTON STEEL

SAMPLING LOCATION QUENCH TOWER

Run Number	Date Used	Initials	Locked?	Date Cleanup	% S. Gel Spent	Initials	Locked?
145-162	9-6	NH	✓	9-6	✓	NH	✓
163-180	9-6	NH	✓	9-6	✓	NH	✓

Received in Lab Date 9/8 Initials ME Locked? ✓

Sampling Method: M-5

Remarks:

Zero & Span Balance Initials ME

Filter #	Tare Weight (mgms)	Used on Test
7046	451.0	145-162
7045	447.9	163-180

ENTROPY ENVIRONMENTALISTS, INC

APPENDIX C

September 4, 1980
Weirton Steel
Weirton, West Virginia

Quenching Tower (Pushes from Battery #8 only)

Door/Quench	
34/ 1	white all during quench
44/ 2	white all during quench
24/ 3	white all during quench
5/ 4	white all during quench
16/ 5	white all during quench
26/ 6	white all during quench
36/ 7	white all during quench
8/ 8	white all during quench
18/ 9	white all during quench
28/ 10	white all during quench
38/ 11	white with yellow tint for 30 seconds then white for rest of "q"
1/ 12	white with gray tint for 15 seconds then white for rest of quench
11/ 13	white all during quench
21/ 14	white with gray tint for 15 seconds then white for rest of quench
31/ 15	white all during quench
41/ 16	white with yellow tint for 15 seconds then white with gray for 15 seconds then white for rest of "q"

September 3, 1980
Weirton Steel
Weirton, West Virginia

Quenching Tower (Pushes from Battery #8 only)

Door/Quench	
9 / 1	white all during quench
19 / 2	white all during quench
29/ 3	white all during quench
39/ 4	white all during quench
2/ 5	white all during quench
12/ 6	white all during quench
22/ 7	white all during quench
32/ 8	white all during quench
42/ 9	white all during quench
4/ 10	white all during quench
14/ 11	white all during quench
24/ 12	white all during quench
34/ 13	white all during quench
44/ 14	white all during quench
6/ 15	white all during quench
16/ 16	white all during quench
26/ 17	white all during quench
36/ 18	white all during quench

September 5, 1980
Weirton Steel
Weirton, West Virginia

Quenching Tower (Pushes from Battery #8 only)

Door/	Quench	
38/	1	white all during quenching
1/	2	white all during quench
11/	3	white all during quench
21/	4	white all during quench
31/	5	white all during quench
41/	6	white all during quench
3/	7	white all during quench
13/	8	white all during quench
23/	9	white all during quench
33/	10	white all during quench
43/	11	white all during quench
5/	12	white all during quench
15/	13	white all during quench
25/	14	white all during quench
35/	15	white all during quench
45/	16	white all during quench

September 6, 1980
Weirton Steel
Weirton, West Virginia

Quenching Tower (Pushes from Battery #8 only)

Door/Quench	
33/	1 white all during quench
43/	2 white all during quench
5/	3 white all during quench
15/	4 white all during quench
25/	5 white with gray tint for 30 seconds then white for rest of quench
35/	6 white all during quench
45/	7 white all during quench
7/	8 white all during quench
17/	9 white all during quench
27/	10 white with gray tint for 15 seconds then white for rest of quench
37/	11 white all during quench
9/	12 white all during quench
19/	13 same as push 10
29/	14 same as 12
39/	15 same as 10
2/	16 white with yellow tint for 15 seconds then white for rest of quench
12/	17 same as 10
22/	18 same as 11

APPENDIX D

TEST PARTICIPANTS

DAVID W. FINLEY	PROJECT DIRECTOR
NEILL M. HARDEN	SAMPLING TEAM LEADER
LEE TAYLOR	ENGINEERING TECHNICIAN

APPENDIX E

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:

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

where L = length and W = width.

2.2 Determining the Number of Traverse Points.

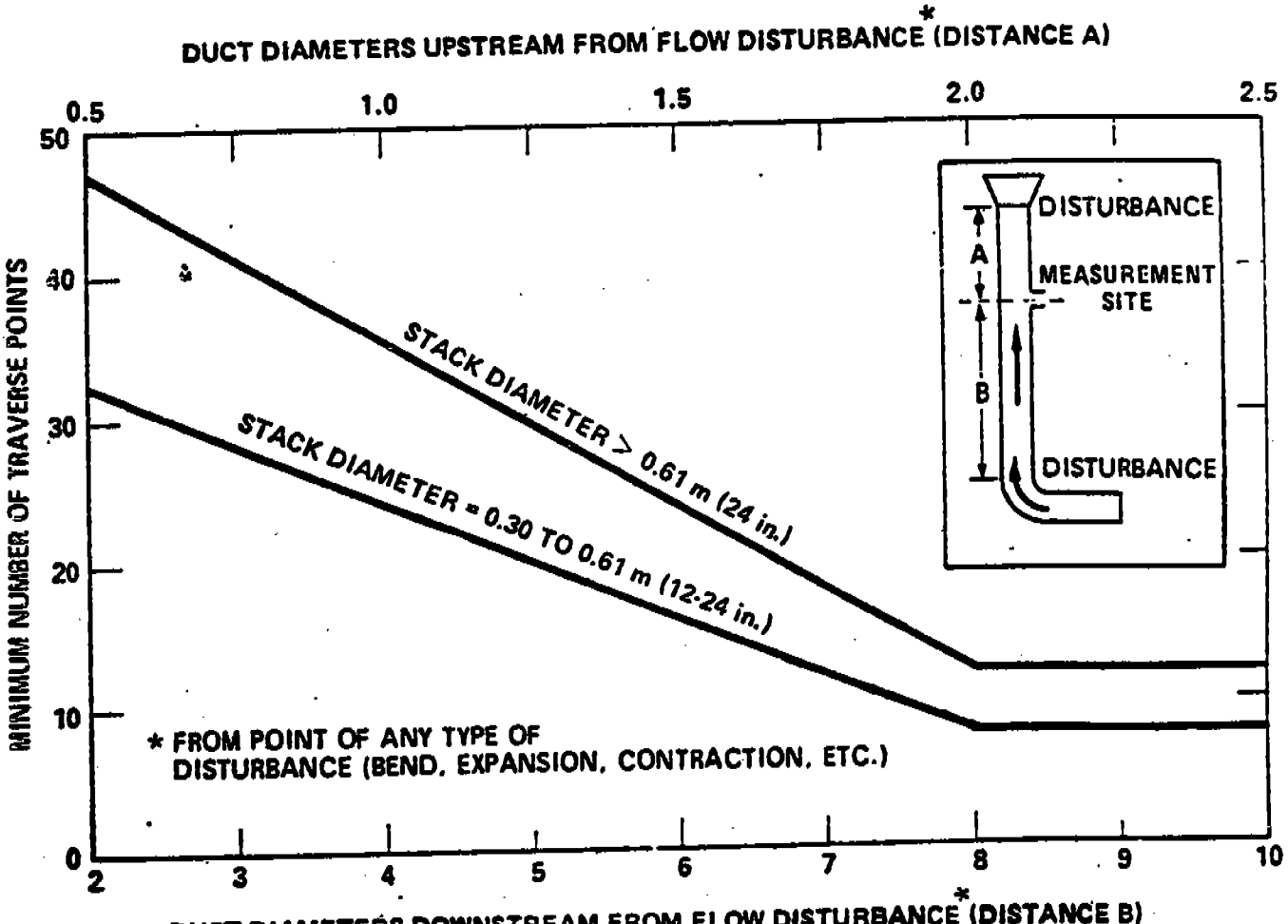
2.2.1 Particulate Traverses. When the eight- and two-diameter criterion can be met, the minimum number of traverse points shall be: (1) twelve, for circular or rectangular stacks with diameters (or equivalent diameters) greater than 0.61 meter (24 in.); (2) eight, for circular stacks with diameters between 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
8	2x4
12	3x4
16	4x4
20	5x4
25	5x5
30	6x5
36	6x6
42	7x6
49	7x7

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



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

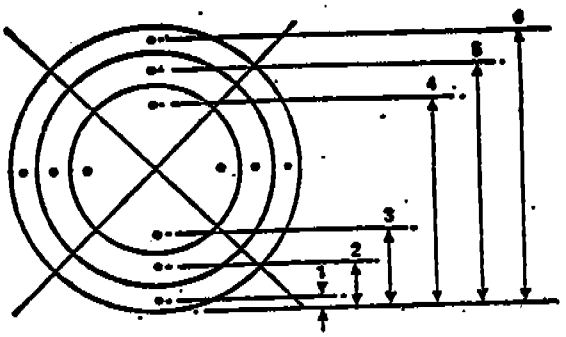


Figure 1-3. Example showing circular stack cross section divided into 12 equal areas, with location of traverse points indicated.

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.

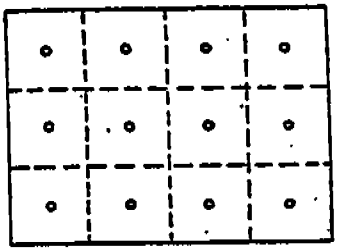


Figure 1-4. Example showing rectangular stack cross section divided into 12 equal areas, with a traverse point at centroid of each area.

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

3. *Bibliography*

1. Determining Dust Concentration in a Gas Stream. ASME. Performance Test Code No. 27. New York. 1957.

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

4. Standard Method for Sampling Stacks for Particulate Matter. In: 1971 Book of ASTM Standards, Part 23. ASTM Designation D-2928-71. Philadelphia, Pa. 1971.

5. Hanson, R. A., et al. Particulate Sampling Strategies for Large Power Plants Including Nonuniform Flow. USEPA, ORD, ESRL, Research Triangle Park, N.C. EPA-600/2-76-170. June 1976.

6. Entropy Environmentalists, Inc. Determination of the Optimum Number of Sampling Points: An Analysis of Method 1 Criteria. Environmental Protection Agency. Research Triangle Park, N.C. EPA Contract No. 68-01-2172, Task 7.

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

1. *Principle and Applicability*

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

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

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

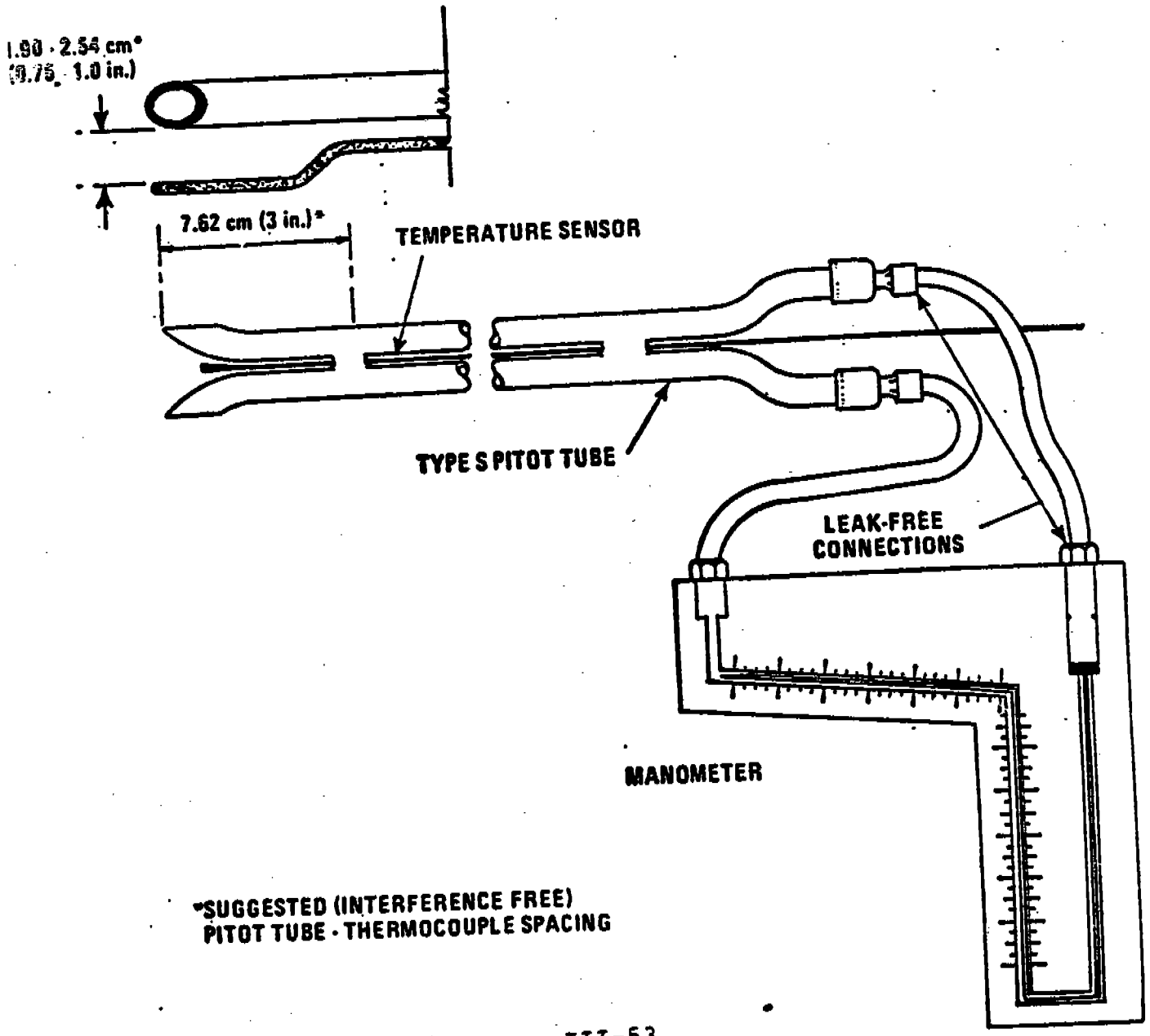
2. *Apparatus*

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

2.1 Type S Pitot Tube. The Type S pitot tube (Figure 2a) shall be made of metal tubing (e.g., stainless steel). It is recommended that the external tubing diameter (dimension D_t, Figure 2-2b) be between 0.48 and 0.95 centimeters (3/16 and 3/8 inch). There shall be an equal distance from the base of each leg of the pitot tube to its face-opening plane (dimensions P_A and P_B, Figure 2-2b); it is recommended that this distance be between 1.05 and 1.50 times the external tubing diameter. The face openings of the pitot tube shall, preferably, be aligned as shown in Figure 2-2; however, slight misalignments of the openings are permissible (see Figure 2-3).

The Type S pitot tube shall have a known coefficient, determined as outlined in Section 4. An identification number shall be assigned to the pitot tube; this number shall be permanently marked or engraved on the body of the tube.

Figure 2-1. Type S pitot tube manometer assembly.



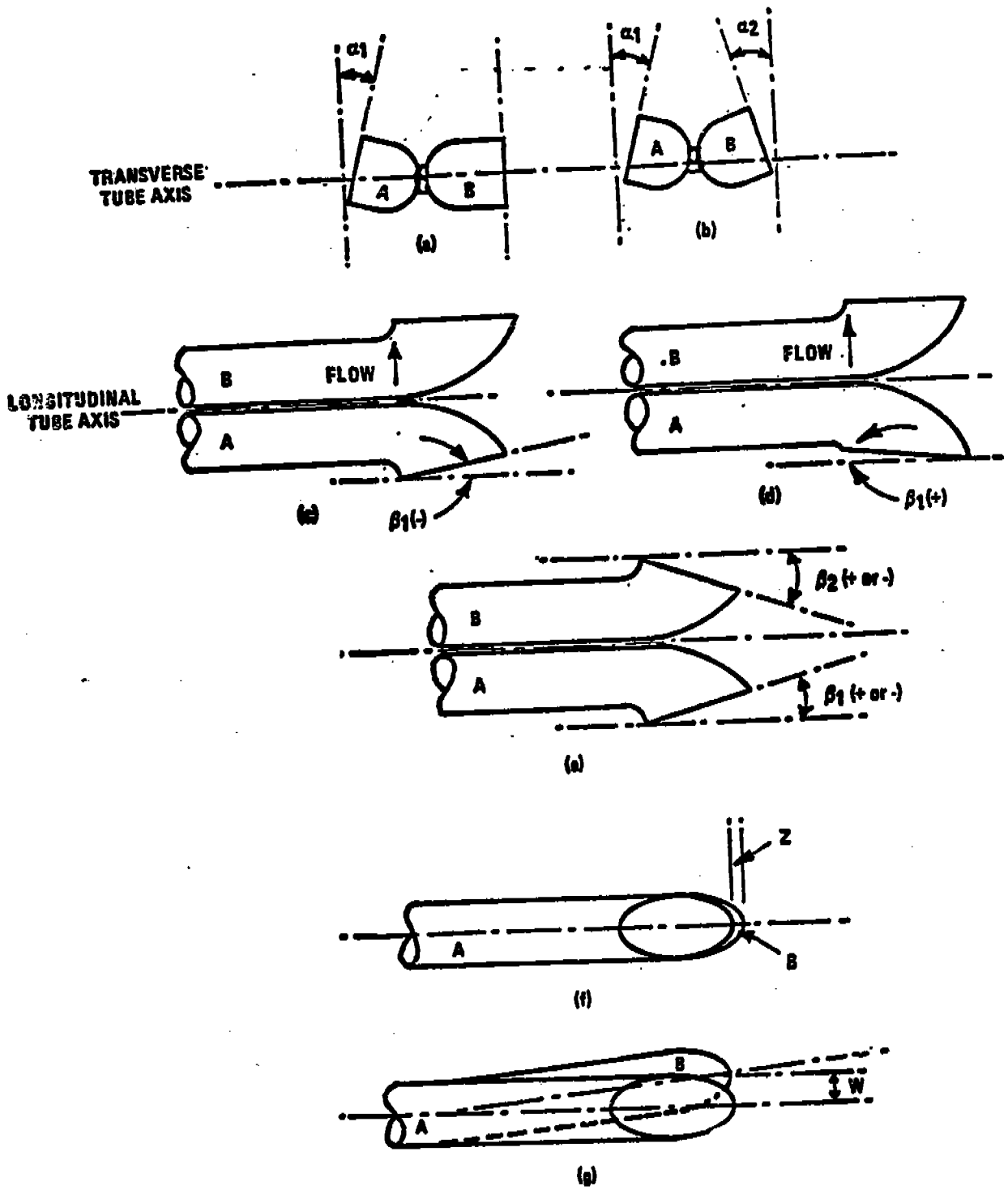


Figure 2-3. Types of face-opening misalignment that can result from field use or improper construction of Type S pitot tubes. These will not affect the baseline value of $\bar{C}p(s)$ so long as α_1 and $\alpha_2 < 10^o$, β_1 and $\beta_2 < 5^o$, $z < 0.32$ cm (1/8 in.) and $w < 0.08$ cm (1/32 in.) (citation 11 in Section 6).

PLANT ____________________

DATE ____________________ RUN NO. ____________

STACK DIAMETER OR DIMENSIONS, m(in.) ____________

BAROMETRIC PRESSURE, mm Hg (in. Hg) ____________

CROSS SECTIONAL AREA, m^2(ft^2) ____________

OPERATORS ____________________

PITOT TUBE I.D. NO. ____________________

AVG. COEFFICIENT, C_p = ____________

LAST DATE CALIBRATED ____________

SCHEMATIC OF STACK CROSS SECTION

Traverse Pt. No.	Vel. Hd., Δp mm (in.) H_2O	Stack Temperature		P_g mm Hg (in.Hg)	$\sqrt{\Delta p}$
		t_s, °C (°F)	T_s, °K (°R)		
		Average			

Figure 2-5. Velocity traverse data.

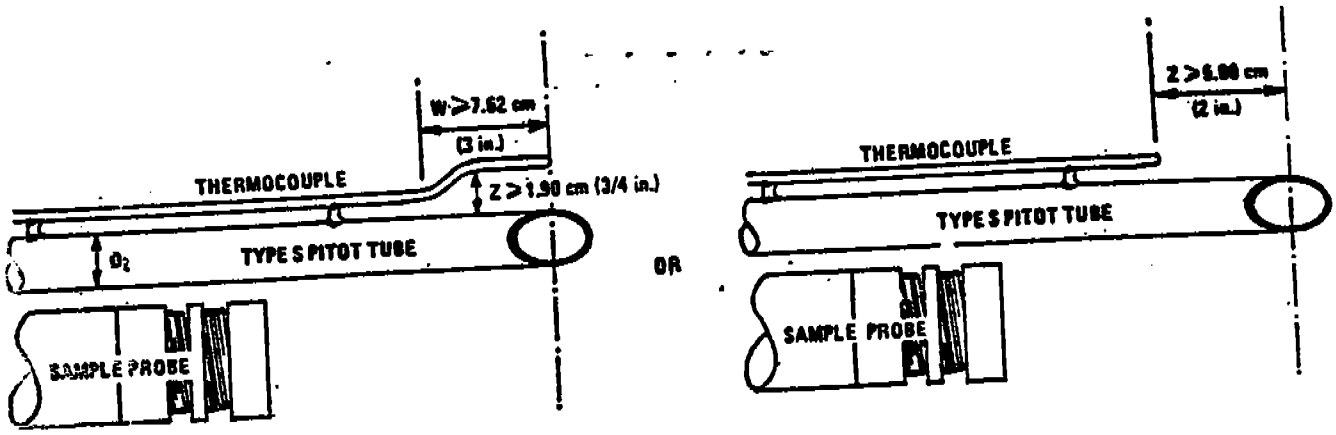


Figure 2-7. Proper thermocouple placement to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

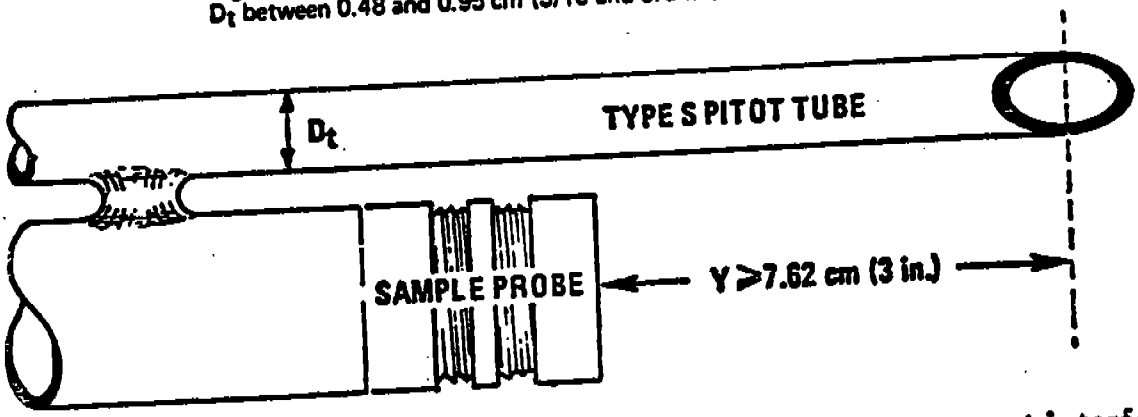


Figure 2-8. Minimum pitot-sample probe separation needed to prevent interference; D_t between 0.48 and 0.95 cm (3/16 and 3/8 in.).

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

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

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

Equation 2-1

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

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

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

4.1.2.3 The flow system shall have the capacity to generate a test-section velocity around 915 m/min (3,000 ft/min). This velocity must be constant with time to guarantee steady flow during calibration. Note that Type S pitot tube coefficients obtained by single-velocity calibration at 915 m/min (3,000 ft/min) will generally be valid to within ±3 percent for the measurement of velocities above 305 m/min (1,000 ft/min) and to within ±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 Section 4.1.5.1), and align the tube so that its tip is pointed directly into the flow. Particular care should be taken in aligning the tube to avoid yaw and pitch angles. Make sure that the entry port surrounding the tube is properly sealed.

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

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

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

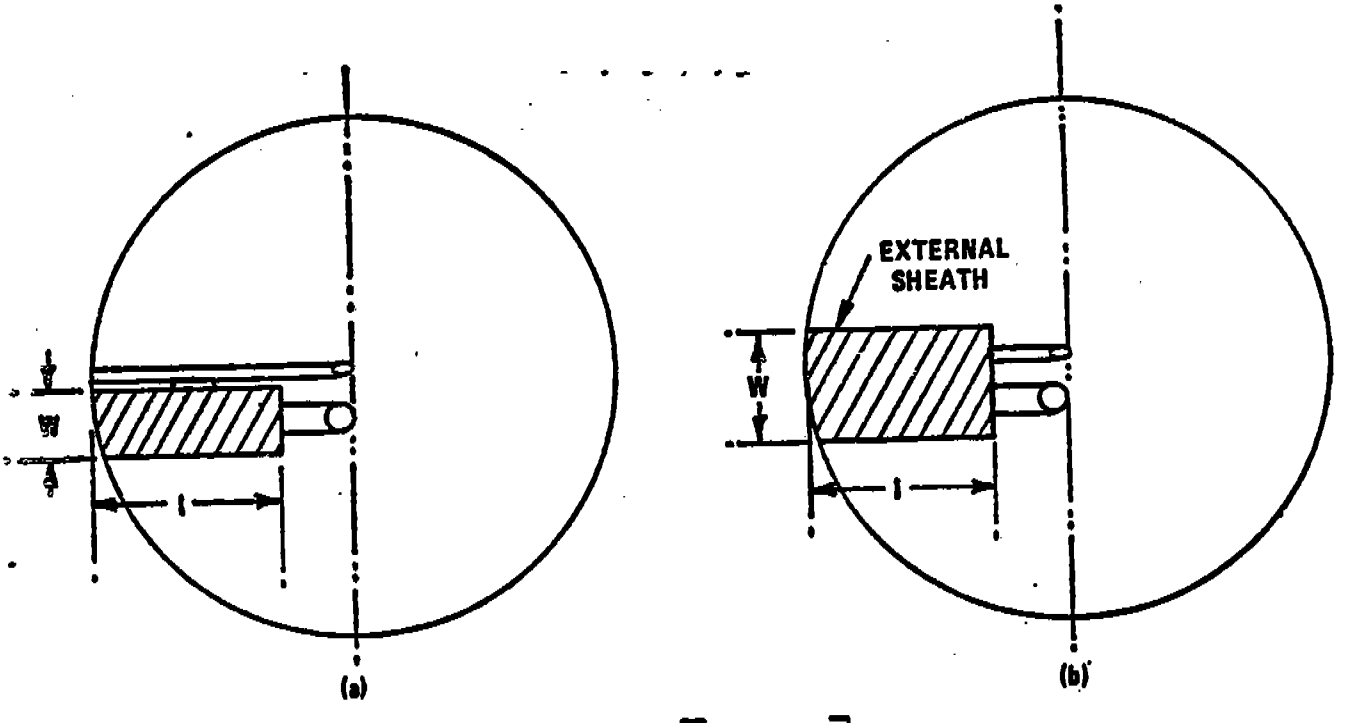
4.1.3.7 Repeat steps 4.1.3.3 through 4.1.3.6 above until three pairs of Δp readings have been obtained.

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:



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

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 $C_{p(s)}$. 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, m^2 (ft^2).

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

C_p = Pitot tube coefficient, dimensionless.

K_p = Pitot tube constant,

$$34.97 \frac{m}{sec}\left[\frac{(g/g\text{-mole})(mm\ Hg)}{(°K)(mm\ H_2O)}\right]^{1/2}$$

for the metric system and

$$85.49 \frac{ft}{sec}\left[\frac{(lb/lb\text{-mole})(in.\ Hg)}{(°R)(in.\ H_2O)}\right]^{1/2}$$

for the English system.

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

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

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

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

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

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

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

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

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

t_s = Stack temperature, °C (°F).

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

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

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

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

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

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

3,600 = Conversion factor, sec/hr.

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

5.2 Average stack gas velocity.

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

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

6. *Bibliography*

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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.

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

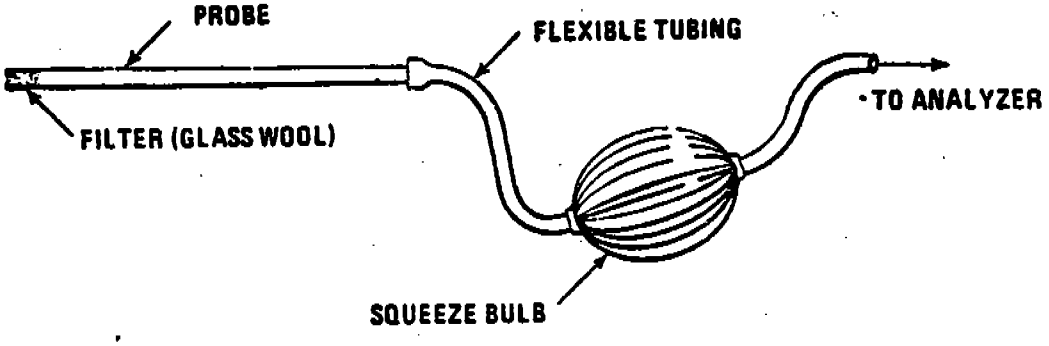

Figure 3-1. Grab-sampling train.

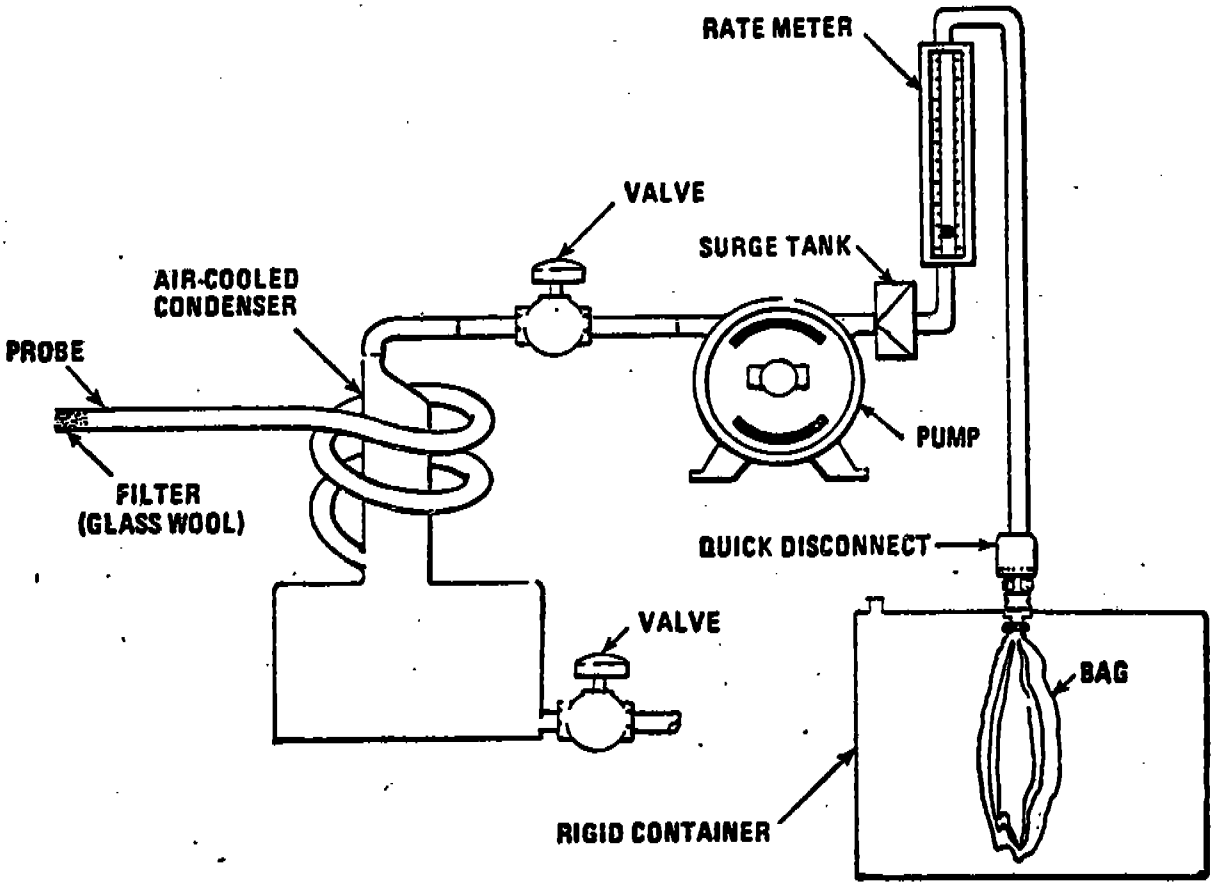

Figure 3-2. Integrated gas-sampling train.

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 3.2.1 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.

7. *Bibliography*

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Method 4—Determination of Moisture Content in Stack Gases

1. Principle and Applicability

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

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

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

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

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

2. Reference Method

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

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

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.

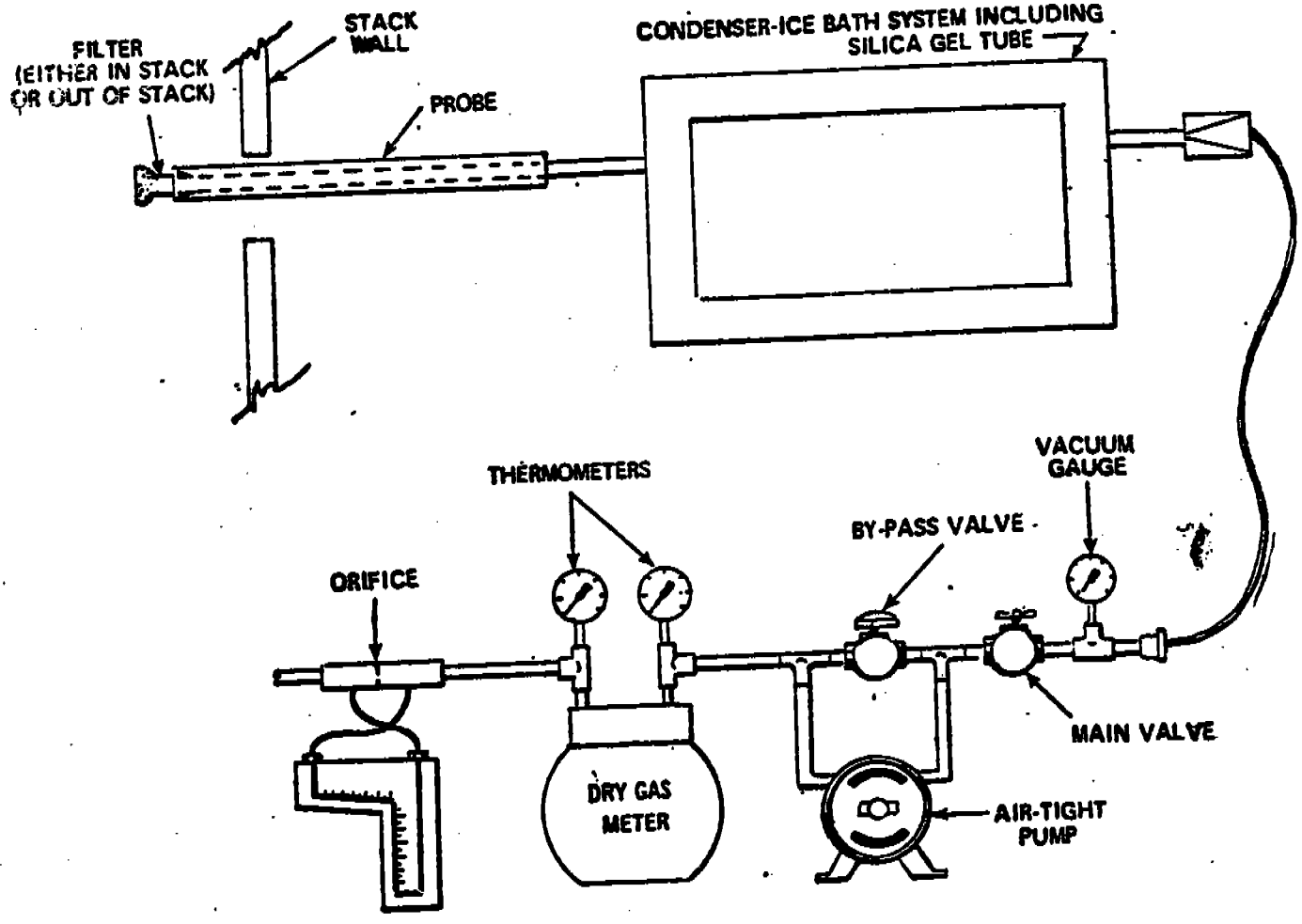

Figure 4-1. Moisture sampling train-reference method.

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

Figure 4-3. Analytical data - reference method.

2.3.1 Nomenclature.

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

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

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

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

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

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

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

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

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

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

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

$V_{wsg(std)}$ = 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.

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

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.

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

Equation 4-2

where:

K_2 = 0.001333 m^3/g for metric units
= 0.04715 ft^3/g for English units

2.3.4 Sample gas volume.

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

Equation 4-3

where:

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

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

2.3.5 Moisture Content.

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

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 l pm (0 to 0.11 cfm).

3.1.9 Graduated Cylinder. 25 ml.

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

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

3.2 Procedure.

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

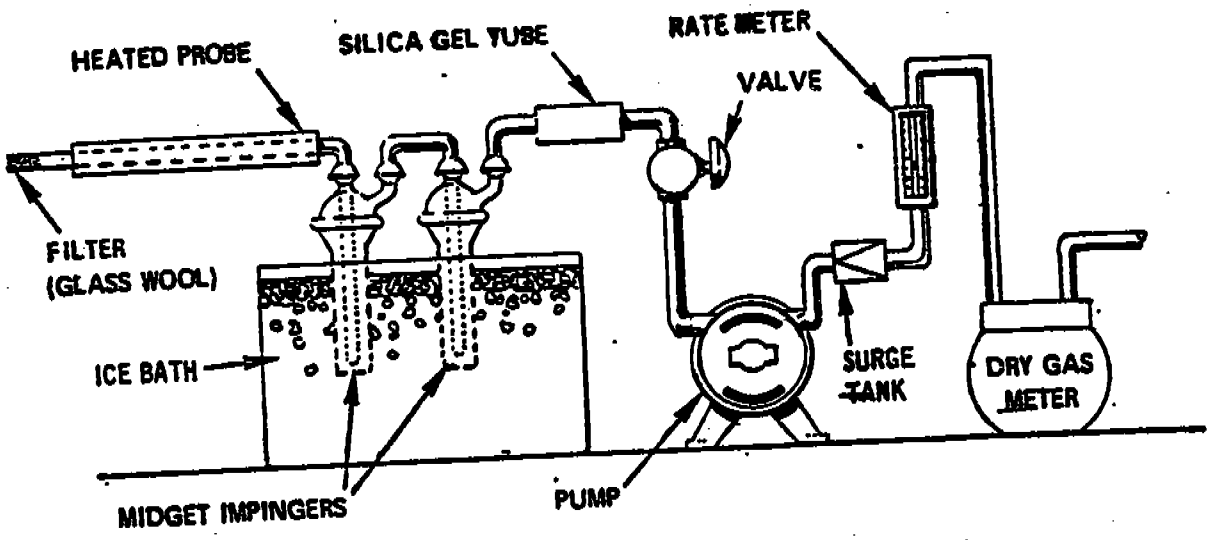

Figure 4-4. Moisture-sampling train - approximation method.

FROM STATIONARY SOURCES

[illegible] and Applicability

1.1 [illegible]. 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:

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

A [illegible] 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.

Unless otherwise specified by the Administrator, a probe liner shall be used for stack temperatures less than 538° C (1000° F). Sampling trains operated at higher stack temperatures may use an unheated probe liner as long as it is maintained at a temperature higher than 120° C (248° F). Either borosilicate or quartz glass liners may 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, borosilicate or quartz glass tubing may be used with a stainless steel, Incoloy 825,[2] or other metal liners (e.g., 316 stainless steel, Incoloy 825, or other corrosion resistant metals) made of seamless tubing may be used, subject to the approval of the Administrator.

2.1.3 Pitot 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. A temperature gauge, capable of measuring temperature to within 1° C (2° F), shall be placed at the outlet of the fourth impinger for monitoring purposes.

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

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

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

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

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

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

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

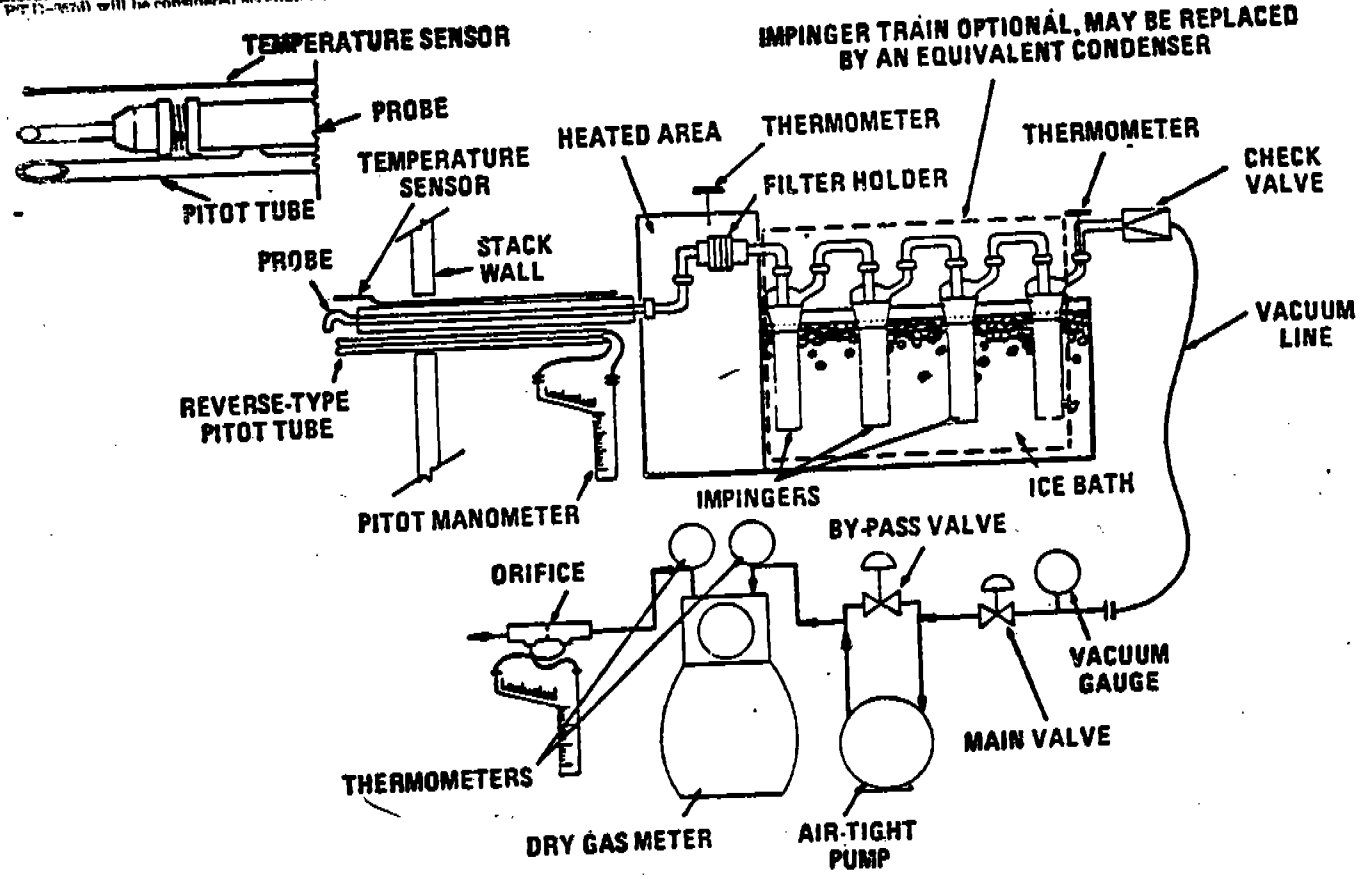

Figure 5 1. Particulate-sampling train.

Take meter 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_s are outside the above stated ranges do not use the nomographs unless appropriate steps (see Citation 7 in Section 7) are taken to compensate for the deviations.

PLANT _____

LOCATION _____

OPERATOR _____

DATE _____

RUN NO. _____

SAMPLE BOX NO. _____

METER BOX NO. _____

METER ΔH@ _____

C FACTOR _____

PITOT TUBE COEFFICIENT, C_p _____

SCHEMATIC OF STACK CROSS SECTION

AMBIENT TEMPERATURE _____

BAROMETRIC PRESSURE _____

ASSUMED MOISTURE, % _____

PROBE LENGTH, m (ft) _____

NOZZLE IDENTIFICATION NO. _____

AVERAGE CALIBRATED NOZZLE DIAMETER, cm (in.) _____

PROBE HEATER SETTING _____

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

PROBE LINER MATERIAL _____

STATIC PRESSURE, mm Hg (in. Hg) _____

FILTER NO. _____

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

Figure 5-2. Particulate field data.

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

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

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

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

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

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

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

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

4.1.6 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

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

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

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

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

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

5. Calibration

Maintain a laboratory log of all calibrations.

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

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

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

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

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

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

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

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

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

5.7 Barometer. Calibrate against a mercury barometer.

6. Calculations

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

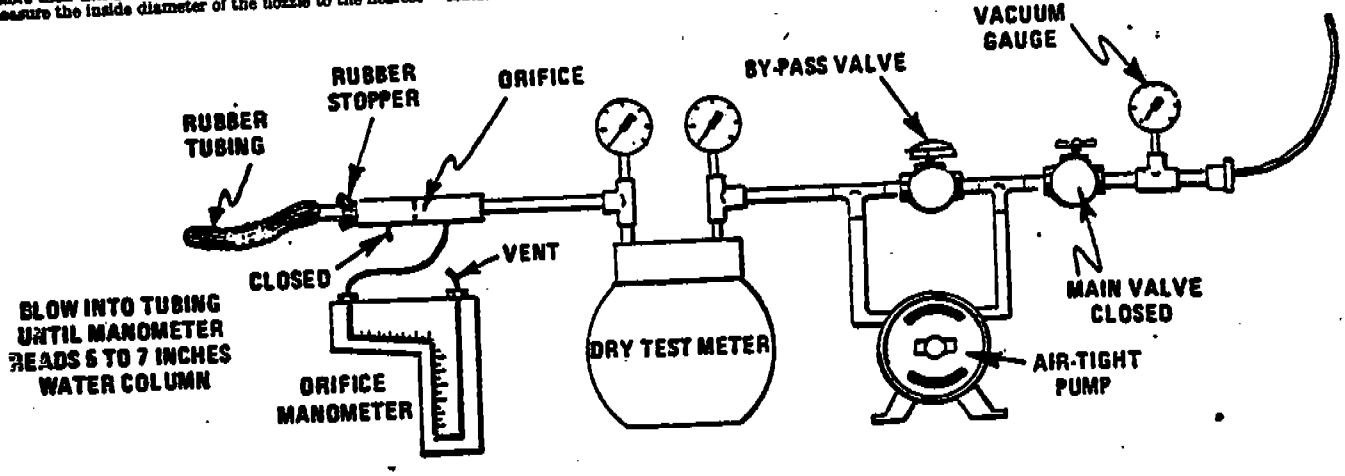

Figure 5-4. Leak check of meter box.

6.1 Nomenclature

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

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

C_a = Acetone blank residue concentration, mg/g.

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

I = Percent of isokinetic sampling.

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

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

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

m_a = Total amount of particulate matter collected, mg.

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

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

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

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

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

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

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

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

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

V_a = Volume of acetone blank, ml.

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

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

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

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

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

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

W_a = Weight of residue in acetone wash, mg.

Y = Dry gas meter calibration factor.

ΔH = Average pressure differential across the orifice meter (see Figure 5-2), mm H_2O (in. H_2O).

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

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

θ = Total sampling time, min.

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

θ_2 = 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

APPENDIX F

CALIBRATIONS

GENERAL

All measuring equipment Entropy uses is initially calibrated before use. Equipment which can change calibration is both checked upon return from each field use and is also periodically recalibrated in full. When an instrument is found out of calibration, it is so noted in the report and appropriate adjustments are made to the final results. The equipment is then repaired and recalibrated or retired as needed. Specific equipment is handled as follows:

PITOT TUBE

All pitot tubes used by Entropy, whether separate or attached to a sampling probe, are constructed in-house or by Nutech Corporation. Prior to their initial usage, they are calibrated using EPA geometry standards. In general, if a type "S" pitot tube is assembled correctly, and positioned properly in relation to the probe nozzle, it will have an average Cp of 0.84. As long as it is not damaged, it should not change its calibration. The recalibration schedule for pitot tubes is related to the physical condition and usage of the pitot tube, not a fixed time schedule. Each pitot tube is inspected upon return to the laboratory from each field use.

DRY GAS METER AND ORIFICE METER

All Entropy meter boxes are calibrated upon purchase and at least once every six months against a secondary test meter (one calibrated against a wet test meter) according to their usage history. Basic procedures are outlined in the EPA Publication No. APTD-0576. The only differences are in the choice of flow rates used and the volumes metered at each flow rate. After each field use, quick checks are performed to insure ΔH@ changes of less than 5%. These checks compare the orifice against the dry gas meter. If greater than 5% changes occur, recalibration and repair are instituted.

NOZZLES

Each nozzle is calibrated upon purchase, and thereafter whenever it becomes apparent that the nozzle has become damaged. Each nozzle is inspected upon return to laboratory from each field use. The diameter is measured on four different axes, with the high and low readings differing by no more than 0.004 inches as a tolerance.

TEMPERATURE MEASURING INSTRUMENTS

After each field use, the thermocouples or thermometers are calibrated against an ASTM precision mercury-in-glass thermometer across a wide range of temperatures. If the initial

reading is not within ± 1.5% of the absolute temperature reading of the standard thermometer, the instrument is adjusted until it is in the acceptable range.

MAGNEHELIC GAUGES

After each field use, each magnehelic gauge is calibrated against an inclined manometer at three different settings (low, medium, high) over the range of the individual gauges. If the readings differ more than ± 5% from the manometer readings, the magnehelics are recalibrated.

BAROMETER

After each field use, each barometer is checked against a mercury barometer.

DATE: 11-21-79

DRY GAS METER IDENTIFICATION: # 1017057

BAROMETRIC PRESSURE (P_b): 29.74 in. Hg

APPROXIMATE FLOW RATE ($\bar{Q}$) Δ H / cfm		SPIROMETER (WET METER) GAS VOLUME (V_s) ft³	DRY GAS METER VOLUME (V_{dg}) ft³	TEMPERATURES: SPIROMETER (WET METER) (t_s) °F/°R	TEMPERATURES: DRY GAS METER (t_d) °F/°R	DRY GAS METER PRESSURE (Δp) in. H_2O / in. Hg	TIME (θ) min.	FLOW RATE (Q) cfm	METER METER COEFFICIENT (Y_{ds})	AVERAGE METER COEFFICIENT ($\bar{Y}_{ds}$)
0.51	0.4	1.000	1.005	530.5	532.5	-0.8	2.52	0.39	1.0008	
	0.4	1.000	1.007	530.5	532.5	-0.8	2.52	.39	0.9988	1.0005
	0.4	1.000	1.004	530.5	532.5	-0.8	2.52	.39	1.0018	
1.25	0.6	1.000	1.002	530.5	532	-1.3	1.62	.61	1.0041	
	0.6	1.000	1.008	530.5	532	-1.3	1.63	.61	.9981	0.9991
	0.6	1.000	1.011	530.5	532	-1.3	1.65	.60	.9951	
2.18	0.8	1.000	1.018	530.5	532.5	-1.8	1.27	.78	.9904	
	0.8	1.000	1.013	530.5	532.5	-1.8	1.27	.78	.9953	0.9947
	0.8	1.000	1.010	530.5	532.5	-1.8	1.27	.78	.9983	
3.3	1.0	1.000	1.020	530	532.5	-2.3	1.02	.97	.9907	
	1.0	1.000	1.021	530	532.5	-2.3	1.03	.96	.9897	0.9920
	1.0	1.000	1.015	530	532.5	-2.3	1.03	.96	.9955	
4.8	1.2	1.000	1.023	530	532.5	-3.1	0.88	1.12	.9897	
	1.2	1.000	1.021	530	532.5	-3.1	0.87	1.14	.9917	0.9910
	1.2	1.000	1.021	530	532.5	-3.1	0.87	1.14	.9917	
								Average:	.99544	.99546

$$Q = 17.65 \cdot \frac{V_s}{\theta} \cdot \frac{P_b}{(t_s + 460)}$$

$$Y_{ds} = \frac{V_s}{V_{dg}} \cdot \frac{(\bar{t}_d + 460)}{(t_s + 460)} \cdot \frac{P_b}{\left(P_b + \frac{\Delta p}{13.6}\right)}$$

ENTROPY ENVIRONMENTALISTS, INC.

METER BOX CALIBRATION

METER BOX N-2

DATE 8/13/80 P_B 29.58 INITIALS DE

Date* " P_B* " Initials* "

ΔH	V_T	T_T	θ	T_M	V_M		
ORIFICE SETTING	TEST METER VOLUME cf	TEST METER TEMP. °F	TIME, MINUTES M:SEC / M.dec	METER BOX TEMP °F	METER BOX VOLUME cf	Y	ΔH@
6.0	5	75°	3:25 / 3.42	89°	4.948	1.0217	1.5684
4.0	5	75°	4:09 / 4.15	85°	4.961	1.0166	1.5509
2.0	5	75°	5:54 / 5.90	89°	5.015	1.0180	1.5559
1.5	5	75°	7:01 / 7.02	89°	5.037	1.0148	1.6520
1.0	3	75°	5:07 / 5.12	90°	3.039	1.0123	1.6244
0.7	3	75°	6:10 / 6.17	90°	3.031	1.0158	1.6513
0.5	3	75°	7:15 / 7.25	89°	3.045	1.0097	1.6315
0.3	2	75°	6:12 / 6.20	89°	2.039	1.0058	1.6108
					AVERAGE	1.0143	1.6057

* Indicates date of calibration

$$\Delta H@ = \frac{[(T_T + 460)\,\theta\,]^2\,(0.0317)\,(\Delta H)}{(V_T)^2\,(P_B)\,(T_M + 460)}$$

$$Y = \frac{(T_M + 460)\,(P_B)\,(V_T)}{(\Delta H/13.6 + P_B)(T_T + 460)(V_M)}$$

note: calculate $[(T_R + 460)\,\theta\,]^2$ first

ENTROPY ENVIRONMENTALISTS, INC.

METER BOX CALIBRATION

METER BOX N-4

DATE 5-8-80 P_B 29.34 INITIALS PZO

Date*_____ P_B*_____ Initials*_____

ΔH	V_T	T_R	θ	T_M	V_M		
ORIFICE SETTING	TEST METER VOLUME cf	ROOM TEMP. °F	TIME, MINUTES M:SEC / M.dec	METER BOX TEMP °F	METER BOX VOLUME cf	Y	ΔH@
6.0	5	68	3:39 / 3.65	85	4.977	1.0171	1.767
4.0	5	68	4:28 / 4.47	82	6.035	1.0093	1.777
2.0	5	68	6:16 / 6.27	80	5.071	1.0034	1.754
1.5	5	68	7:27 / 7.45	78	5.026	0.9999	1.864
1.0	3	68	5:21 / 5.35	76	3.041	0.9990	1.787
0.7	3	68	6:24 / 6.40	75	3.050	0.9949	1.794
0.5	3	68	7:34 / 7.57	73	3.032	0.9976	1.799
0.3	2	68	6:34 / 6.57	71	2.044	0.9833	1.836
						AVERAGE	1.0006	1.80

* Indicates date of calibration

$$\Delta H@ = \frac{[(T_R + 460)\,\theta\,]^2\,(0.0317)\,(\Delta H)}{(V_T)^2\,(P_B)\,(T_M + 460)}$$

$$Y = \frac{(T_M + 460)\,(P_B)\,(V_T)}{(\Delta H/13.6 + P_B)(T_R + 460)(V_M)}$$

note: calculate $[(T_R + 460)\,\theta\,]^2$ first

ENTROPY ENVIRONMENTALISTS, INC.

NOZZLE CALIBRATION DATA

NOZZLE # 310

DATE	INITIALS	DIAMETER, in. 1	2	3	4	AVERAGE
7-18-77	WN	.367	.367	.367	.367	.367
4-5-78	MH	.368	.369	.367	.368	.368
1-4-80	JTN	.363	.366	.366	.366	.365
2-26-80	MH	.369	.365	.369	.365	367

NOZZLE CALIBRATION DATA

NOZZLE # 371

DATE	INITIALS	DIAMETER, in. 1	2	3	4	AVERAGE
7-18-77	WN	.369	.373	.370	.371	.371
4-6-78	MH	.371	.371	.367	.371	.370
1-4-80	JTN	.365	.368	.366	.368	.367
4-11-80	LAT	.373	.375	.374	.374	.374