BR 2.2
33
4.0

The Commonwealth of Massachusetts
Executive Office of Environmental Affairs
Department of Environmental Quality Engineering
Southeast Region
Lakeville Hospital, Lakeville, Massachusetts 02346
947-1231, Ext. 680-684

ANTHONY D. CORTESE Sc. D
Commissioner

PAUL T. ANDERSON
Regional Environmental Engineer

October 4, 1983

Mr. Robert M. Dykes
Radian Corporation
3024 Pickett Road
Durham, North Carolina 27705

RE: SMAPCD--ATTLEBORO--Massachusetts General Laws, Chapter 111, Section 142B, Attleboro Advanced Waste Water Treatment Facility

Dear Mr. Dykes:

Enclosed is a stack sampling report prepared by David Gordon Associates, Inc., relative to emissions tests performed during the week of May 9, 1983, on the sludge incinerator at the Attleboro Advanced Waste Water Treatment Facility in Attleboro, Massachusetts. Additional information on the subject incinerator including test data; operating conditions and source description; compliance status and operating schedule; and the facility representative; has been summarized below.

1. To date, three series of compliance tests have been performed at this facility of which we have provided the most recent stack sampling report.

2. Data on the test operating conditions as well as a description of the tested incinerator are contained in the referenced test report.

3. To date, this facility has not demonstrated compliance with the "Regulations," although this status may change pending our decision on the results of the May 9, 1983 test which is currently under Departmental review. As a result, the subject incinerator is only operated on an intermittent basis for the purpose of training City personnel.

4. Mr. David Butterfield, Superintendent, Attleboro Department of Public Works, may be contacted at the facility for additional information.

This information should adequately answer the request contained in your letter dated September 9, 1983 relative to emissions and operating data for sewerage sludge incinerators located in Southeastern Massachusetts. If you need any additional information, please contact Ms. Mary Guiney at the above address.

Very truly yours,

For the Commissioner

Vaughan M. Steeves

Vaughan M. Steeves, Chief
Air Quality Control Section

S/MG/re

Enclosure

cc: Mr. David Butterfield
Superintendent
Dept of Public Works
25 So. Main Street
Attleboro, MA 02703

Board of Health
25 So. Main Street
Attleboro, MA 02703

DAQC - Engineering Branch

STACK SAMPLING REPORT

COMPLIANCE TEST #3

AT

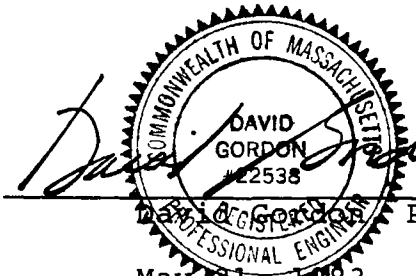
ATTLEBORO ADVANCED WASTE WATER TREATMENT FACILITY
ATTLEBORO, MASSACHUSETTS

FOR

ENVIROTECH, BSP
ONE DAVIS DRIVE
BELMONT, CA 94002

Prepared by:

DAVID GORDON ASSOCIATES, INC.
385 ELLIOT STREET
NEWTON UPPER FALLS, MA 02164



David A. Gordon, P.E.

May [illegible], 1983

Project No. 83082

I. INTRODUCTION

David Gordon Associates, Inc. was contracted by Envirotech, BSP to perform emission testing of the sludge incinerator at the Attleboro Advanced Waste Water Treatment Facility in Attleboro, Massachusetts. The purpose of these tests is to show compliance with the Code of Federal Regulations Title 40, Part 60, Subpart 0. Methods 1-5 of the Code of Federal Regulations Title 40, Part 60, Appendix A were used for the tests. The tests were performed by personnel from David Gordon Associates, Inc. who have extensive experience in running these tests. Testing was completed during the week of May 9, 1983. The testing was observed by Mr. John Winkler of the Department of Environmental Quality Engineering.

This is the third series of compliance tests to be performed on this incinerator. The first series was performed in December, 1981. During the first series of tests the incinerator was operated by personnel from Envirotech, BSP. The second series of tests was performed during the week of February 14, 1983, with the incinerator operated by personnel from the City of Attleboro. However, the incinerator failed to meet allowable emission rates.

During the second series of tests, scum was fed into the incinerator by atomization onto hearths #4 and #6. It is the belief of Envirotech, BSP that if scum was fed into hearth #6 alone, without atomization, that the incinerator would meet allowable emission rates. The incinerator was operated in this manner for this test.

II. DESCRIPTION OF INCINERATOR BEING TESTED

The incinerator tested is a multi-hearth sludge incinerator with seven hearths. Hearth #1 has an afterburner which is used to burn off hydrocarbons. The afterburner is capable of burning either gas, at a maximum rate of 4890 cfh, or #2 fuel oil, at a maximum rate

of 35 gph. The afterburner was not operated during this test. Hearth #2 is the drying hearth. Hearths #3-#6 are the burning hearths and hearth #7 is for cool down of the ash. The incinerator is equipped with six burners rated at 19.3 gph of #2 fuel oil and 6 burners rated at 2700 cfh of gas. Gas was used exclusively during the testing period. Combustion air is supplied by combustion air blowers, auxiliary combustion air blowers and shaft cooling air return.

The incinerator is rated to burn 3350 lb/hr of sludge dry basis. The sludge is fed into the incinerator via a continuous variable conveyor which is equipped with a Merrick scale. Scum is fed into the incinerator via a separate feed, and is fed at a rate up to 1.4 gpm.

The emissions exit from the incinerator at hearth #1. The gas immediately enters a pre-cooler and then through a venturi scrubber, an impingment scrubber and then through an induced draft fan. Figure 1 is a schematic of this system. The venturi scrubber is operated at a pressure drop of approximately 20" and the impingment scrubber has a pressure drop of 6"-8" H_2O. The I.D. fan is rated at 10,000 cfm.

III. TESTING PROGRAM

The emissions from the incinerator were tested for total particulates. During the testing, hourly samples of sludge feed and ash, and 15 minute samples of scum were taken. The sludge feed was taken from the end of the feed belt just prior to entering the furnace. The ash was taken from hearth #7. The scum was taken from the outlet of the scum concentrator. The sludge and scum samples were analyzed for solids content, and the ash was analyzed for percent volatiles.

IV. LOCATION OF SAMPLING PORTS

Figure 2 shows the location of sampling ports on the stack. There are two sampling ports at 90° to each other. These ports are 10' downstream and 18' upstream of any disturbance of the flow. The stack is equipped with a Lear Siegler RM-41 optical transmisometer which is located 2' above the sampling ports.

V. TRAVERSE PLAN

In accordance with the provisions of Reference Method #1, 36 sampling points were taken per sample. The traverse plan is presented in Figure 3. Each point was tested for 2 minutes for a total of 72 minutes per test.

VI. SAMPLING TRAIN DESCRIPTION

The sampling train utilized for the test is a Bendix Corporation Stack Sampler which is approved by the EPA. We used a heated, 5 foot long, glass lined probe, a cyclone bypass, a high efficiency fiberglass membrane filter in a gasketed, heated holder. The filter was followed by four large impingers in an ice bath. The first two impingers were used to collect water vapor and contained 100 mls of water. The third impinger was used as a dry trap while the last was a weighed silica gel trap to collect water vapor. Gas flow was monitored by a calibrated orifice meter and the total volume monitored by a dry gas meter. Temperatures and pressures were monitored at appropriate locations in the system. Flow was drawn through the system by a positive displacement pump utilizing appropriate throttle and bypass valves for accurate flow adjustment insuring isokineticity at the nozzle. The gas profile in the duct was checked for cyclonic flow before testing. The sampling train was leak

checked before and after each sample.

The filters, fiberglass - 99.99% efficient on 0.3 micron diameter particles were kept in an air tight, dust free container both before and after testing. The samples were handled with forceps and care taken that material was neither gained nor lost. Care was taken to clean out the probe after each test, and the contents saved in glass containers. The filters were weighed before and after testing on the same balance (accurate to 0.1 mg). The filters were kept in a desiccator for 24 hours prior to any weighing.

Orsat gas analysis was performed at the sampling location. A sample of the stack gas was taken at each sample point in the stack and stored in an air tight gas sampling bag. This sample was saved until the completion of each test. The stored gas was then analyzed with a Fisher Scientific Orsat Analyzer to determine the percentages of CO_2 and O_2 in the stack gas. The gas samples were also analyzed for total hydrocarbons using a Beckman total hydrocarbon analyzer.

VII. CHAIN OF CUSTODY AND QUALITY CONTROL

The responsibility for maintaining the integrity of samples collected rested with the project engineer. Samples were stored in sealed containers for transport back to our laboratories for analysis. The personnel taking the samples also performed the analysis and data reduction of the samples. The personnel who performed the tests were Kevin Drinan, project engineer; Andrea Fee, senior technician; and Thomas Cavanaugh, technician.

VIII. RESULTS

The results of the testing are shown in the following tables. These results show that the incinerator does comply with the Code of Federal Regulations Title 40, Part 60, Subpart O.

TABLE 1

RESULTS OF PARTICULATE SAMPLES

Sample	Emission lb/hr	SLUDGE FEED * Tons/hr Wet	% Solids	Tons/hr Dry	Scum Feed Dry Ton/hr	Emission lb/Ton Dry Solids	Allowable lb/Ton Dry Solids
1	0.85	4.796	34.7	1.66	0.04	0.50	1.3
2	0.84	4.802	34.4	1.65	0.02	0.50	1.3
3	0.95	4.802	36.0	1.73	0.04	0.54	1.3
Average						0.51	1.3

* Feed rate based on average of 10 minute readings on feed belt scale.

RESULTS OF EXHAUST GAS ANALYSIS

Sample #	VLC	Vm Std.	CS	BWO	MD	VS	QS	E	%O_2	%CO_2	Ts	I
1	26.2	51.18	0.010	2.4	29.57	42.5	9923	0.85	11.7	6.9	110	92
2	33.5	57.37	0.010	2.7	29.56	42.9	9823	0.84	11.8	6.8	118	104
3	32.0	57.82	0.011	2.6	29.54	43.8	10040	0.95	12.2	6.6	118	102

VLC = Volume of water collected, milliliters
Vm Std = Volume of dry gas sampled at STP, cubic feet
CS = Concentration of particulate matter, grains per dscf
BWO = Percent of water vapor in gas (by volume)
MD = Molecular weight dry basis, lb per lb - mole
VS = Stack gas velocity, feet per second
QS = Volumetric flow rate @ STP, cubic feet per minute
E = Emission rate in lb/hr
O_2 = Percent O_2 in gas stream by weight
CO_2 = Percent CO_2 in gas stream by weight
Ts = Average stack gas temperature ^{o}F
I = Percent isokinetic variation

TABLE 2

TABLE 3

ANALYSIS OF SLUDGE FEED CAKE

Date	Time	% Solids
5/11/83	12:03	33.7
	13:03	34.5
	14:13	34.8
	14:34	34.9
5/12/83	11:01	33.6
	12:01	35.5
	13:01	35.5
	13:57	36.1
	14:24	36.3

TABLE 4

ANALYSIS OF SCUM

Date	Time	mg/l
5/11/83	13:18	108,582
	13:33	111,018
	13:48	149,886
	14:03	106,079
	14:18	176,248
5/12/83	10:54	136,006
	11:09	41,192
	11:24	44,940
	11:39	36,242
	11:54	27,925
	12:09	39,810
5/12/83	13:04	107,517
	13:19	104,117
	13:34	72,635
	13:49	90,772
	14:04	242,841

TABLE 5

ANALYSIS OF ASH

Date	Time	% Volatiles by weight
5/11/83	12:10	2.4
	13:05	1.2
	14:08	2.0
	14:38	1.0
5/12/83	10:58	0.6
	11:58	0.8
	13:58	0.7
	14:27	0.5
	14:55	1.3

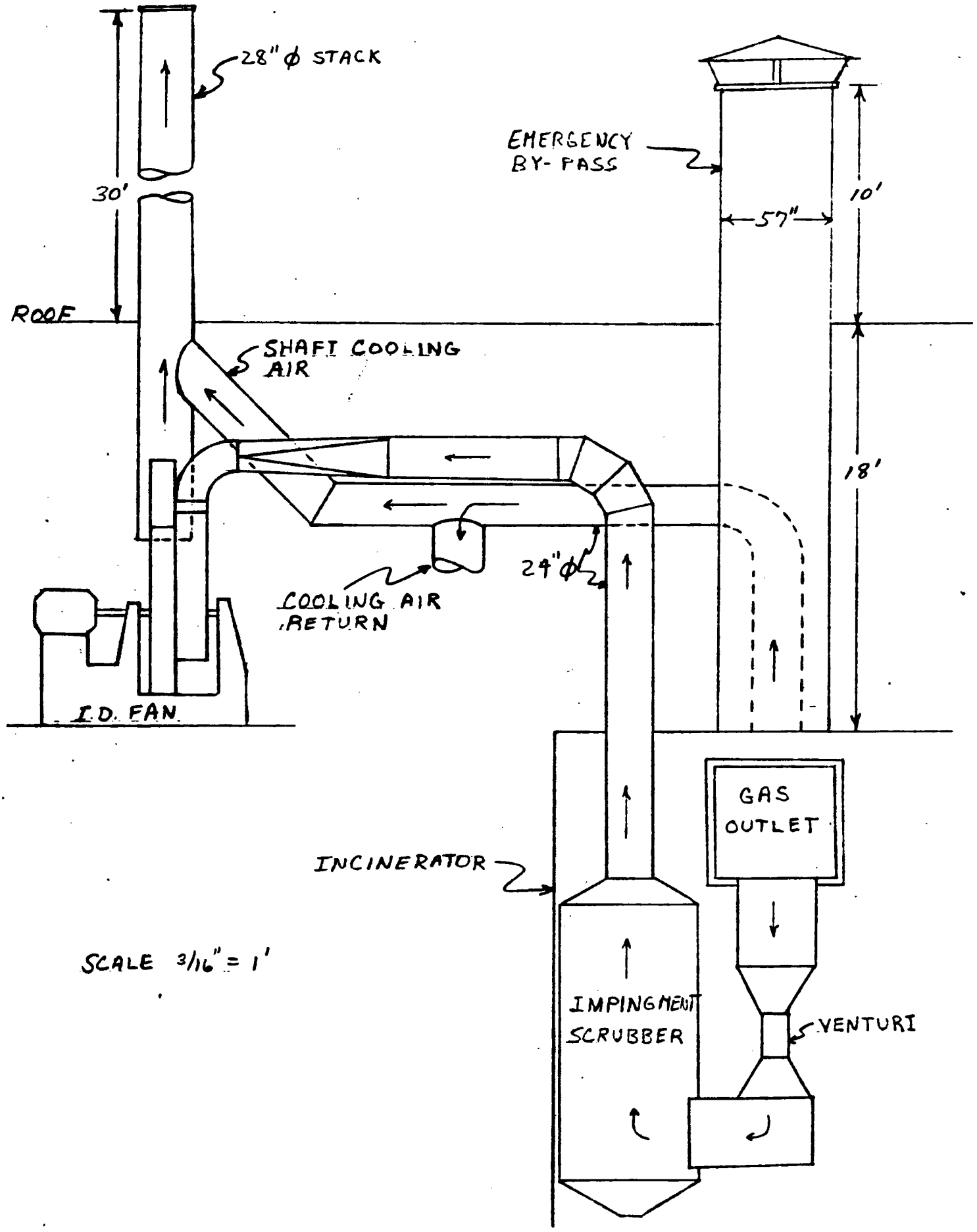
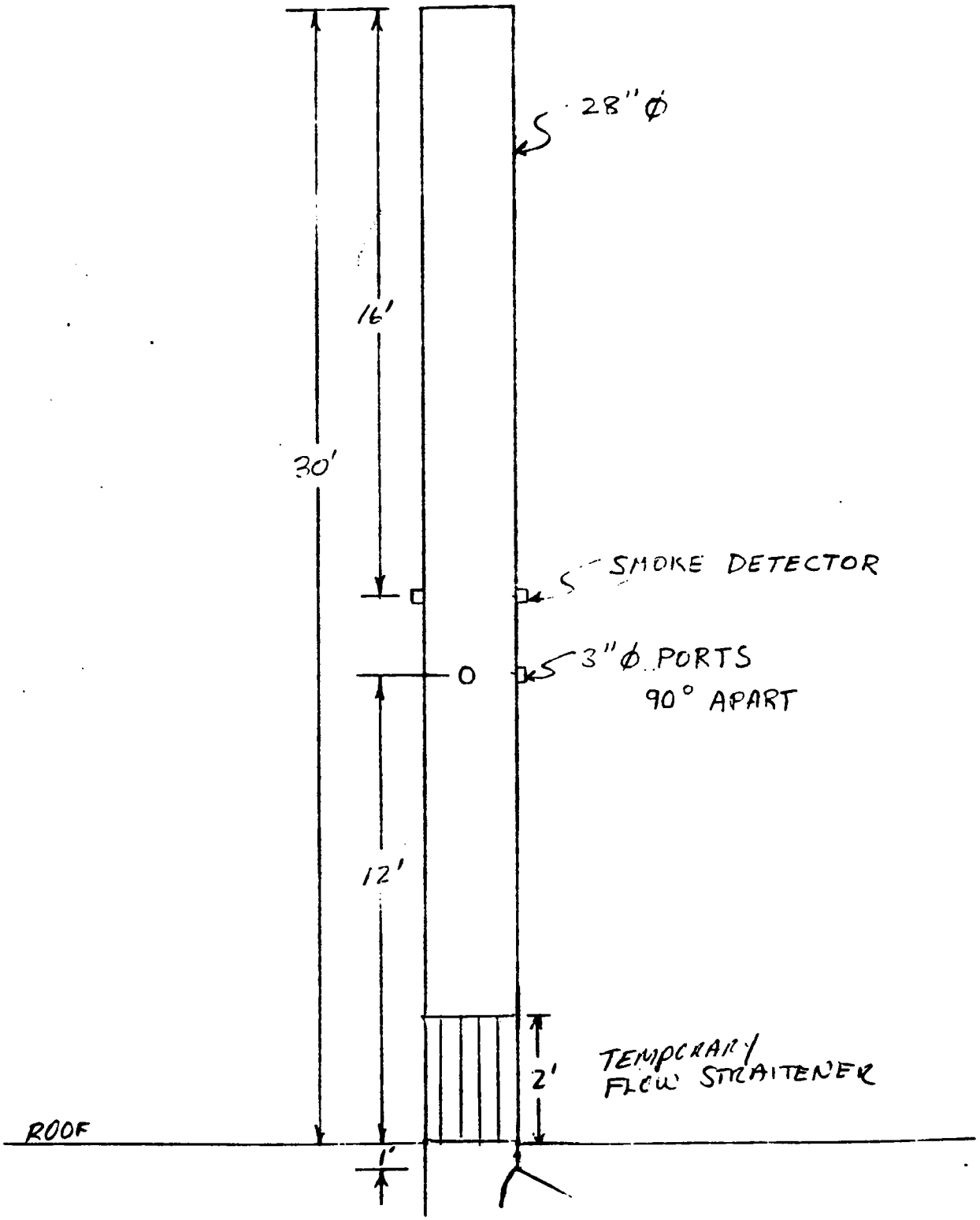


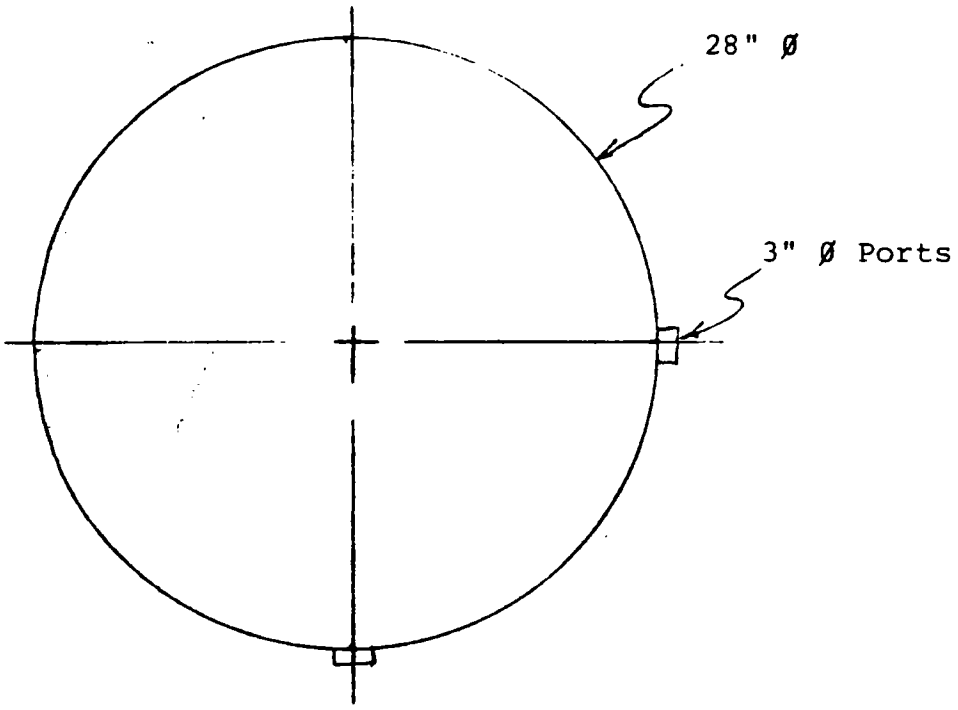
FIGURE 1
EXHAUSTS GAS FLOW

FIGURE 2

SAMPLING LOCATION



TRAVERSE PLAN



POINT	DISTANCE
1	1.00"
2	1.25"
3	2.10"
4	3.05"
5	4.10"
6	5.25"
7	6.6"
8	8.3"
9	10.70"
10	17.3"
11	19.7"
12	21.4"
13	22.75"
14	23.9"
15	24.95"
16	25.90"
17	26.75"
18	27.00"

FIGURE 3

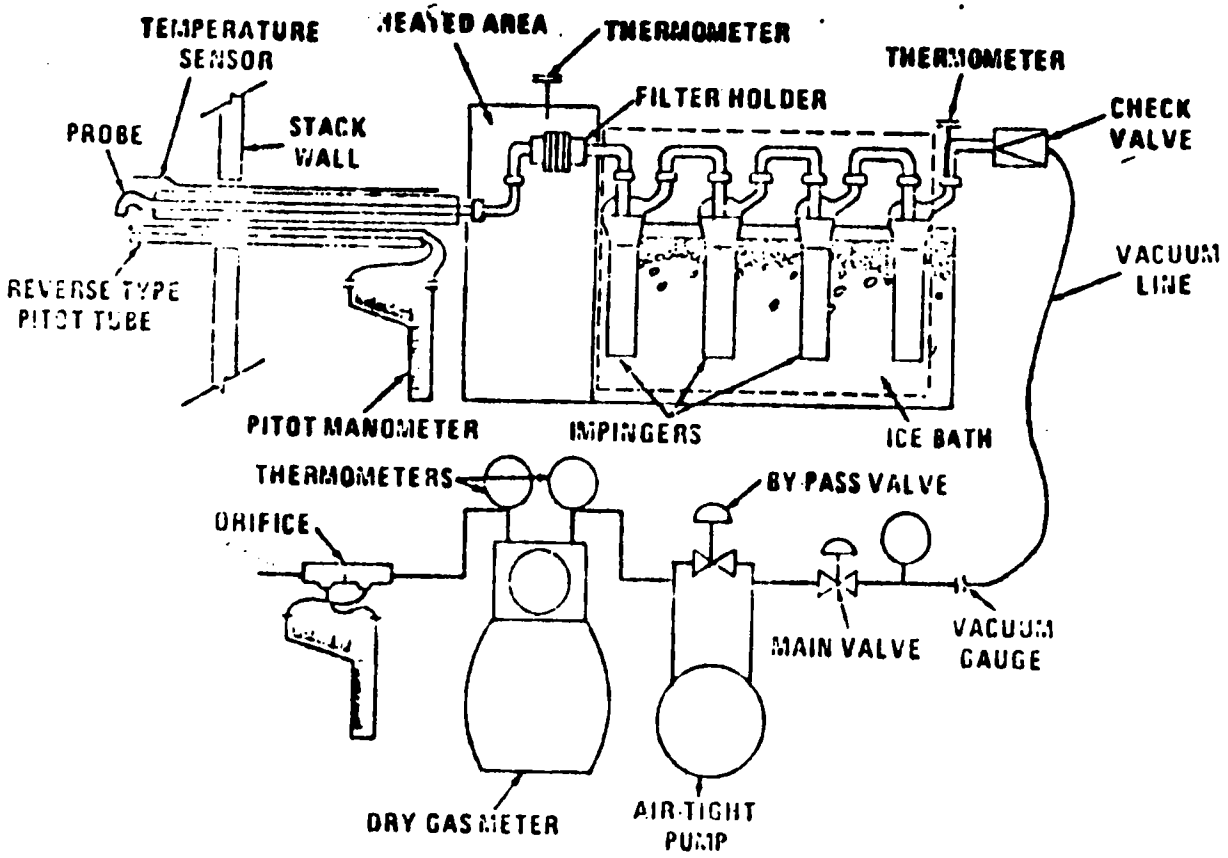


FIGURE 4

SAMPLING TRAIN

APPENDIX

INCINERATOR LOG

A-2

35-163

Attleboro Mass. Furnace Performance test

Date 5/11/83 Data

	Feed Sludge X.001 = Tons		Natural GAS				TE
					H-1	H-2	H-3
TIME	Totalizer	TPH	Meter	CFM	1	2	3
10 22	0	0	80480		1100	1220	1325
11 20	4069	4.069	87178		874	954	1304
1:07	12761	4.88	93420		974	1100	1596
2:06	17321		95900		939	1076	1537
3:06	22140		98519		829	975	1412
	5/12/83 test2						
~~8:30~~	11100		14350		939	968	1363
10:55	13230		16100		954	1012	1415
11:55	17835		20420		1012	1049	1449
	test 3						
255	22851		25065		1022	1074	1508
1355	27672		28970		1026	1074	1518

A-3

6	7	8	9	10	11	12	13
MPERATURES							
H-4	H-5	H-6	H-7	shaft air	Precooler	Seperator	Seperator
4	5	6	7	8	9	10	11
1280	1475	1150	150	248	919	75	72
1423	1468	1177	125	238	816	99	85
1717	1442	1123	341	256	926	125	86
1652	1426	1122	401	278	917	118	77
1548	1426	1155	363	268	874	112	84
1498	1458	1120	350	256	875	125	79
1533	1473	1120	346	249	907	138	81
1555	1458	1141	380	266	953	147	83
1633	1448	1145	445	281	940	129	78
1630	1441	1173	402	274	943	127	90

35-163 Attleboro Mass Furnace Performance test #4

	TIME	Incinerator Oxygen %	Breaching OXYGEN %	Stack Opacity %	1 Center Shaft Speed RPM	2 Shaft Cool Air Damper Position %	3 Aux. Comb. Air Flow SCFM	4 Aux. Comb. Air Fan Position %	5
1	10 25	10.6	12.5	.1	1.0	40	4	3	
2	10 21	5.7	7.5	1.2	1.0	40	72	2	
3	13 10	3.0	6.6	1.6	1.0	40	1945	100	
4	14 07	3.7	7.6	1.3	1.0	40	939	4	
5	15 06	6.4	9.6	3.6	1.0	40	834	5	
6									
7	5/12/83								
8		test 2							
9	10:30	6.1	7.3	1.5	1.0	45	974	3	
10	1055	3.7	6.7	2.0	1.0	45	1360	29	
11	11:55	4.5	6.0	1.4	1.0	45	1573	100	
12									
13									
		test 3							
15	12 55	6.1	7.4	1.5	1.0	45	1776	71	
16	13 55	4.7	6.1	1.7	1.0	45	1760	99	
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									
33									
34									
35									

6 Hearth 3 Aux Air Position %	7 Hearth 4 Aux Air Position %	8 Hearth 5 Aux Air Position %	9 Hearth 3 Burner setting %	10 Hearth 5 Burner Setting %	11 Hearth 6 Burner Setting %	12 Venturi Differential Pressure "wc	13 Venturi Damper Position %
1	0	1	1325 20	1475 30	1150 25	25"	100
2	0	1	1325 10	1475 12	1150 27	22.1	100
13	19	14	1310 off	1440 14	1150 17	25	84
20	25	25	1310 off	1425 17	1125 14	21.9	88
10	10	25	1310 off	1425 05	1125 0.4	16.9	100
1	0	7	1325 off	1460 17	1130 18	22.0	99
0	0	7	1325 off	1460 14	1130 25	21.6	97
0	4	14	1325 off	1460 19	1130 29	22.4	98
0	9	19	1325 off	1430 23	1130 4	22.1	100
0	5	19	1325 off	1450 22	1140 19	23.3	99

$\bar{x} = 22$

NATIONAL 35-163 Attleboro Mass. Furnace Performance test H-6

TIME	Furnace Draft " W.C.	I.D Fan Damper Position %	1 Scrubber ΔP " W.C.	2 Water Gallons Pre-Cooler	3 Venturi	4 Separator W.G/A.B.	5 Per M Expansion Joint.
10 26	-0.18	48%	8.4	150	75	278	15
11 23	-0.25	34%	9.0	150	75	273	15
13 12	-0.2	49%	11.2	150	80	275	15
14 09	-0.21	44%	10.9	150	80	274	15
15 07	-0.17	48%	9.9	150	80	275	15
		60%					
5/12/83 test #2							
10:30	-0.18	60%	11.0	150	75	280	15
10 56	-0.18	60%	11.2	155	80	278	15
11 56	-0.16	62%	11.0	155	75	278	15
Test #3						2	
12:55	-0.20	61%	11.2	155	75	278	15
13 55	-0.20	60%	12.1	155	75	278	15
			10.6				

H-1

7 Ambient Air °C	8 Scum Feed tank level	9 Scum Pump Feed setting Gallons/minute	10	11 Remarks	12	13
15	OFF					
15	33" OFF	1.0		11:40 AM Scum Pump start 33"		
14	42" ON	1.0		13:06 Emissions test start		
14	49" ON	1.0		14:24 Emissions test stop.		
15	51" OFF			14:25 Scum Pump off		
				Total scum burned - 179.5 gallons		
				Scum Average Feed Rate - 1.088 gpm (Measured)		
	36.5 off					
14	36.5" ON	1.0		10:30 Scum pump started at 36.5" Level		
14	42"	1.0		10:55 Emissions test start.		
15	47.5"	1.0		12:10 Emissions test stop.		
				Scum Average Feed Rate 1.3 gpm (Measured)		
15	54"	1.0		12:55 Emission test start		
16	61"	1.0		14:10 Emission test stop.		
	64"	1.0		14:25 Scum pump stopped.		
				Scum Average feed Rate 1.2 gpm (Measured)		

Instantaneous Feed Readings

IT 0

Merrick Scale

RUN #1			RUN #2			RUN #3		
Time	Feed	TPH	Time	Feed	TPH	Time	Feed	TPH
1:00	12224		11:~~0~~5	4890	13972	12:55	6090	22699
1:13	4.800	13041	11:15	4.746	14763	1:05	4.788	23410
1:23	4.822	13831	11:25	4.806	15405	1:15	4.808	24320
1:33	4.854	14631	11:35	4.782	16384	1:25	4.722	25069
1:43	4.668	15428	11:45	4.908	17119	1:35	4.830	25870
1:53	4.764	16228	11:55	4.635	17990	1:45	4.800	26725
2:03	4.965	17031	12:05	4.824	18767	1:55	4.818	27561
2:13	4.794	17832	12:15	4.824	19581	2:05	4.830	28470
2:23	4.734	18630	~~12:25~~			2:15	4.818	28719
2:33	4.716	19427	~~12:35~~					
	Ave 4.8 ta/hr.			Ave 4.8			Ave 4.9	
	Test start 1:06			Test start 11:05			Test start ~~12:50~~ 12:55	
	Test stop 2:~~24~~			Test stop 12:10			Test stop 2:10	

Log Book

H-1

5/11/83

1050 Start feed @ 7600 lbs/hr.

1036 Increased feed rate to 9600 lbs/hr.
* 1140 Started scum @ 1 GPM. to H#6
1143 Decreased H#3 temp from 1325 to 1310°.

1200 Opened pie plates to about 1". on H#7.

1230 Decreased H#5 temp from 1475° to 1465°.
1231 Increased Aux Air H#4 from 7% to 12%.
1245 Decr H#5 temp from 1465 - 1450°F.

100 Increased Aux Air on H#3 from 3% to 12%.

103 Increased Aux Air H#4 from 12% to 20%.
* 106 Stopped 1st test.
112 Decreased temp on H#5 from 1450° to 1440°.

123 Increased Aux Air H#3 from 12% to 16%.
Increased Aux Air H#4 from 20% to 22%.

131 Increased Aux Air H#3 from 16% to 20%.
Increased Aux Air H#5 from 20% to 25%.

134 Decreased temp on H#5 from 1440° to 1425°.
Decreased temp on H#6 from 1150° to 1125°.
Increased Aux air on H#4 from 22% to 30%.

152 Increased O2 set point from 6.8 to 7.0.

154 Decreased Aux Air H#4 from 30% to 25%.
* 224 1st. test ended

* 224 End Test I. Shut off scum feed
Decr. H#3 aux air to 15 from 20%
Decr H#4 " " to 20 " 25%.

240 Decr H#3 aux air to 10
" H#4 " " to 10

315 End feed

400 Turned down scrubber water to minimum flow.

May 12, 1983

0715 Visual check of equipment
Opened center shaft. Bled air compressor

0815 Start fuel at 4.8 T/H
Plant water up to max flow

936 DECREASED AUX. AIR ON H#5 FROM. 12% to 7%.

9:50 Computer time 21:50. 5/11/83

1000 Problem - gas pressure low coming into building. Notified Bay State Gas. KW decided to run gas v_al.

10:30 Scum Level 36.5" from top of tank.

* 10:30 STARTED SCUM FEED

* 10:55 STARTED 2ND. TEST

5/12/83

##
1120 Drew out on H#5 to 10%

11:39 Opened the other door on H#7 also increased Aux Air H#4 from 0 to 5%.

11:47 Increased Aux Air H#5 from 10% to 15%.

1203 Increased Aux. Air H#5 from 15% to 20%.

* 1210 Ended 2nd test.

1211 Increased H#4 from 5% to 10%.

1213 Decreased H#5 temp from 1460° to 1455°.

12:45 Change Drag conveyor #1 on #2 off

12.46 Hearth 5 from 1455 to 1450

* 1255 Start 3rd test.

104 Decreased Aux. Air H#4 from 10% to 5%

115 Increased temp on H#6 from 1130° to 1140°.

123 Decreased DRAG Belt #1 Setpoint from 20 to 17.

* 2:10 3rd test ended.

A-12

CALCULATION AND FIELD DATA SHEETS

A-13

DAVID GORDON ASSOCIATES, INC.
CONSULTANTS IN POLLUTION CONTROL

385 ELLIOT STREET
NEWTON UPPER FALLS, MA. 02164
(617) 964-1330

CALCULATION OF PARTICULATE EMISSION RATE AS PER EPA METHOD 5

PLANT: Attleboro Advanced Waste Water Treatment Plant

PROCESS: Sludge Incinerator Run #1

DATE OF TESTS: May 11, 12, 1983

PERFORMED BY: _____

TEST DATA, CALCULATIONS AND RESULTS

1. FIELD MEASUREMENT AVERAGES

P = Average $\sqrt{\Delta P}$ = 0.736 inches of water

H = $(Pb + \frac{\Delta H}{13.6})$ = $(30.09 + \frac{1.17}{13.6})$ = 30.18 inches of Hg

PS = $(Pb + \frac{Ps}{13.6}$ = $(30.09 + \frac{-.20}{13.6})$ = 30.08 inches of Hg

TM = Average temperature of meter + 460 = 60 + 460 = 520° Rankine

TS = Average stack temperature + 460 = 110 + 460 = 570° Rankine

Where

Pb = barometric pressure, inches of Hg

P = mean square root of velocity pressures, inches of water

ΔP = velocity pressure, inches of water

H = average absolute pressure drop across the orifice, inches of Hg

ΔH = average pressure drop across the orifice, inches of water

PS = average absolute pressure of stack, inches of Hg

Ps = average pressure of stack, inches of water

2. VOLUME OF WATER VAPOR SAMPLED

2.1 Water Collected

	Initial	Final	Net Collected
1st Impinger	100 ml	104 ml	4 ml
2nd Impinger	100 ml	110 ml	10 ml
3rd Inpinger	0 ml	2 ml	2 ml
4th Impinger (silica gel)	458.9 gr	469.1 gr	10.2 ml
	gr	gr	ml
		TOTAL VLC	26.2 ml

2.2 Volume of Water Vapor Collected at Standard Conditions (70°F, 29.92 inches Hg)

VW std = (0.04715 cu.ft./ml) (VLC)

VW std = (0.04715) (26.2) = 1.24 cu. ft.

Where

VLC = volume of water collected, ml

VW std = volume of water vapor collected @ STP, cubic feet

3. VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

3.1 Volume of Dry Gas Sampled at Gas Meter Conditions

Final dry gas meter reading	886.114	cu.ft.
Initial dry gas meter reading (minus)	838.047	cu.ft.
Subtotal VM	48.067	cu.ft.
Leak Tests (minus)	—	cu.ft.
TOTAL VM	48.067	cu.ft.

3.2 Volume of Dry Gas Sampled at Standard Conditions

$$VM_{std} = (17.64)(Y)\left(\frac{VM\ H}{TM}\right)$$

$$VM_{std} = (17.64)(1.04)(48.067)\left(\frac{30.18}{520}\right) = 51.18 \text{ SCF}$$

Where

VM std = volume of dry gas sampled @ STP, cubic feet

VM = the dry gas volume measured by meter in cubic feet

H = average absolute pressure drop across the orifice, inches Hg

TM = average absolute dry gas meter, degree Rankine

Y = dry gas meter calibration factor

4. COLLECTED SAMPLE WEIGHT AND CONCENTRATION OF PARTICULATE MATTER

4.1 Collected Sample Weight

Filter Number	Initial Weight	Final Weight	Sample
434	616.8 mg	643.8 mg	27.0 mg
	mg	mg	mg
	mg	mg	mg
	mg	mg	mg
	mg	mg	mg

Sample recovered from probe and glassware 7.2 mg

Total Sample Weight 34.2 mg

4.2 Concentration of Particulate Matter

CS = (0.0154 gr/mg)(MN/VM std)

CS = (0.0154)(34.2 / 51.18) = .010 gr/SCF

(.010 gr/SCF)/7000 = 1.47×10^{-6} lbs/SCF

Where

CS = concentration of particulate matter, grains/dscf

MN = total sample weight, mg

VM std = volume of dry gas sampled @ STP, cubic feet

5. MOISTURE CONTENT OF STACK GAS

BWO = (100)(VW std) / (VM std + VW std)

BWO = (100)(1.24) / (51.18 + 1.24) = 2.37 %

Where

BWO = percent of water vapor by volume

VW std = volume of water vapor collected @ STP, cubic feet

VM std = volume of dry gas sampled @ STP, cubic feet

6. ORSAT ANALYSIS OF STACK GAS

% CO_2 = 6.9 % O_2 = 11.7 % CO = 0

% N_2 = 81.4

Molecular Weight Dry Basis

$MD = (0.44)(\%\ CO_2) + (0.32)(\%\ O_2) + (0.28)(\%\ N_2)$

$MD = (0.44)(\ 6.9\ ) + (0.32)(\ 11.7\ ) + (0.28)(\ 81.4\ )$

$= 29.57$ lb/lb-mole

Molecular Weight Wet Basis

$MS = MD(1-(BWO/100)) + (18)(BWO/100)$

$MS = (29.57)(1-(2.37/100)) + (18)(2.37/100) = 29.30$ lb/lb-mole

Where

BWO = percent moisture water vapor by volume

MD = molecular weight dry basis, lb/lb-mole

MS = molecular weight wet basis, lb/lb-mole

7. EXCESS AIR

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

$$EA = (100)\left\{[(\quad)-0.5(\quad)] \Big/ [0.264(\quad)-(\quad)+0.5(\quad)]\right\}$$

EA = N/A %

8. AVERAGE STACK GAS VELOCITY

VS = (K) (C) (P) $\sqrt{(TS)(PS)(MS)}$

VS = (85.48)(.84)(0.736) $\sqrt{\frac{570}{(30.08)(29.30)}}$ = 42.5 fps

Where

VS = stack gas velocity, feet per second

K = 85.48 (ft./sec.)(lb/lb-mole-^{o}Rankine)$^{\frac{1}{2}}$

C = pitot tube coefficient, dimensionless

P = mean square root of velocity presure, inches H_2O

TS = average absolute temperature of stack gas, degrees Rankine

PS = average absolute stack pressure, inches Hg

MS = molecular weight of stack gas(wet basis), lb/lb-mole

9. STACK GAS FLOW RATE

Stack dimensions or inside diameter = 2.33 feet

Stack cross sectional area A = 4.28 sq. feet

QS = (60) (1-BWO/100)(VS) (A) (TST/TS) (PS/PST)

QS = (60) (1- (2.37/100)(42.5) (4.28) (528/570) (30.08/29.92)

= 9923 cfm dscfm

Where

QS = volumetric flow at STP, cubic feet per minute

BWO = percent moisture water vapor by volume

VS = velocity of stack gas, feet per second

A = area of stack, square feet

TST = absolute temperature at standard conditions, degrees Rankine

TS = average absolute temperature of stack gas, degrees Rankine

PS = average absolute pressure of stack, inches Hg

PST = absolute pressure at standard conditions, inches Hg

12. ISOKINETIC VARIATION

$$I = \frac{100(0.01667 \text{ min/sec}) \left[(0.00267 \frac{\text{in. Hg - cu.ft.}}{\text{ml - }^{o}R}) VLC + (Y)(VM)(H)/TM\right] TS}{\theta \, VS \, PS \, AN}$$

$$I = \frac{(1.667)\left[(0.00267)(26.2) + (104)(48.067)(30.18)/(520)\right](570)}{(72)(42.5)(30.08)(.000335)}$$

I = 92 % Isokinetic Variation

Where

VLC = volume of water collected, ml

VM = volume of gas collected at meter, cubic feet

TM = average absolute dry gas meter temperature, degrees Rankine

H = average absolute pressure drop across the orifice, in. Hg

TS = average absolute temperature of stack, degrees Rankine

θ = total sampling time, minutes

VS = velocity of stack gas, feet/second

PS = average pressure of stack, inches Hg

AN = area of nozzle, square feet

Y = dry gas meter calibration factor

A-20

LABORATORY DATA SHEET

PLANT: ATTLEBORO ADVANCED WASTE WATER TREATMENT PLANT

LOCATION: ATTLEBORO MA.

DATE OF TEST: MAY 11, 1983

DESCRIPTION OF SOURCE: SLUDGE INCINERATOR

RUN NUMBER: 1 OPERATOR: _____

Stack Filters

Serial Number:	434					
Final Wt.(mg):	643.8					
Initial Wt.(mg):	616.8					
Sample Wt.(mg):	27.0					

Total Sample Wt: _____ mg.

Probe and Nozzle Washing

Final Beaker Wt.(g):	99.6120	100.2764
Beaker Tare Wt.(g):	99.6043	100.2745
Sample Wt.(g):	7.7	1.9

= 9.6 mg

Total Sample Wt: _____ mg.

blank = 2.4 ~~8.5~~ %

Cyclone, Catch Flask and Filter Assembly Washings (INCLUDED above)

Final Beaker Wt.(g):		
Beaker Tare Wt.(g):		
Sample Wt.(g):		

= _____ mg

Total Sample Wt: _____ mg.

Impinger Contents

	Impinger #1	Impinger #2	Impinger #3
Final Volume(ml):	104	110	2
Initial Volume(ml):	100	100	0
Volume Collected(ml):	4	10	2

Final Silica Gel Wt.(g):	469.1	
Initial Silica Gel Wt.(g):	458.9	
Amount Collected (g):	10.2	

Total Volume of Liquid Collected: _____ ml.

DAVID GORDON ASSOCIATES, INC.
CONSULTANTS IN POLLUTION CONTROL

Plant Attleboro
Run Number 1
Location Stack
Date 5-11-83
Operator QF KD RL TC
Sample Box Number 2
Meter Number 2

Cyclonic

point	ΔP	θ
3	.33	6°
6	.33	0°
9	.35	-5°
11	.47	0°
14	.45	3°
16	.51	3°

Boiler or Process: Advanced Waste Water Treatment Plant
Ambient Temperature, °F 45
Barometric Pressure, in Hg. 30.09
Assumed Moisture % 4
Heater Box Setting, °F 250
Probe Tip Diameter, in. .25
Probe length, ft. 5
Probe Heater Setting 250

Schematics of Stack Cross Section

Point	Clock Time	Dry gas meter, ft^3	Pitot in. H_2O ΔP	Orifice ΔH, in. H_2O Desired	Orifice ΔH, in. H_2O Actual	Dry Gas Temperature, °F Inlet	Dry Gas Temperature, °F Outlet	Pump Vacuum in.Hg gage	Box Temp. °F	Impinger Temp. °F	Stack Pressure in.H_2O	Stack Temp. °F
1	1:05	838.047	.47	.80	.80	45	46	1	230	50		90
2	1:07	839.3	.35	.74	.74	49	46	1	230	50		90
3	1:09	840	.35	.74	.74	53	47	1	230	50		90
4	1:11	841.7	.45	.94	.94	55	47	1	230	50		90
5	1:13	842.9	.42	.90	.90	54	47	1	230	50		90
6	1:15		.42	.90	.90	54	47	1	230	50		90
7	1:17	844.3	.38	.83	.83	57	47	1	240	50		90
8	1:19	846.1	.43	.91	.91	58	47	1	250	50		90
9	1:21	847.5	.44	.94	.94	60	49	1	225	50	-.18	85
10	1:23	848.1	.55	1.2	1.2	63	49	1	250	50		75
11	1:25	849.9	.50	1.1	1.1	64	50	1	232	50		95
12	1:27	851.3	.65	1.4	1.4	65	50	1	232	50		75
13	1:29	853	.70	1.5	1.5	66	51	1	240	50		90
14	1:31	854.2	.70	1.5	1.5	66	51	1	240	50		90
15	1:33	856	.75	1.6	1.6	69	52	2	245	50		95
16	1:35	857	.70	1.5	1.5	70	53	2	245	50		100

P_i (impact) = _____ T_m °F _____
P_s (static) = _____ T_s °F _____
P_v (veloc.) = _____ C = _____
P_m = _____ D_{pn} = _____
P_s / P_m = _____ ΔH_a = _____

	CO_2 %	O_2 %
	7.0	11.6
	7.0	11.6
	6.8	11.8

Boiler Steam Rate _____ (lb/hr)
Boiler Gage Pressure _____ psig.
Boiler Fuel Rate _____ gph
Sulfur% Weight _____
Process Weight Rate _____ (lb/hr)

DAVID GORDON ASSOCIATES, INC.
CONSULTANTS IN POLLUTION CONTROL

385 Elliot Street
Newton Upper Falls, Ma 02164

Plant Attleboro
Run Number 1
Location Stack
Date 5-11-83

Point	Clock Time	Dry gas meter, ft^3	Pitot in. H_2O ΔP	Orifice ΔH in H_2O Desired	Orifice ΔH in H_2O Actual	Dry Gas Temperature, °F Inlet	Dry Gas Temperature, °F Outlet	Pump Vacuum in.Hg gage	Box Temp. °F	Impringer Temp. °F	Stack Pressure in.H_2O	Stack Temperature °F
17		859	.85	1.9	1.9	72	55	1	275	50		110
18		860	.76	1.6	1.6	73	55	1	270	50		105
31	1:46	861.596	.45	.96	.96	59	55	1	275	50		120
2	1:48	863	.45	.96	.96	65	56	1	275	50		120
3	1:50	864	.52	1.05	1.05	69	56	1	275	50		110
4	1:52	865.7	.47	1.0	1.0	71	67	1	275	50		125
5	1:54	867	.52	1.1	1.1	73	57	1	275	50	-.15	130
6	1:56	868.4	.47	1.0	1.0	74	58	1	275	50		130
7	1:58	869.5	.51	1.1	1.1	76	59	1	275	50		125
8	2:00	870.5	.45	.96	.96	76	60	1	275	50		125
9	2:02	872	.48	1.0	1.0	77	60	1	260	50		110
10	2:04	874	.50	1.10	1.10	77	61	1	260	50		105
11	2:06	874	.60	1.3	1.3	78	61	1	260	50		105
12	2:08	876	.65	1.4	1.4	79	62	2	260	50		105
13	2:10	877.5	.60	1.3	1.3	78	63	2	265	50	-.26	125
14	2:12	879.1	.67	1.45	1.45	78	63	2	265	50		130
15	2:14	880.4	.67	1.45	1.45	78	64	2	265	50		140
16	2:16	881.9	.65	1.4	1.4	78	64	2	265	50		155
17	2:18	883.4	.64	1.35	1.35	77	64	2	265	50		160
18	2:20	884.8	.65	1.4	1.4				2[illegible]			160
	2:22	886.114										

Averages

H-45

DAVID GORDON ASSOCIATES, INC.
CONSULTANTS IN POLLUTION CONTROL

385 ELLIOT STREET
NEWTON UPPER FALLS, MA. 02164
(617) 964-1330

CALCULATION OF PARTICULATE EMISSION RATE AS PER EPA METHOD 5

PLANT: Attleboro Advanced Waste Water Treat Attleboro, MA

PROCESS: Sludge Incin. Run #2

DATE OF TESTS: 5/12/83

PERFORMED BY: A.P., K.D., R.L., T.C.

TEST DATA, CALCULATIONS AND RESULTS

1. FIELD MEASUREMENT AVERAGES

P = Average $\sqrt{\Delta P}$ = .737 inches of water

H = $(Pb + \frac{\Delta H}{13.6})$ = $(30.02 + \frac{1.49}{13.6})$ = 30.13 inches of Hg

PS = $(Pb + \frac{Ps}{13.6}$ = $(30.02 + \frac{-.21}{13.6})$ = 30.01 inches of Hg

TM = Average temperature of meter + 460 = 70 + 460 = 530 °Rankine

TS = Average stack temperature + 460 = 118 + 460 = 578 °Rankine

Where

Pb = barometric pressure, inches of Hg

P = mean square root of velocity pressures, inches of water

ΔP = velocity pressure, inches of water

H = average absolute pressure drop across the orifice, inches of Hg

ΔH = average pressure drop across the orifice, inches of water

PS = average absolute pressure of stack, inches of Hg

Ps = average pressure of stack, inches of water

H 4

2. VOLUME OF WATER VAPOR SAMPLED

2.1 Water Collected

	Initial	Final	Net Collected
1st Impinger	100 ml	99 ml	−1 ml
2nd Impinger	100 ml	113 ml	+13 ml
3rd Inpinger	0 ml	4 ml	+4 ml
4th Impinger (silica gel)	4972 gr	5147 gr	17.5 ml
	gr	gr	ml
		TOTAL VLC	33.5 ml

2.2 Volume of Water Vapor Collected at Standard Conditions (70°F, 29.92 inches Hg)

VW std = (0.04715 cu.ft./ml) (VLC)

VW std = (0.04715) (33.5) = 1.58 cu. ft.

Where

VLC = volume of water collected, ml

VW std = volume of water vapor collected @ STP, cubic feet

3. VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

3.1 Volume of Dry Gas Sampled at Gas Meter Conditions

Final dry gas meter reading	941.237	cu.ft.
Initial dry gas meter reading (minus)	886.232	cu.ft.
Subtotal VM	55.005	cu.ft.
Leak Tests (minus)	0	cu.ft.
TOTAL VM	55.005	cu.ft.

3.2 Volume of Dry Gas Sampled at Standard Conditions

$$VM_{std} = (17.64)\,(Y)\left(\frac{VM\ H}{TM}\right)$$

$$VM_{std} = (17.64)\,(1.04)\left(55.005\right)\left(\frac{30.13}{530}\right) = 57.366 \text{ SCF}$$

Where

VM std = volume of dry gas sampled @ STP, cubic feet

VM = the dry gas volume measured by meter in cubic feet

H = average absolute pressure drop across the orifice, inches Hg

TM = average absolute dry gas meter, degree Rankine

Y = dry gas meter calibration factor

4. COLLECTED SAMPLE WEIGHT AND CONCENTRATION OF PARTICULATE MATTER

4.1 Collected Sample Weight

Filter Number	Initial Weight	Final Weight	Sample
435	624.2 mg	651.7 mg	27.5 mg
	mg	mg	mg
	mg	mg	mg
	mg	mg	mg
	mg	mg	mg

Sample recovered from probe and glassware 9.3 mg

Total Sample Weight 36.8 mg

4.2 Concentration of Particulate Matter

CS = (0.0154 gr/mg)(MN/VM std)

CS = (0.0154)(36.8 / 57.366) = 0.010 gr/SCF

(0.010 gr/SCF)/7000 = 1.41×10^{-6} lbs/SCF

Where

CS = concentration of particulate matter, grains/dscf

MN = total sample weight, mg

VM std = volume of dry gas sampled @ STP, cubic feet

5. MOISTURE CONTENT OF STACK GAS

BWO = (100)(VW std) / (VM std + VW std)

BWO = (100)(1.58) / (57.366 + 1.58) = 2.68 %

Where

BWO = percent of water vapor by volume

VW std = volume of water vapor collected @ STP, cubic feet

VM std = volume of dry gas sampled @ STP, cubic feet

6. ORSAT ANALYSIS OF STACK GAS

% CO_2 = 6.8 % O_2 = 11.8 % CO = 0

% N_2 = 81.4

Molecular Weight Dry Basis

$MD = (0.44)(\%\ CO_2) + (0.32)(\%\ O_2) + (0.28)(\%\ N_2)$

$MD = (0.44)(\ 6.8\ ) + (0.32)(\ 11.8\ ) + (0.28)(\ 81.4\ )$

$= 29.56$ lb/lb-mole

Molecular Weight Wet Basis

$MS = MD(1-(BWO/100)) + (18)(BWO/100)$

$MS = (\ 29.56\ )(1-(\ 2.68/100)) + (18)(\ 2.68\ /100) = 29.25$ lb/lb-mole

Where

BWO = percent moisture water vapor by volume

MD = molecular weight dry basis, lb/lb-mole

MS = molecular weight wet basis, lb/lb-mole

7. EXCESS AIR

$EA = (100)\{[(\%\ O_2)-0.5(\%\ CO)] / [0.264(\%\ N_2)-(\%\ O_2)+0.5(\%\ CO)]\}$

$EA = (100)\{[(\ )-0.5(\ )] / [0.264(\ )-(\ )+0.5(\ )]\}$

EA = NA %

8. AVERAGE STACK GAS VELOCITY

VS = (K) (C) (P) $\sqrt{(TS)/(PS)(MS)}$

VS = (85.48)(.84)(.737) $\sqrt{\frac{578}{(30.01)(29.25)}}$ = 42.9 fps

Where

VS = stack gas velocity, feet per second

K = 85.48 (ft./sec.)(lb/lb-mole-^{o}Rankine)$^{\frac{1}{2}}$

C = pitot tube coefficient, dimensionless

P = mean square root of velocity presure, inches H_2O

TS = average absolute temperature of stack gas, degrees Rankine

PS = average absolute stack pressure, inches Hg

MS = molecular weight of stack gas(wet basis), lb/lb-mole

9. STACK GAS FLOW RATE

Stack dimensions or inside diameter = 2.33 feet

Stack cross sectional area A = 4.28 sq. feet

QS = (60)(1-BWO/100)(VS)(A)(TST/TS)(PS/PST)

QS = (60)(1- (2.68/100)(42.9)(4.28)(528/ 578)(30.01 /29.92)

= 9823 cfm

Where

QS = volumetric flow at STP, cubic feet per minute

BWO = percent moisture water vapor by volume

VS = velocity of stack gas, feet per second

A = area of stack, square feet

TST = absolute temperature at standard conditions, degrees Rankine

TS = average absolute temperature of stack gas, degrees Rankine

PS = average absolute pressure of stack, inches Hg

PST = absolute pressure at standard conditions, inches Hg

H-24

12. ISOKINETIC VARIATION

$$I = \frac{100(0.01667 \text{ min/sec}) \left[(0.00267 \frac{\text{in. Hg - cu.ft.}}{\text{ml - }^{o}R}) VLC + \frac{(Y)(VM)(H)}{TM}\right] TS}{\theta \; VS \; PS \; AN}$$

$$I = \frac{(1.667)\left[(0.00267)(33.5) + (1.04)(55.005)(30.13)/(530)\right](578)}{(72)(42.9)(30.01)(.000335)}$$

I = 104 % Isokinetic Variation

Where

VLC = volume of water collected, ml

VM = volume of gas collected at meter, cubic feet

TM = average absolute dry gas meter temperature, degrees Rankine

H = average absolute pressure drop across the orifice, in. Hg

TS = average absolute temperature of stack, degrees Rankine

θ = total sampling time, minutes

VS = velocity of stack gas, feet/second

PS = average pressure of stack, inches Hg

AN = area of nozzle, square feet

Y = dry gas meter calibration factor

H-30

LABORATORY DATA SHEET

PLANT: ATTLEBORO ADVANCED WASTE WATER TREATMENT PLANT

LOCATION: ATTLEBORO MA.

DATE OF TEST: MAY 12, 1983

DESCRIPTION OF SOURCE: Sludge Incinerator

RUN NUMBER: 2 OPERATOR: _____

Stack Filters

Serial Number:	435					
Final Wt.(mg):	651.7					
Initial Wt.(mg):	624.2					
Sample Wt.(mg):	27.5					

Total Sample Wt: _____ mg.

Probe and Nozzle Washing

Final Beaker Wt.(g):	101.8220	96.2197	
Beaker Tare Wt.(g):	101.8142	96.2158	
Sample Wt.(g):	.0078	.0039	= 11.7 mg

Total Sample Wt: _____ mg. Blank - 2.4 = 9.3

Cyclone, Catch Flask and Filter Assembly Washings (INCLUDED above)

Final Beaker Wt.(g):			
Beaker Tare Wt.(g):			
Sample Wt.(g):			= mg.

Total Sample Wt: _____ mg.

Impinger Contents

	Impinger #1	Impinger #2	Impinger #3
Final Volume(ml):	99	113	4
Initial Volume(ml):	100	100	0
Volume Collected(ml):	-1	13	4

Final Silica Gel Wt.(g):	514.7	
Initial Silica Gel Wt.(g):	497.2	
Amount Collected (g):	17.5	

Total Volume of Liquid Collected: _____ ml.

DAVID GORDON ASSOCIATES, INC.

CONSULTANTS IN POLLUTION CONTROL

Plant Attleboro

Run Number 2

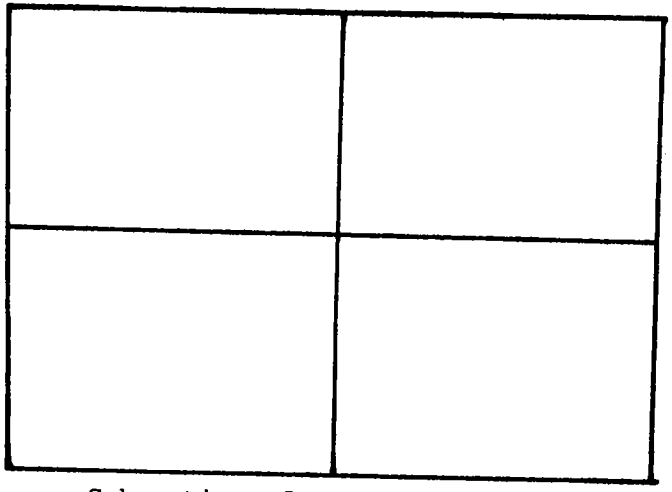
Location Stack

Date 5-12-83

Operator QF KD RL TC

Sample Box Number 1

Meter Number 2



Schematics of Stack Cross Section

Boiler or Process: Waste Water Treatment

Ambient Temperature, °F 57

Barometric Pressure, in Hg. 30.02

Assumed Moisture % 4

Heater Box Setting, °F 250

Probe Tip Diameter, in. .248

Probe length, ft. 5

Probe Heater Setting 250

Point	Clock Time	Dry gas meter, ft^3	Pitot in. H_2O ΔP	Orifice ΔH, in. H_2O Desired	Orifice ΔH, in. H_2O Actual	Dry Gas Temperature, °F Inlet	Dry Gas Temperature, °F Outlet	Pump Vacuum in.Hg gage	Box Temp. °F	Impinger Temp. °F	Stack Pressure in.H_2O	Stack Temp. °F
1	10:55	886.232	.40	1.1	1.1	57	59	2	250	60		110
2	57	887.8	.40.38	1.0	1.0	60	59	2	225	60		110
3	59	888.9	.40	1.1	1.1	63	59	2	225	60		110
4	11:01	890	.40	1.1	1.1	66	59	2	250	60		125
5	03	891.6	.41	1.1	1.1	68	59	2	250	60	-.16	145
6	05	892.9	.40	1.1	1.1	70	59	2	235	60		145
7	07	894.4	.36	.96	.96	71	60	2	265	60		140
8	09	895.6	.38	1.0	1.0	72	60	2	275	60		135
9	11	897	.42	1.15	1.15	73	60	2	230	60		130
10	13	898.5	.49	1.3	1.3	74	61	2	250	60		110
11	15	900	.65	1.8	1.8	76	62	2	230	60		100
12	17	901.4	.55	1.5	1.5	77	62	2	260	60		105
13	19	903	.62	1.7	1.7	78	63	2	265	60	-.26	110
14	21	904.9	.75	2.1	2.1	78	64	2 3	265	60		125
15	23	906.4	.70	1.9	1.9	79	64	2 3	265	60		125
16	25	908.1	.65	1.8	1.8	80	65	3	265	60		125

P_i (impact) = _____ T_m °F _____

P_s (static) = _____ T_s °F _____

P_v (veloc.) = _____ C = _____

P_m = _____ D_{pn} = _____

P_s / P_m = _____ ΔH_a = _____

CO_2 6.8 % O_2 11.8 %

6.8 11.8

6.8 11.8

Boiler Steam Rate _____ (lb/hr)

Boiler Gage Pressure _____ psig.

Boiler Fuel Rate _____ gph

Sulfur% Weight _____

Process Weight Rate _____ (lb/hr)

...ES, INC.
...LUTION CONTROL

385 Elliot St... t
Newton Upper Falls, Ma 02164

Plant Attleboro
Run Number 2
Location Stack
Date 5-12-83

...int	Clock Time	Dry gas meter, ft^3	Pitot in. H_2O ΔP	Orifice ΔH in H_2O		Dry Gas Temperature, ^oF		Pump Vacuum in.Hg gage	Box Temp. ^oF	Impringer Temp. ^oF	Stack Pressure in.H_2O	Stack Temperature ^oF
				Desired	Actual	Inlet	Outlet					
17	11 27	909.7	.70	1.9	1.9	80	65	3	230	60		130
18	29	911.4	.65	1.8	1.8	81	66	3	230	60		130
	11:31	912.736										
1	11:34	912.736	.48	1.3	1.3	74	66	2	230	60		100
2	36	914	.48	1.3	1.3	78	67	2	230	60		100
3	38	915.7	.48	1.3	1.3	79	67	2	230	60		100
4	40	917.5	.52	1.4	1.4	80	68	2	230	60		100
5	42	918	.58	1.6	1.6	81	68	2 3	240	60	-.18	95
6	44	920.3	.58	1.6	1.6	83	68	3	240	60		95
7	11:46	922	.56	1.5	1.5	83	69	3	240	60		95
8	48	923	.56	1.5	1.5	83	69	3	240	64		100
9	50	925.3	.56	1.5	1.5	82	70	3	270	64		100
10	52	926.7	.59	1.6	1.6	82	70	3	270	64		100
11	54	928.7	.56	1.5	1.5	83	70	3	270	64		110
12	56	930	.60	1.6	1.6	82	70	3	270	64		115
13	58	931	.62	1.7	1.7	82	70	3	270	64		120
14	12:00	933.1	.64	1.75	1.75	82	70	3	270	64	-.24	130
15	02	935	.65	1.8	1.8	82	70	3	270	64		135
16	04	936.5	.64	1.75	1.75	83	70	3	270	64		145
17	06	938	.63	1.7	1.7	84	70	3	270	64		150
18	08	940	.70	1.9	1.9	84	70	3	270	64		150
	12:10	941.237										
			.737	[illegible]								
				1.50.								

Averages

#-33

DAVID GORDON ASSOCIATES, INC.
CONSULTANTS IN POLLUTION CONTROL

385 ELLIOT STREET
NEWTON UPPER FALLS, MA. 02164
(617) 964-1330

CALCULATION OF PARTICULATE EMISSION RATE AS PER EPA METHOD 5

PLANT: Attleboro Advanced Waste Water Treatment Plant

PROCESS: Sludge Incinerator Run #3

DATE OF TESTS: May 11, 12 1983

PERFORMED BY: _____

TEST DATA, CALCULATIONS AND RESULTS

1. FIELD MEASUREMENT AVERAGES

P = Average $\sqrt{\Delta P}$ = .751 inches of water

H = $(Pb + \frac{\Delta H}{13.6})$ = $(30.01 + \frac{1.53}{13.6})$ = 30.12 inches of Hg

PS = $(Pb + \frac{Ps}{13.6}$ = $(30.01 + \frac{-.20}{13.6})$ = 30.00 inches of Hg

TM = Average temperature of meter + 460 = 73 + 460 = 533° Rankine

TS = Average stack temperature + 460 = 118 + 460 = 578° Rankine

Where

Pb = barometric pressure, inches of Hg

P = mean square root of velocity pressures, inches of water

ΔP = velocity pressure, inches of water

H = average absolute pressure drop across the orifice, inches of Hg

ΔH = average pressure drop across the orifice, inches of water

PS = average absolute pressure of stack, inches of Hg

Ps = average pressure of stack, inches of water

A-34

2. VOLUME OF WATER VAPOR SAMPLED

2.1 Water Collected

	Initial	Final	Net Collected
1st Impinger	100 ml	100 ml	0 ml
2nd Impinger	100 ml	114 ml	14 ml
3rd Inpinger	0 ml	4 ml	4 ml
4th Impinger (silica gel)	478.3 gr	492.3 gr	14.0 ml
	gr	gr	ml
		TOTAL VLC	32 ml

2.2 Volume of Water Vapor Collected at Standard Conditions (70°F, 29.92 inches Hg)

VW std = (0.04715 cu.ft./ml) (VLC)

VW std = (0.04715) (32) = 1.51 cu. ft.

Where

VLC = volume of water collected, ml

VW std = volume of water vapor collected @ STP, cubic feet

3. VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

3.1 Volume of Dry Gas Sampled at Gas Meter Conditions

Final dry gas meter reading	997.052	cu.ft.
Initial dry gas meter reading (minus)	941.279	cu.ft.
Subtotal VM	55.773	cu.ft.
Leak Tests (minus)		cu.ft.
TOTAL VM	55.773	cu.ft.

3.2 Volume of Dry Gas Sampled at Standard Conditions

$$VM_{std} = (17.64)\ (Y)\ \left(\frac{VM\ H}{TM}\right)$$

$$VM_{std} = (17.64)\ (10^{4})\ (55.773)\ \left(\frac{30.12}{533}\right) = 57.82 \text{ SCF}$$

Where

VM_{std}	=	volume of dry gas sampled @ STP, cubic feet
VM	=	the dry gas volume measured by meter in cubic feet
H	=	average absolute pressure drop across the orifice, inches Hg
TM	=	average absolute dry gas meter, degree Rankine
Y	=	dry gas meter calibration factor

4. COLLECTED SAMPLE WEIGHT AND CONCENTRATION OF PARTICULATE MATTER

4.1 Collected Sample Weight

Filter Number	Initial Weight	Final Weight	Sample
436	616.4 mg	648.5 mg	32.1 mg
	mg	mg	mg
	mg	mg	mg
	mg	mg	mg
	mg	mg	mg

Sample recovered from probe and glassware 7.7 mg

Total Sample Weight 39.8 mg

4.2 Concentration of Particulate Matter

CS = (0.0154 gr/mg)(MN/VM std)

CS = (0.0154)(39.8 / 57.82) = 0.011 gr/SCF

(.011 gr/SCF)/7000 = 1.52×10^{-6} lbs/SCF

Where

CS = concentration of particulate matter, grains/dscf

MN = total sample weight, mg

VM std = volume of dry gas sampled @ STP, cubic feet

5. MOISTURE CONTENT OF STACK GAS

BWO = (100)(VW std) / (VM std + VW std)

BWO = (100)(1.51) / (57.82 + 1.51) = 2.55 %

Where

BWO = percent of water vapor by volume

VW std = volume of water vapor collected @ STP, cubic feet

VM std = volume of dry gas sampled @ STP, cubic feet

6. ORSAT ANALYSIS OF STACK GAS

% CO_2 = 6.6 % O_2 = 12.2 % CO = 0

% N_2 = 81.2

Molecular Weight Dry Basis

$MD = (0.44)(\%\ CO_2) + (0.32)(\%\ O_2) + (0.28)(\%\ N_2)$

$MD = (0.44)(\ 6.6\ ) + (0.32)(\ 12.2\ ) + (0.28)(\ 81.2\ )$

$= 29.54$ lb/lb-mole

Molecular Weight Wet Basis

$MS = MD(1-(BWO/100)) + (18)(BWO/100)$

$MS = (\ 29.54\ )(1-(2.55/100)) + (18)(\ 2.55/100) = 29.25$ lb/lb-mole

Where

BWO = percent moisture water vapor by volume

MD = molecular weight dry basis, lb/lb-mole

MS = molecular weight wet basis, lb/lb-mole

7. EXCESS AIR

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

$EA = (100)\left\{[(\quad)-0.5(\quad)] \Big/ [0.264(\quad)-(\quad)+0.5(\quad)]\right\}$

EA = NA %

8. AVERAGE STACK GAS VELOCITY

$VS = (K)\ (C)\ (P)\ \sqrt{(TS)/(PS)\ (MS)}$

$VS = (85.48)(\ .84\ )(\ .751\ )\ \sqrt{\frac{578}{(30.00)(29.25)}} = 43.8$ fps

Where

VS = stack gas velocity, feet per second

K = 85.48 (ft./sec.)(lb/lb-mole-^{o}Rankine)$^{\frac{1}{2}}$

C = pitot tube coefficient, dimensionless

P = mean square root of velocity presure, inches H_2O

TS = average absolute temperature of stack gas, degrees Rankine

PS = average absolute stack pressure, inches Hg

MS = molecular weight of stack gas(wet basis), lb/lb-mole

9. STACK GAS FLOW RATE

Stack dimensions or inside diameter = 2.33 feet

Stack cross sectional area A = 4.28 sq. feet

$QS = (60)(1-(BWO/100))(VS)\ (A)\ (TST/TS)\ (PS/PST)$

$QS = (60)(1-(2.55/100))(\ 43.8\ )(\ 4.28\ )(528/578)(30.00/29.92)$

$= 10040$ cfm

Where

QS = volumetric flow at STP, cubic feet per minute

BWO = percent moisture water vapor by volume

VS = velocity of stack gas, feet per second

A = area of stack, square feet

TST = absolute temperature at standard conditions, degrees Rankine

TS = average absolute temperature of stack gas, degrees Rankine

PS = average absolute pressure of stack, inches Hg

PST = absolute pressure at standard conditions, inches Hg

12. ISOKINETIC VARIATION

$$I = \frac{100(0.01667 \text{ min/sec}) \left[(0.00267 \frac{\text{in. Hg - cu.ft.}}{\text{ml - }^{o}R}) VLC + \frac{(Y)(VM)(H)}{TM}\right] TS}{\theta \, VS \, PS \, AN}$$

$$I = \frac{(1.667)\left[(0.00267)(32) + (1.04)\frac{(55.773)(30.12)}{(533)}\right](578)}{(72)(43.8)(30.00)(.000335)}$$

I = 102 % Isokinetic Variation

Where

VLC = volume of water collected, ml

VM = volume of gas collected at meter, cubic feet

TM = average absolute dry gas meter temperature, degrees Rankine

H = average absolute pressure drop across the orifice, in. Hg

TS = average absolute temperature of stack, degrees Rankine

θ = total sampling time, minutes

VS = velocity of stack gas, feet/second

PS = average pressure of stack, inches Hg

AN = area of nozzle, square feet

Y = dry gas meter calibration factor

A-40

LABORATORY DATA SHEET

PLANT: ENVIROTECH

LOCATION: Attleboro

DATE OF TEST: 5/12/83

DESCRIPTION OF SOURCE: _____

RUN NUMBER: 3 OPERATOR: _____

Stack Filters

Serial Number:	436					
Final Wt.(mg):	648.5					
Initial Wt.(mg):	616.4					
Sample Wt.(mg):	32.1					

Total Sample Wt: _____ mg.

Probe and Nozzle Washing

Final Beaker Wt.(g):	98.7571		
Beaker Tare Wt.(g):	98.7478		
Sample Wt.(g):	9.3	=	9.3 mg

Total Sample Wt: _____ mg.

blank = 1.6

7.7

Cyclone, Catch Flask and Filter Assembly Washings

Final Beaker Wt.(g):			
Beaker Tare Wt.(g):			
Sample Wt.(g):		=	mg

Total Sample Wt: _____ mg.

Impinger Contents

	Impinger #1	Impinger #2	Impinger #3
Final Volume(ml):	100	114	4
Initial Volume(ml):	100	100	0
Volume Collected(ml):	[illegible]	[illegible]	[illegible]

Final Silica Gel Wt.(g):	492.3	
Initial Silica Gel Wt.(g):	~~508.3~~ 498.3	
Amount Collected (g):		

Total Volume of Liquid Collected: _____ ml.

DAVID GORDON ASSOCIATES, INC.

CONSULTANTS IN POLLUTION CONTROL

Boiler or Process: advanced Waste Water treatment

Attleboro Waste Water

Run Number 3

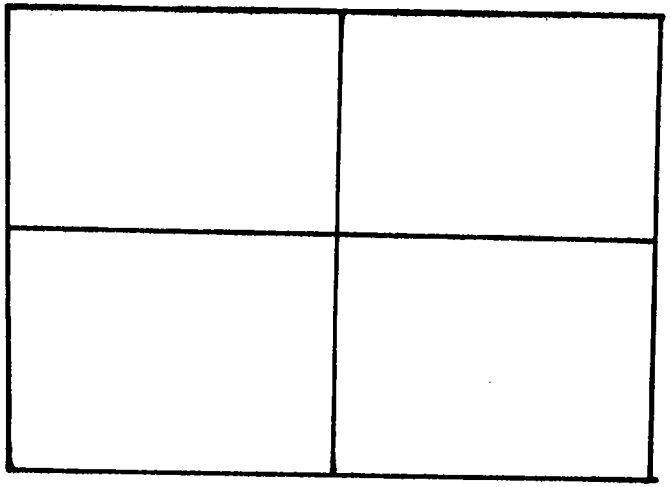
Location stack

Date 5-12-83

Operator QF KD RL TC

Sample Box Number 1

Meter Number 2



Schematics of Stack Cross Section

Ambient Temperature, °F 60

Barometric Pressure, in Hg. 30.01

Assumed Moisture % 4

Heater Box Setting, °F 250

Probe Tip Diameter, in. .248

Probe length, ft. 5

Probe Heater Setting 250

Point	Clock Time	Dry gas meter, ft^3	Pitot in. H_2O ΔP	Orifice ΔH, in. H_2O Desired	Orifice ΔH, in. H_2O Actual	Dry Gas Temperature, °F Inlet	Dry Gas Temperature, °F Outlet	Pump Vacuum in.Hg gage	Box Temp. °F	Impinger Temp. °F	Stack Pressure in.H_2O	Stack Temp. °F
A 1	12:55	941.279	.40	1.05	1.05	60	61	1	240	50		100
2	57	942.6	.42	1.1	1.1	66	62	2	260	50		115
3	59	943	.40	1.05	1.05	70	62	2	260	50		115
4	1:01	945.4	.42	1.1	1.1	72	62	2	225	50		130
5	03	946.6	.40	1.05	1.05	74	63	2	225	50		150
6	05	948	.44	1.2	1.2	76	63	2	265	50	-.16	145
7	07	949.6	.38	1.0	1.0	77	64	2	265	50		140
8	09	950.7	.40	1.05	1.05	78	64	2	265	50		140
9	11	952	.45	1.2	1.2	78	65	2	265	50		125
10	13	953.4	.60	1.6	1.6	80	65	2	265	50		110
11	15	955	.63	1.7	1.7	81	66	2	265	50		100
12	17	956.7	.66	1.8	1.8	83	67	2	265	50		100
13	19	958.2	.67	1.8	1.8	84	67	2	250	50		110
14	21	960.2	.73	2.0	2.0	84	68	2.5	250	50	-2.6	120
15	23	962	.68	1.8	1.8	85	69	2	225	50		120
16	25	963.6	.75	2.0	2.0	84	70	2.5	225	50		130

P_i (impact) = _____ T_m °F _____

P_s (static) = _____ T_s °F _____

P_v (veloc.) = _____ C = _____

P_m = _____ D_{pn} = _____

P_s / P_m = _____ ΔH_a = _____

	CO_2 %	O_2 %
	6.6	12.2
	6.6	12.2
	6.6	12.0

Boiler Steam Rate _____ (lb/hr)

Boiler Gage Pressure _____ psig.

Boiler Fuel Rate _____ gph

Sulfur% Weight _____

Process Weight Rate _____ (lb/hr)

DAVID GORDON ASSOCIATES, INC.
CONSULTANTS IN POLLUTION CONTROL

385 Elliot Street
Newton Upper Falls, Ma 02164

Plant Attleboro
Run Number 3
Location Stack
Date 5-12-83

Point	Clock Time	Dry gas meter, ft^3	Pitot in. H_2O ΔP	Orifice ΔH in H_2O		Dry Gas Temperature, °F		Pump Vacuum in.Hg gage	Box Temp. °F	Impringer Temp. °F	Stack Pressure in.H_2O	Stack Temperature °F
				Desired	Actual	Inlet	Outlet					
17	1 27	965	.74	2.0	2.0	84	60	2.5	225	55		130
18	1 29	967	.74	2.0	2.0	84	60	2.5	225	55		135
	1 31	968.387										
1	1:34	968.387	.46	1.2	1.2	73	69	2	225	50		90
2	36	970	.49	1.3	1.3	76	69	2	245	50		85
3	38	971.8	.47	1.25	1.25	79	69	2	260	50		85
4	40	973	.53	1.4	1.4	79	69	2	265	50		90
5	42	974.4	.56	1.5	1.5	80	69	2	270	50	-.21	100
6	44	976.1	.60	1.6	1.6	81	69	2	270	50		100
7	46	977.6	.60	1.6	1.6	82	69	2	270	50		95
8	48	979.2	.55	1.5	1.5	82	69	2	270	50		100
9	50	980.7	.60	1.6	1.6	82	69	2	270	50		100
10	52	982.3	.55	1.5	1.5	82	69	2	275	55		105
11	54	983.9	.63	1.7	1.7	82	69	2.5	275	55		105
12	56	985.6	.68	1.9	1.9	82	70	2.5	275	55		115
13	58	987.2	.65	1.8	1.8	83	70	2.5	275	55		125
14	2:00	988.9	.63	1.7	1.7	83	70	2.5	230	55	-.29	140
15	02	990	.67	1.8	1.8	83	70	2.5	245	55		140
16	04	992.3	.65	1.8	1.8	83	70	2.5	270	55		150
17	06	993.7	.65	1.8	1.8	83	70	2.5	270	55		160
18	08	995.3	.65	1.8	1.8	83	70	2.5	270	55		160
	2:10	997.052										
				leak check		.022	@	3.5" VHG				
Averages												

EMISSION RATES IN lb/hr

$WP = (QS)(CS)(60)/7000$

Where:

QS = Volumetric flow rate STP – ft^3/min

CS = Concentration of particulate matter – grains/DSCF

Run #1

$WP = (9923)(0.010)60/7000 = 0.85$

Run #2

$WP = (9823)(0.010)60/7000 = 0.84$

Run #3

$WP = (10040)(0.011)60/7000 = 0.95$

Determination of Scum Feed Rate.

Run #1 avg % solids = 130,363 mg/l.

$$\frac{\text{Tons}}{\text{hr}} = 130{,}363 \frac{\text{mg}}{\text{l}} \times \frac{3.785\,\text{l}}{\text{gal}} \times \frac{\text{lb}}{454000\,\text{mg}} \times \frac{\text{ton}}{2000\,\text{lb}} \times \frac{1.09\,\text{gal}}{\text{min}} \times \frac{60\,\text{min}}{\text{hr}}$$

$$= .036\ \text{ton/hr}$$

Run #2 — 54,352 mg/l.

$$TPH = \frac{54352 \times 3.785}{(454000)(2000)} \times 1.3\,\frac{\text{gal}}{\text{hr}} \times 60 = .018$$

Run #3 — 125,176 mg/l.

$$\frac{(125{,}176)(3.785)}{(454000)(2000)} \times 1.2\,\frac{\text{gal}}{\text{hr}} \times 60 = .037$$

C A L I B R A T I O N S

A-46

NOZZLE CALIBRATION

(Pre-Test Report)

Nozzle Number	D_1	D_2	D_3	D_n avg.	D_n dev.	Date / Initial
1/4"	.248	.248	.248	.248	0	4/12
						/
						/
						/
						/
						/
						/
						/

WHERE:

D_n average = $\frac{D_1 + D_2 + D_3}{3}$

$D_{1,2,3,}$ = Measurement of nozzle at three different diameters. Tolerance 0.025mm (0.001 in.)

D_n deviation = Difference between maximum and minimum diameter. Measurement not to exceed 0.1mm (0.004 in.)

Note: Nozzles nicked, dented, or corroded are to be reshaped, sharpened, and recalibrated before use. (Reference: Federal Register Vol. 42, No. 160 - Thursday, August 18, 1977).

Date January 20, 1983 No. 2

Barometric pressure, P_b = 30.18 in. Hg Dry gas meter No. _____

Orifice manometer setting, ΔH, in. H_2O	Gas volume wet test meter V_w, ft^3	Gas volume dry gas meter V_d, ft^3	Temperature: Wet Test Meter t_w, °F	Temperature: Dry gas meter Inlet t_{di}, °F	Temperature: Dry gas meter Outlet t_{do}, °F	Temperature: Dry gas meter Average t_d, °F	Time θ, min.	γ	$\Delta H_@$
0.5	5	4.813	63	67	80	74	10.77	1.06	1.25
1.0	5	4.912	63	70	86	78	7.61	1.04	1.24
2.0	10	9.935	63	75	94	85	10.77	1.04	1.22
4.0	10	10.030	63	79	100	90	7.78	1.04	1.26
6.0	10	10.068	63	83	104	94	6.22	1.04	1.20
8.0	10								
							Average	1.04	1.23

Calculations

ΔH	$\frac{\Delta H}{13.6}$	$\gamma = \frac{V_w P_b (t_d + 460)}{V_d \left[P_b + \frac{\Delta H}{13.6}\right] (t_w + 460)}$	$\Delta H_@ = \frac{0.0317\ \Delta H}{P_b (t_d + 460)} \left[\frac{(t_w + 460)\,\theta}{V_w}\right]^2$
0.5	0.0368	$\frac{(5)(30.18)(534)}{(4.813)(30.22)(523)}$	$\frac{0.0317\ (.5)}{(30.18)(534)} \left[\frac{(523)(10.77)}{5}\right]^2$
1.0	0.0737	$\frac{(5)(30.18)(535)}{(4.912)(30.25)(523)}$	$\frac{0.0317\ (1)}{(30.18)(535)} \left[\frac{(523)(7.61)}{5}\right]^2$
2.0	0.147	$\frac{(10)(30.18)(545)}{(9.935)(30.33)(523)}$	$\frac{0.0317\ (2)}{(30.18)(545)} \left[\frac{(523)(10.77)}{10}\right]^2$
4.0	0.294	$\frac{(10)(30.18)(550)}{(10.030)(30.49)(533)}$	$\frac{0.0317\ (4)}{(30.18)(550)} \left[\frac{(523)(7.78)}{10}\right]^2$
6.0	0.431	$\frac{(10)(30.18)(554)}{(10.068)(30.62)(523)}$	$\frac{0.0317\ (6)}{(30.18)(554)} \left[\frac{(523)(6.22)}{10}\right]^2$
8.0	0.588		

γ = Ratio of accuracy of wet test meter to dry test meter. Tolerance = ± 0.01

$\Delta H_@$ = Orifice pressure differential that gives 0.75 cfm of air at 70°F and 29.92 inches of mercury, in. H_2O. Tolerance = ± 0.15

Figure 7. Suggested Orifice and Dry Gas Meter Calibration and Calculation Form

A-48

REQUIREMENTS FOR ASSIGNING A BASELINE COEFFICIENT VALUE OF 0.84 (Cp) TO AN "S" TYPE PITOT

Pitot # 5' Date JAN 24, 1983

Measurements and Observations By: L. Dinna

1). All construction criteria for an isolated "S" type pitot are within given tolerances prescribed in Federal Register, Vol. 42, No. 160. Thursday, August 18, 1977. (See Fig. 2-2 and 2-3).

REQUIRED MEASUREMENTS

(a) External tubing diameter (see Fig. 2-2b)

D_t = 0.94

Tolerance D_t, between 0.48 and 0.95 cm

(b) Base to Opening Plane Distance

P_A = 1.32

P_B = 1.33

Tolerance P, $P_A = P_B$ and between 1.05 and 1.50 cm

2). All assembly criteria to prevent aerodynamic interference for a sampling arrangement of a "S" type pitot, nozzle, and thermal couple, are within given tolerances prescribed in Federal Register, Vol. 42, No. 160 - Thursday, August 18, 1977. (see Fig. 2-6, 2-7, 2-8).

REQUIRED MEASUREMENTS

(a) External tubing diameter (see 1-a)

(b) Pitot nozzle separation (see Fig. 2-6A)

D_n = 1.3

X = 2.2

Tolerance X, $\geq$ 1.90 cm for D_n = 1.3 cm

(c) Plane of impact side of pitot in relation to plane of nozzle opening (see Fig. 2-6B).

(d) Thermal Couple Placement (see Fig. 2-7A or B)

Z = 2.0

Tolerance A-Z $\geq$ 1.90 cm A-W $\geq$ 7.62 cm

Tolerance B-Z $\geq$ 5.08 cm

(e) Pitot Probe Sheath Distance (see Fig. 2-8)

Y = 7.65

Tolerance Y $\geq$ 7.62 cm

Date 5/13/83 Test Nos. 1-3

Meter Box No. 2 Plant BATTLEBORO TREATMENT PLANT

Barometric pressure, P_b 29.7 in. Hg Dry gas meter No. _____ Pretest Y 1.04

Orifice manometer setting, ΔH, in H_2O	Gas volume wet test meter V_w, ft^3	Gas volume dry gas meter V_d, ft^3	Temperature: Wet test Meter t_w, °F	Temperature: Dry gas meter Inlet t_{di}, °F	Temperature: Dry gas meter Outlet t_{do}, °F	Temperature: Dry gas meter Average[a] t_d, °F	Time θ, min	Vacuum setting in Hg	Yi	Yi $\frac{V_w P_b (t_d + 460)}{V_d \left(P_b + \frac{\Delta H}{13.6}\right)(t_w + 460)}$
1.3	10	10.143	72	97	87	92	13.68	3	1.02	(10)(29.70)(532) / (10.143)(29.80)(526)
1.3	10	10.193	72	101	89	95	13.74	3	1.02	(10)(29.70)(535) / (10.193)(29.80)(532)
1.3	10	10.265	72	102	91	97	13.84	3	1.02	(10)(29.70)(537) / (10.265)(29.80)(535)
									Y= 1.02	

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

where:

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

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

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

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

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

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

ΔH = Pressure differential across orifice, in H_2O.

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

Y = Average ratio of accuracy of wet test meter to dry test meter for all three runs. Tolerance = Pretest Y ±0.05 Y.

P_b = Barometric pressure, in. Hg.

θ = Time of calibration run, minutes.

Post-test meter calibration data form (English units).

A-46