ENVISAGE ENVIRONMENTAL INCORPORATED
P. O. Box 152, Richfield, Ohio 44286
Phone (216) 526-0990

STAPPA/ALAPCO

REPORT NO. 85-9110 53
COMPANY NEORSD
TITLE Particulate & C
DATE 5-22-86

#124 11/12/86

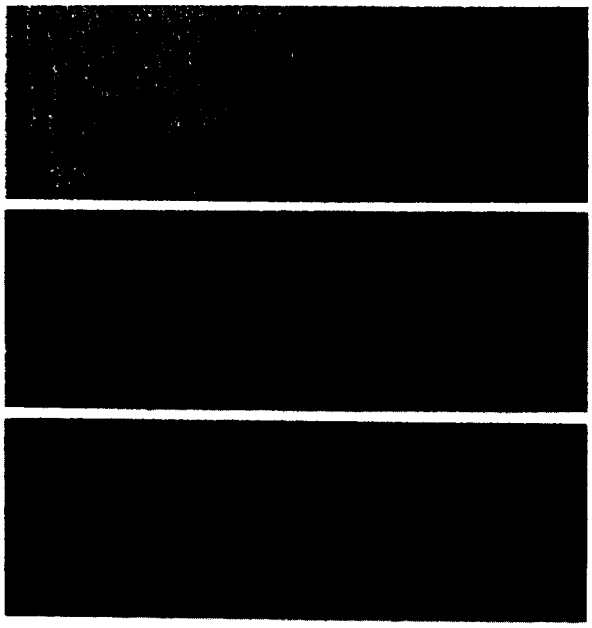
SOUTHERLY WASTEWATER TREATMENT PLANT

CLEVELAND, OHIO

INCINERATOR #3

EPA METHODS 1-5 & 101A
PARTICULATE & MERCURY COMPLIANCE TEST

CONDUCTED - MAY 22, 1985



June 3, 1985

Mr. Robert Dominak, P.E.
Northeast Ohio Regional Sewer District
1127 Euclid Avenue
Cleveland, Ohio 44115

Dear Mr. Dominak:

The following report is the result of the E.P.A. Method 1-5 and 101A Compliance Stack Test conducted on May 22, 1985. The test for Particulate and Mercury Emissions was conducted at the Southerly Sewage Treatment Plant, Incinerator #3, Cleveland, Ohio.

The results are true and accurate to the degree specified in the pertinent sections of the Federal Register, in force at the time of testing concerning Source Sampling for Particulate and Mercury Emissions.

Respectfully submitted,

Robert S. Anderson
President
ENVISAGE ENVIRONMENTAL INC.

TABLE OF CONTENTS

PAGE

INTRODUCTION

MH/I per Gary Mied 1/8/87

3

INTRODUCTION

On May 22, 1985, Envisage Environmental Inc. conducted a Particulate Emission Compliance test at the Northeast Ohio Regional Sewer District, Southerly Sewage Treatment Plant, Cleveland, Ohio. The testing consisted of three (3) test runs of EPA Methods 1-5 to determine the particulate emission rate into which was incorporated EPA Method 101A to determine the Mercury emission rate. The purpose of this test was to determine the emission rates from the exhaust stack venting the Sludge Incinerator #3 in order to ascertain compliance with EPA regulations.

The incinerator was monitored throughout the test by Northeast Ohio Regional Sewer District personnel. Ohio Environmental Protection Agency representatives were present during testing. The signature on the field data sheets of Mr. Jim Krause of the Cleveland Division of Air Pollution Control shows his approval of the on-site procedures.

The results contained in this report represent the particulate and mercury emission rates for the three test runs and the various temperature, volumetric, and velocity measurements taken with these tests.

DESCRIPTION OF PROGRAM

DESCRIPTION OF PROGRAM

This testing was conducted in the exhaust stack through two (2) sample ports located approximately twenty-five (25) feet above the roof level. Twelve sample points were utilized in each sample port making a total of twenty-four (24) sample points per test run. The sample was drawn for two and one-half (2.5) minutes at each sample point for a total test time of sixty (60) minutes per test run. A diagram of the sample point locations is included in this report.

The samples were drawn from the gas stream iso-kinetically through a one quarter (0.25) inch diameter nozzle and a three foot Pyrex lined probe. This probe was heated its entire length and was attached to a Modified EPA Method Five Sample Train. The sample box was heated to a 250 degrees Fahrenheit and was monitored throughout each test to ensure that no condensation formed in the sample train before the impingers. The impingers were set up for Mercury Collection according to EPA Method 101A. Impinger #1 & 2 contained 100 ml of Potassium Permanganate and were analyzed for Mercury content after the measurements for moisture collection.

Flue gas analysis was conducted by drawing an integrated air bag sample and was analyzed with a Hays Republic Model 621A "Orsat" Portable Gas Analyzer. The average of these readings for each test run were used in calculating the emission rates.

Calibration of equipment used, to include the dry gas meter, orifice meter, and the "S" type pitot tube was conducted April 2, 1985. Calibration data is included in this report.

Description of Program - con't

All analytical procedures were performed in accordance with the methods specified in the Federal Register, Title 40, Part 60, Volume 43, as published March 3, 1978 and its amendments. During the laboratory analysis, a blank was performed on the residue left from the acetone and distilled water used in the evaluation. The acetone blank was recorded and incorporated into the results. The distilled water blank was less than could be measured on a 0.1 milligram analytical balance and therefore was considered to be zero.

A set of sample stack testing equations used for data reduction and evaluation are included in this report for convenience and to aid in understanding the presented data. Figures included as sample calculations are from Test Run #1.

TEST RESULTS

SUMMARY

TEST RESULTS SUMMARY

North East Ohio Regional Sewer District

Southerly Sewage Treatment Plant

Sludge Incinerator # 3

EPA Methods 1-5

Particulate Emissions

Compliance Test

Conducted - May 22, 1985

PARAMETER	Run # 1	Run # 2	Run # 3	
Particulate Emissions				
Pounds/hour	3.44	3.15	3.20	
Grains/dscf	0.0176	0.0160	0.0160	*
System Flow Rates				
Feet/second	61.89	61.77	63.18	
ACFM	26,248	26,196	26,797	
SCFM	22,828	22,937	23,274	
Moisture Content				
Volume percent	3.13	2.83	3.33	
Sample Location Temperature				
Degrees Fahrenheit	122	120	121	

* dry, per p. 46

TEST RESULTS

DETAILED

TEST RESULTS

North East Ohio Regional Sewer District

Southerly Sewage Treatment Plant

Sludge Incinerator # 3

	Date: May 22, 1985		Units	RUN # 1	RUN # 2	RUN # 3
	Time of Day			9:30am-11:01am	11:19am-12:21pm	12:40pm-1:43pm
1	Gas Volume-dry,std.	Vmstd	cu. ft.	64.34	64.43	62.10
2	Condensate Vapor Vol.	Vwstd	cu. ft.	2.08	1.87	2.14
3	Gas Stream Moisture	Bws	vol.dec	0.0313	0.0283	0.0333
4	Mol.Wt-flue gas (dry)	Msd	lb/lb mo.	29.18	29.38	29.30
5	Mol.Wt-flue gas (wet)	Ms	lb/lb mo.	28.83	29.05	28.92
6	Flue Gas Velocity	Vs	ft/sec	61.89	61.77	63.18
7	Flue Gas Volume-Actual	ACFM	cu. ft.	26,248	26,196	26,797
8	Flue Gas Volume-Std.	SCFM	cu. ft.	22,828	22,937	23,274
9	Particulate Conc.	Cs				
	- Probe		gr/scf	0.0017	0.0010	0.0008
	- Filter		gr/scf	0.0159	0.0151	0.0153
	- Impingr(Mercury)	C Hg	gr/scf	0.000028	0.000027	0.000029
	- Total *		gr/scf	0.0176	0.0160	0.0160
10	Emission Rate	E				
	- Probe		lb/hr	0.33	0.19	0.15
	- Filter		lb/hr	3.10	2.96	3.04
	- Impingr(Mercury)	E Hg	lb/hr	0.0055	0.0053	0.0057
	- Total *		lb/hr	3.44	3.15	3.20
11	Isokinetic Rate	I	%	97.4	97.1	92.2

* Totals DO NOT include impinger Mercury weights.

OPERATIONAL PARAMETERS

NORTHEAST OHIO REGIONAL SEWER DISTRICT

5-24-85

May 23, 1985

Envisage Environmental, Inc.
8055 Broadview Road
Broadview Heights, Ohio 44147

Attn: Mr. Tom E. Holder

Re: Southerly Incinerator No. 3
Emission Test

Dear Mr. Holder:

Transmitted herewith is a copy of the scale reading taken during the emission test of the No. 3 Incinerator at the Southerly W.W.T.C. on Wednesday May 22, 1985.

If you have any questions, please contact me.

Very truly yours,

Robert P Dominak

Robert P. Dominak, P.E.
Project Manager

RPD/amr

cc: File No. 2052

850522

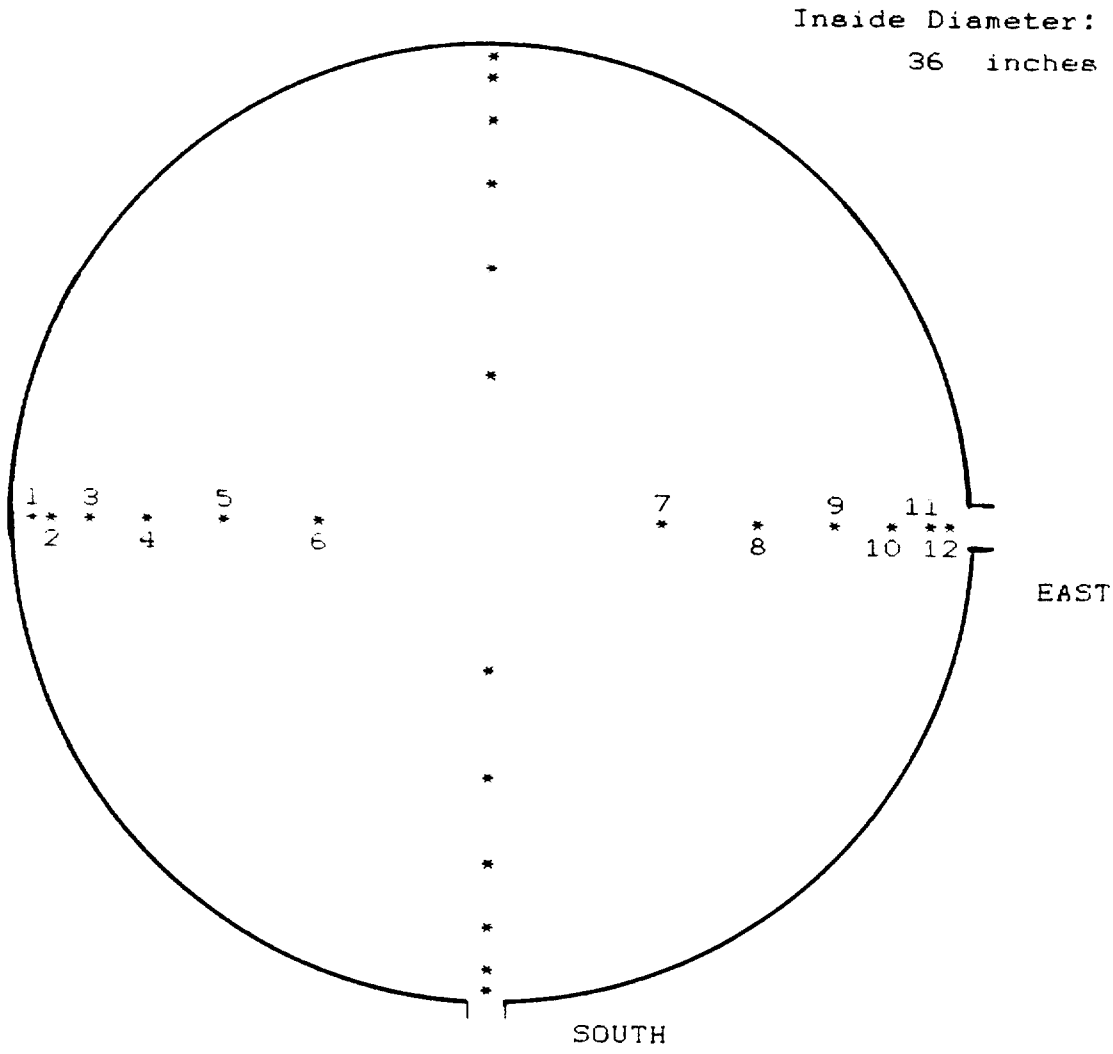
Stack test - #3 incinerator

time	Scale reading	TPH	Comments
0930	534236		Start of 1st run
1030	534885	6.49	interruption of test - lost I.D. fans
1055	535082		resumed 1st test
1101	535161	.79	end of 1st test
		7.28	tons during first test
1119	535344		Start of 2nd test
1220	536044	7.0	End " " "
		7.0	tons during the 2nd test
1240	536259		Start of 3rd test
	536962	7.03	End of 3rd test
		7.03	tons during test #3

SAMPLE POINT LOCATION DIAGRAM

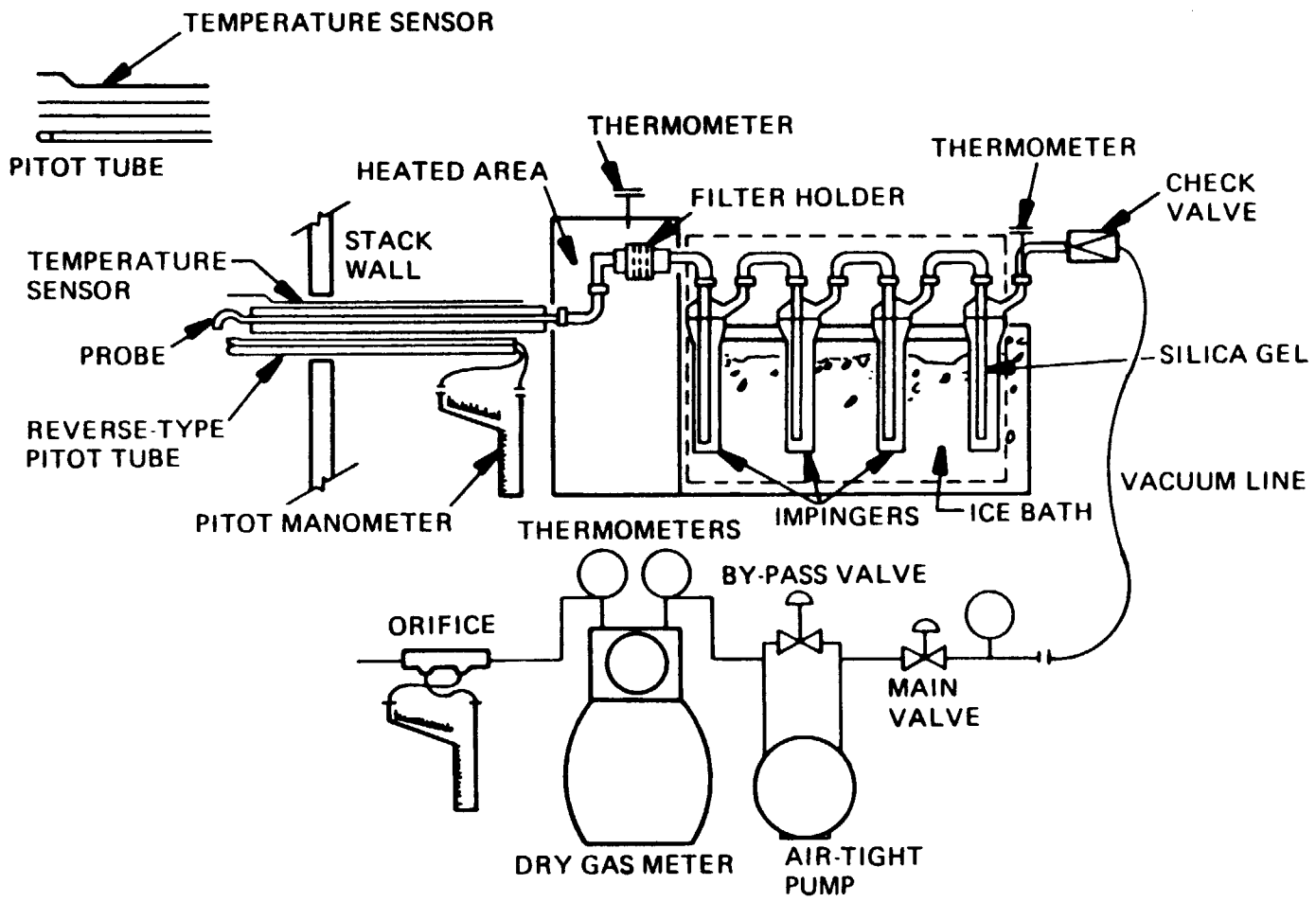
SAMPLE POINT LOCATIONS

Northeast Ohio Regional Sewer District
Southerly Sewage Treatment Plant
Sludge Incinerator # 3
Exhaust Stack



Point #	Distance From Inside Wall	Point #	Distance From Inside Wall
1	35.0 inches	7	12.8 inches
2	33.6 inches	8	9.0 inches
3	31.8 inches	9	6.4 inches
4	29.6 inches	10	4.2 inches
5	27.0 inches	11	2.4 inches
6	23.2 inches	12	1.0 inches

SAMPLING TRAIN DIAGRAM



EPA METHOD 5 PARTICULATE SAMPLE APPARATUS

STACK TESTING

EQUIPMENT SPECIFICATIONS

Control Unit (Meter box)	Equipment designation
Envisage Environmental Inc. (E.E.I.)	Control Unit #'s MB-01 & 02
Andersen Samplers	Control Unit # MB-03
Remanufactured R.A.C.	Control Unit #'s MB-04 - 08

Sample Box	
E.E.I.	SB-01, 02 & 05 - 07
Remanufactured R.A.C.	SB-03 & 04
E.E.I. (special design)	SB-08 - 11

Impingers - per sample train (each set changed for each test run)

E.E.I.	3 Modified Smith-Greenburg type
E.E.I.	1 Smith-Greenburg type

Probes	Length	Lining types
E.E.I.	3 foot	SS, Pyrex, Quartz, Teflon
E.E.I.	5 foot	SS, Pyrex, Quartz, Teflon
E.E.I.	3 foot	SS, Pyrex, Teflon
E.E.I.	7 foot	SS, Pyrex, Teflon
E.E.I.	10 foot	SS, Pyrex, Teflon
E.E.I.	12 foot	Pyrex, Teflon
E.E.I.	15 foot	SS, Pyrex, Teflon
E.E.I.	24 foot	SS, Teflon

Temperature Sensors	Equipment designation - Type
Omega Engineering (K type thermocouple)	PY-01 & 02
Thermo Electric (K type thermocouple)	PY-03 - 08
Fisher Scientific	Mercury Thermometer
Fisher Scientific	Bimetalic Thermometer

Pressure Gages	Type
Dwyer Incline Manometer	Oil, 0 - 10 inch water
Dwyer Magnehelic	Magnetic/Mechanical 0 - 1 inch water
Dwyer Magnehelic	Magnetic/Mechanical 0 - 10 inch water
Dwyer "U" Tube Manometer	Mercury, 36 inch
Dwyer "U" Tube Manometer	Water, 72 inch
Dwyer Microtector (Micro-manometer)	Water, 0 - 1 inch water

Chemicals & Reagents	
Water	Deionized/distilled
Acetone	Reagent grade ($<$ 0.001 % residue)
Silica Gel	6 - 16 mesh
Stopcock Grease	Acetone-insoluble & Heat stable

LABORATORY SECTION

LABORATORY SUMMARY SHEET

North East Ohio Regional Sewer District

Southerly Sewage Treatment Plant

Sludge Incinerator # 3

	Date: May 22, 1985	Symbol	Units	RUN # 1	RUN # 2	RUN # 3
1	Sampling Time	t	minutes	60.0	60.0	60.0
2	Barometric Pressure	Pb	in. Hg	29.66	29.64	29.63
3	Static Pressure	Pg	in. H2O	-0.55	-0.55	-0.55
	Stack Pressure	Ps	in. Hg	29.62	29.60	29.59
4	Gas Meter Volume	Vm	cu. ft.	65.73	66.99	64.48
5	Stack Area	A	sq. ft.	7.07	7.07	7.07
6	Nozzle Diameter	Dn	dec. in.	0.25	0.25	0.25
7	Meter Temperature		degrees F	80.2	89.4	88.7
		Tm	degrees R	540.2	549.4	548.7
8	Stack Temperature		degrees F	122.2	119.7	121.2
		Ts	degrees R	582.2	579.7	581.2
9	Velocity Head	^P	in. H2O	1.096	1.100	1.121
10	Orifice Pressure	^H	in. H2O	4.12	4.14	4.30
11	Carbon dioxide	CO2	%	3.4	5.0	4.5
12	Oxygen	O2	%	16.0	14.4	14.4
13	Carbon monoxide	CO	%	0.0	0.0	0.0
14	Nitrogen	N2	%	80.6	80.6	81.1
15	Pitot Coefficient	Cp		0.80	0.80	0.80
16	Water Collected	Vlc	ml	44.1	39.8	45.4
	Sample Weight:	Mn				
17	- Probe		g	0.0071	0.0040	0.0031
18	- Filter		g	0.0661	0.0629	0.0614
19	- Impinger(Mercury)	M Hg	g	0.000118	0.000112	0.000115

Envisage Environmental Incorporated
P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

PLANT Southerly Sewage
DATE May 22, 1985
RUN NO. 1
CASE NO. 2

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED			
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN	
913	.6929	.6268	.0661	FILTER
				IMPINGERS
920	100.4306	100.4235	.0071	PROBE *
TOTAL				

* Corrected for Acetone Blank

	VOLUME OF LIQUID WATER COLLECTED		
	IMPINGER VOLUME, ml	SILICA GEL WEIGHT, g	
FINAL	226.	253.0	
INITIAL	200.	234.9	
LIQUID COLLECTED	26.	18.1	
TOTAL VOLUME COLLECTED	44.1	g*	ml

*Convert weight of water to volume by dividing total weight increase by density of water. (1 g/ml):

$$\frac{\text{Increase g}}{(1\ \text{g/ml})} = \text{Volume Water, ml}$$

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PLANT Southerly Sewage
DATE May 22, 1985
RUN NO. 2
CASE NO. 3

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED			
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN	
867	.6927	6298	.0629	FILTER
				IMPINGERS
925	97.3684	97.3644	0040	PROBE *
TOTAL				

* Corrected for Acetone Blank

	VOLUME OF LIQUID WATER COLLECTED		
	IMPINGER VOLUME, ml	SILICA GEL WEIGHT, g	
FINAL	215.	259.7	
INITIAL	200.	234.9	
LIQUID COLLECTED	15.	24.8	
TOTAL VOLUME COLLECTED	398	g*	ml

*Convert weight of water to volume by dividing total weight increase by density of water. (1 g/ml):

$$\frac{\text{Increase g}}{(1\ \text{g/ml})} = \text{Volume Water, ml}$$

Envisage Environmental Incorporated
P.O. Box 152 Richfield, Ohio 44286
Phone (216) 526-0990

PLANT Southerly Sewage
DATE 5-22-85
RUN NO. 3
CASE NO. 4

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED			
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN	
927	.6777	.6163	.0614	FILTER
				IMPINGERS
926	99.3289	99.3258	.0031	PROBE *
TOTAL				

* Corrected for Acetone Blank

	VOLUME OF LIQUID WATER COLLECTED		
	IMPINGER VOLUME, ml	SILICA GEL WEIGHT, g	
FINAL	221.	259.3	
INITIAL	200.	234.9	
LIQUID COLLECTED	21	24.4	
TOTAL VOLUME COLLECTED	45.4	g*	ml

*Convert weight of water to volume by dividing total weight increase by density of water. (1 g/ml):

$$\frac{\text{Increase g}}{(1\ \text{g/ml})} = \text{Volume Water, ml}$$

National Spectrographic Laboratories

DIVISION OF REXHAM CORPORATION #13-2694421
7650 HUB PARKWAY, CLEVELAND, OHIO 44125 • P.O. BOX 31480, CLEVELAND, OHIO 44131
TELEPHONE: 216-447-1550

Rexham

TO Envisage Enviromental Inc.
PO Box 152
Richfield, OH 44286

Attn: Tom Holder

RECEIVED 5-28-85

DATE	CUSTOMER DESCRIPTION	YOUR ORDER NO.	REPORT NO.
5/24/85	Liquid		05225-5

ELEMENTS DETERMINED ppm	SAMPLE NO. 209	SAMPLE NO. 214	SAMPLE NO. 215	SAMPLE NO. 216	SAMPLE NO.	SAMPLE NO.	SAMPLE NO.
Hg	<0.005	0.52	0.52	0.52			

Lab No. 11945-11948

We certify the above analysis to be the true results on the designated samples.

NATIONAL SPECTROGRAPHIC LABORATORIES

E. A. Mastanik Reporting Officer

Sworn to and subscribed before me a Notary Public in and for the County of Cuyahoga, State of Ohio, this

DAY OF , 19

ORIGINAL REPORT OF ANALYSIS

CALIBRATION SECTION

METER BOX CALIBRATION

Meter Box Number: MB - 03

Calibration Date: April 2, 1985

$$Y = \frac{V_t \; P_b \; (T_m + 460)}{V_m \left[P_b + \frac{\Delta H}{13.6} \right] (T + 460)}$$

$$\Delta H_@ = \frac{0.0317 \; \Delta H}{P_b \; (Tm + 460)} \left[\frac{(T_t + 460) \; t}{V_t} \right]$$

Delta H (^H)	in. H20	0.5	1.0	3.0	5.0	7.0
Pres.Barometer (P_b)	in. Hg	29.87	29.87	29.87	29.87	29.87
Vol.Meter Box (V_m)	cu. ft.	4.135	5.890	10.275	13.235	15.560
Vol.Test Meter(V_t)	cu. ft.	4.050	5.610	9.650	12.300	14.530
Temp. Meter Box (T_m)	^oF	79.5	89.2	93.3	99.2	99.7
	^oR	539.5	549.2	553.3	559.2	559.7
Temp. Test Meter (T_t)	^oF	64.0	64.0	64.0	64.0	64.0
	^oR	524.0	524.0	524.0	524.0	524.0
Time (t)	minutes	10.0	10.0	10.0	10.0	10.0
METER FACTOR (Y)		1.007	0.996	0.984	0.980	0.981
- Average				0.99		
METER COEFFICIENT ($\Delta H_@$)		1.646	1.686	1.697	1.722	1.726
- Average				1.70		

"S" TYPE PITOT TUBE CALIBRATION

"S" Type Pitot Tube (Probe) # 3 foot Probe # 3

Calibration Date: April 2, 1985

$$C_p = C_{std} \sqrt{\frac{\Delta P_{std}}{\Delta P_p}} \qquad \text{(EPA Equation 2-2)}$$

where:

C_p = Coefficient of Type S pitot tube, dimensionless

C_{std} = Coefficient of Standard Pitot Tube (0.99), dimensionless

ΔP_{std} = Velocity head measured by standard pitot tube, inches H_2O

ΔP_p = Velocity head measured by Type S pitot tube, inches H_2O

Velocity Head Readings

	ΔP_{std}	ΔP_p	C_p
Side A	0.20	0.31	0.795
Side B	0.20	0.31	0.795
Side A	0.50	0.76	0.803
Side B	0.50	0.76	0.803
Side A	1.00	1.48	0.814
Side B	1.00	1.48	0.814

Average - 0.80

NOZZLE DIAMETER CALIBRATION

I.D. of nozzles are checked periodically by inside micrometer on at least 12 different diameters. If deviation exceeds +0.001" on an average or 0.002" maximum, nozzle is reworked. Sharpening occurs after each test.

CALIBRATION FREQUENCY

The frequency of calibration is dictated by the Federal Register, Volume 42, Number 160, August 18, 1977. The regulations state that you must "use methods and equipment which have been approved by the Administrator to calibrate the orifice meter, pitot tube, dry gas meter, and probe heater. Recalibrate after each test".

The methods of calibration are determined from "Maintenance, Calibration, and Operation of Isokinetic Source Sampling Equipment," published by the U.S. EPA Office of Air Program Publications APTD-0576. Per the above listed regulations, the equipment was checked after the stack test and the values of Y, Cp (Test) and nozzle diameter had not appreciably changed from the acceptable tolerances.

FIELD DATA SHEETS

FIELD DATA

PLANT Southerly Incin #3
DATE May 22, 1985
SAMPLING LOCATION Exhaust Stack
SAMPLE TYPE EPA Method 1-5
OPERATOR DO BF
AMBIENT TEMPERATURE 50's
BAROMETRIC PRESSURE
STATIC PRESSURE -.55
HEATER BOX SETTING 250°

PROBE LENGTH & TYPE 3' Pyrex
NOZZLE I.D. .25
ASSUMED MOISTURE % 6
METER BOX NUMBER 03
METER ΔH @ 1.7
C FACTOR
PITOT CORRECTION FACTOR 8(?)
PRE-TEST LEAK CHECK 0 CFM@ 15 "Hg
POST-TEST LEAK CHECK 0 CFM@ 10 "Hg

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 2 1/2 MINUTES

PAGE 1 OF

TRAVERSE POINT NUMBER	ELAPSED SAMPLING TIME min.	GAS METER READING	VELOCITY HEAD		ORIFICE PRESSURE DIFFERENTIAL	STACK TEMPERATURE	GAS METER TEMPERATURE INLET	GAS METER TEMPERATURE OUTLET	PUMP VACUUM	FILTER HOLDER TEMP.	IMPINGER TEMP.
1	0/9:30	191.00	.96	.980	3.3	121	60	57	6	234	<70
2	2.5	193.4	1.1	1.049	3.8	122	71	57	6	236	
3	5	196.0	1.1	1.049	3.8	124	78	58	6	235	
4	7.5	198.6	1.1	1.049	3.8	122	84	59	6	241	
5	10	201.2	1.2	1.095	4.0	121	89	61	7	237	64
6	12.5	204.1	1.3	1.140	4.4	122	92	63	8	244	
7	15	206.6	1.4	1.183	4.8	126	94	64	8	240	
8	17.5	209.6	1.4	1.183	4.8	125	96	66	8	242	57
9	20	212.7	1.5	1.225	5.1	123	97	66	8	246	
10	22.5	215.7	1.5	1.225	5.1	122	99	67	9	245	
11	25	218.7	1.5	1.225	5.1	122	100	69	9	249	
12	27.5	221.7	1.1	1.049	3.8	121	102	70	8	253	51
1	30/10:03	224.49	.86	.927	2.9	115	90	71	6	255	
2	32.5	226.9	1.0	1.000	3.4	113	93	71	7	256	
3	35	229.3	1.1	1.049	3.8	113	97	72	7	260	
4	37.5	232.0	1.1	1.049	3.8	115	99	72	7	251	
5	40	234.6	1.2	1.095	4.0	117	100	73	7	259	
6	42.5	237.2	1.2	1.095	4.0	121	101	74	7	247	
7	45	240.0	1.3	1.140	4.4	122	101	75	8	252	54
8	47.5	242.9	1.4	1.183	4.8	129	103	76	9	250	
9	50	245.9	1.5	1.225	5.1	127	104	76	9	246	
10	52.5	248.7	1.4	1.183	4.8	127	105	76	9	261	
11	55	251.7	1.0	1.000	3.4	132	77	68	8	244	
12	57.5	254.4	.80	.894	2.7	130	86	69	6	249	
	60/11:01	256.73									
		65.73		1.096	4.12	[illegible]	80.2				

Inn #1
Inn #2
N. Kraus 5/22/85
Stop 10:26 system malfunction restart 10:55

PLANT Southerly Incin #3 DATE May 22, 1985 LEAK CHECK 0 CFM@ 16 "Hg PAGE 2 OF _____

TRAVERSE POINT NUMBER	ELAPSED SAMPLING TIME min.	GAS METER READING	VELOCITY HEAD		ORIFICE PRESSURE DIFFERENTIAL	STACK TEMPERATURE	GAS METER TEMPERATURE		PUMP VACUUM	FILTER HOLDER TEMP.	IMPINGER TEMP.
							INLET	OUTLET			
1	0/11:19	257.30	.80	.894	2.7	110	76	70	3	231	
2	2.5	259.8	.92	959	3.1	112	89	71	3	229	60
3	5	262.1	1.2	1.095	4.1	116	93	71	4	237	
4	7.5	264.9	1.3	1.140	4.4	122	96	72	5	233	
5	10	267.8	1.3	1.140	4.4	120	99	72	5	237	
6	12.5	270.7	1.4	1.183	4.8	121	102	74	5	239	
7	15	273.5	1.4	1.183	4.8	125	104	74	5	240	
8	17.5	276.7	1.4	1.183	4.8	123	105	76	5	238	
9	20	279.7	1.3	1.140	4.4	123	106	77	5	244	
10	22.5	282.6	1.3	1.140	4.4	120	106	77	5	247	56
11	25	285.6	1.2	1.095	4.1	116	107	78	5	242	
12	27.5	288.4	1.1	1.049	3.7	113	106	79	4	239	
1	30	291.04	.80	.894	2.7	112	95	78	3	240	
2	32.5	293.5	.90	.949	3.0	114	100	79	4	243	
3	35	295.9	.96	.980	3.2	115	102	79	4	242	
4	37.5	298.3	1.0	1.00	3.4	118	103	79	4	239	
5	40	300.8	1.1	1.049	3.7	122	104	79	5	247	
6	42.5	303.4	1.3	1.140	4.4	124	105	79	5	256	54
7	45	306.2	1.4	1.183	4.8	126	107	80	5	258	
8	47.5	309.2	1.5	1.225	5.1	124	108	80	5	264	
9	50	312.2	1.5	1.225	5.1	124	108	80	5	263	
10	52.5	315.3	1.5	1.225	5.1	123	109	80	5	261	
11	55	318.4	1.4	1.183	4.8	125	109	80	5	252	
12	57.5	321.4	1.3	1.140	4.4	124	109	80	5	248	
	60/12:21	324.29									
		66.99		1.100	4.14	119.7	89.4				

PLANT Southerly Train #3 DATE May 22, 1985 LEAK CHECK 0 CFM@ 15 "Hg PAGE 3 OF _____

Run 3

TRAVERSE POINT NUMBER	ELAPSED SAMPLING TIME min.	GAS METER READING	VELOCITY HEAD		ORIFICE PRESSURE DIFFERENTIAL	STACK TEMPERATURE	GAS METER TEMPERATURE		PUMP VACUUM	FILTER HOLDER TEMP.	IMPINGER TEMP.
							INLET	OUTLET			
1	0/12:40	324.50	.86	.927	2.9	115	74	72	5	256	
2	2.5	326.6	.94	.970	3.1	116	84	72	5	246	
3	5	329.1	1.1	1.049	3.7	121	91	71	5	250	
4	7.5	331.7	1.1	1.049	3.7	124	96	72	5	251	
5	10	334.3	1.2	1.095	4.1	126	98	72	5	249	
6	12.5	336.9	1.2	1.095	4.1	124	99	73	5	253	56
7	15	339.4	1.3	1.140	4.4	122	101	74	5	260	
8	17.5	342.0	1.4	1.183	4.8	122	102	74	5	262	
9	20	344.6	1.5	1.225	5.1	122	103	75	5	251	
10	22.5	347.3	1.5	1.225	5.1	122	105	76	5	258	
11	25	350.3	1.5	1.225	5.1	121	107	77	5	255	
12	27.5	353.4	1.5	1.225	5.1	121	107	78	5	259	
1	30	356.47	.96	.980	3.2	111	94	78	5	250	
2	32.5	358.5	1.1	1.049	3.7	112	98	78	5	255	
3	35	361.0	1.1	1.049	3.7	115	101	78	5	262	
4	37.5	363.	1.2	1.095	4.1	117	102	78	5	267	
5	40	366.1	1.3	1.140	4.4	117	104	78	5	266	
6	42.5	369.0	1.3	1.140	4.4	120	106	79	5	260	
7	45	371.8	1.4	1.183	4.8	122	107	80	5	258	
8	47.5	374.7	1.4	1.183	4.8	125	107	81	5	252	
9	50	377.6	1.5	1.225	5.1	127	108	81	5	258	
10	52.5	380.7	1.4	1.183	4.8	128	108	81	5	250	
11	55	383.4	1.4	1.183	4.8	131	108	81	5	248	
12	57.5	386.2	1.2	1.095	4.1	128	108	81	5	258	
	60/1:43	388.98									
		6448		1.121	4.30	121.2	88.7				

PARTICULATE SAMPLING

NOMENCLATURE

PARTICULATE SAMPLING NOMENCLATURE

A = Cross sectional area of stack or duct, ft^2.

A_n = Cross sectional area of nozzle, ft^2.

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

C = Nomograph correction factor, dimensionless.

C_p = Pitot tube coefficient, dimensionless.

C_s = Concentration of particulate matter in gas stream, dry basis-corrected to standard conditions, gr/dscf.

D_n = Nominal diameter of probe nozzle tip, inches.

E = Particulate Emission Rate, lb/hr.

ΔH = Average pressure differential across orifice, in. H_2O.

$\Delta H_@$ = Orifice meter calibration factor, in. H_2O.

I = Percent of Isokinetic sampling, %.

K_p = Pitot tube constant, $85.49 \frac{ft}{sec} \left[\frac{(lb/lb\text{-}mole)(in.Hg)}{(^oR)(in.H_2O)} \right]$

M_d = Molecular weight of gas, dry basis, lb/lb-mole.

M_n = Total amount of particulate matter collected in probe wash and on filter, g.

M_s = Molecular weight of gas, wet basis, lb/lb-mole.

M_w = Molecular weight of water, 18 lb/lb-mole.

P_{bar} = Barometric Pressure, in. Hg.

P_g = Pressure differential from gas stream to atmosphere, (static pressure) in.H_2O.

P_s = Absolute gas stream pressure, $(P_{bar} + P_g/13.6)$ in.Hg.

P_{std} = Absolute pressure at standard conditions, 29.92 in. Hg.

P_w = Density of water, 0.0022 lb/ml.

ΔP_{avg} = Average of the square roots of the velocity head readings, ($\sqrt{\Delta p}$) (in.H_2O).

Q = Volumetric flow rate at gas stream conditions, A.C.F.M.

Q_{sd} = Dry volumetric gas flow rate corrected to standard conditions, S.C.F.M.

R = Ideal gas constant, 21.85 in. Hg-ft^3 / ^oR-lb-mole.

t = Total sampling time, minutes.

T_m = Average dry gas meter temperature, ^oR.

T_s = Average absolute gas stream temperature, ^oR.

T_{std} = Standard absolute temperature, 528^o Rankine.

V_{lc} = Volume of water collected in impingers & silica gel, ml.

V_m = Volume of gas sample measured at meter box (meter conditions), ft^3.

$V_{m(std)}$ = Volume of gas sample measured at meter box (corrected to standard conditions), ft^3.

V_s = Average gas stream velocity, ft/sec.

$V_{w(std)}$ = Volume of water vapor in gas sample (standard conditions) ft^3.

13.6 = Specific gravity of mercury (Hg).

% CO_2 = Percent by volume of CO_2 in gas stream (dry basis).

% O_2 = Percent by volume of O_2 in gas stream (dry basis).

% CO = Percent by volume of CO in gas stream (dry basis).

% N_2 = Percent by volume of N_2 in gas stream (dry basis).

SAMPLE STACK TESTING EQUATIONS

1) Volume of dry gas sampled through meter box at standard conditions.

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

(EPA Equation 5-1)

Where:

$V_{m(std)}$ = Volume of gas sample measured at meter box (corrected to standard conditions), ft^3.

V_m = Volume of gas sample measured at meter box (meter conditions), ft^3.

T_{std} = Standard absolute temperature, 528° Rankine.

T_m = Average dry gas meter temperature, $^{\circ}R$.

P_{bar} = Barometric Pressure, in. Hg.

ΔH = Average pressure differential across orifice, in. H_2O.

13.6 = Specific gravity of mercury (Hg).

P_{std} = Absolute pressure at standard conditions, 29.92 in. Hg.

Example: Run 1

V_m = 65.73 ft^3

T_m = 540.2 $^{\circ}R$

ΔH = 4.12 in. H_2O

P_{bar} = 29.66 in. Hg

$$V_{m(std)} = 65.73 \left[\frac{528.0}{540.2} \right] \left[\frac{29.66 + \frac{4.12}{13.6}}{29.92} \right]$$

$$= 65.73 \quad (0.9774) \quad (1.0014)$$

$$= 64.34 \ ft^3$$

2) Volume of water vapor collected at standard conditions.

$$V_{w(std)} = V_{lc} \left[\frac{P_w}{M_w} \right] \left[\frac{(R)(T_{std})}{P_{std}} \right]$$

(EPA Equation 5-2)

Where:

$V_{w(std)}$ = Volume of water vapor in gas sample (standard conditions) ft^3.

V_{lc} = Volume of water collected in impingers & silica gel, ml.

P_w = Density of water, 0.0022 lb/ml.

M_w = Molecular weight of water, 18 lb/lb-mole.

R = Ideal gas constant. 21.83 in. Hg-ft^3/ ^oR-lb-mole.

T_{std} = Standard absolute temperature, 528 ^{o} Rankine.

P_{std} = Absolute pressure at standard conditions, 29.92 in. Hg.

Example: Run 1

V_{lc} = 44.1 ml

$$V_{w(std)} = 44.1 \left[\frac{0.0022}{18.0} \right] \left[\frac{(21.83)(528.0)}{29.92} \right]$$

= 2.08 ft^3

Moisture content of gas stream.

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

(EPA Equation 5-3)

Where:

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

$V_{w(std)}$ = Volume of water vapor in gas sample (standard conditions) ft^3.

$V_{m(std)}$ = Volume of gas sample measured at meter box (corrected to standard conditions), ft^3.

Example: Run 1

$V_{w(std)} = 2.08 \ ft^3$

$V_{m(std)} = 64.34 \ ft^3$

$$B_{ws} = \frac{2.08}{64.34 + 2.08}$$

$$= 0.0313$$

4) Dry Molecular Weight of gas in gas stream,

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

(EPA Equation 3-2)

Where:

M_d = Molecular weight of gas, dry basis, lb/lb-mole.

0.440 = Molecular weight of CO_2 divided by 100.

0.320 = Molecular weight of O_2 divided by 100.

0.280 = Molecular weight of N_2 or CO (same for both compounds) divided by 100.

% CO_2 = Percent by volume of CO_2 in gas stream (dry basis).

% O_2 = Percent by volume of O_2 in gas stream (dry basis).

% CO = Percent by volume of CO in gas stream (dry basis).

% N_2 = Percent by volume of N_2 in gas stream (dry basis).

Example: Run 1

% CO_2 = 3.4

% O_2 = 16.0

% CO = 0.0

% N_2 = 80.6

M_d = 0.440 (3.4) + 0.320 (16.0) + 0.280 (80.6)

= 1.496 + 5.120 + 22.568

= 29.18 lb/lb-mole

5) Molecular Weight of gas in gas stream.

$$M_s = M_d (1 - B_{ws}) + M_w (B_{ws})$$

(EPA Equation 2-5)

Where:

M_s = Molecular weight of gas, wet basis, lb/lb-mole.

M_d = Molecular weight of gas, dry basis, lb/lb-mole.

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

M_w = Molecular weight of water, 18 lb/lb-mole.

Example: Run 1

M_d = 29.18 lb/lb-mole

B_{ws} = 0.0313

M_s = 29.18 (1 - 0.0313) + 18 (0.0313)

= 28.272 + 0.563

= 28.83 lb/lb-mole

6) Average Gas Stream Velocity,

$$V_s = K_p C_p \Delta P_{avg} \sqrt{\frac{T_s}{P_s M_s}}$$

(EPA Equation 2-9)

Where:

V_s = Average gas stream velocity, ft/sec.

K_p = Pitot tube constant, 85.49 $\frac{ft}{sec} \left[\frac{(lb/lb\text{-}mole)(in.Hg)}{(^oR)(in.H_2O)} \right]^{1/2}$

C_p = Pitot tube coefficient, dimensionless.

ΔP_{avg} = Average of the square roots of the velocity head readings, $(\sqrt{\Delta p})$ $(in.H_2O)$.

T_s = Average absolute gas stream temperature, ^oR.

P_s = Absolute gas stream pressure, $(P_{bar} + P_g/13.6)$ in.Hg.

P_{bar} = Barometric Pressure, in. Hg.

P_g = Pressure differential from gas stream to atmosphere, (static pressure) $in.H_2O$.

M_s = Molecular weight of gas, wet basis, lb/lb-mole.

Example: Run 1

C_p = 0.80

ΔP_{avg} = 1.096 $in.H_2O^{1/2}$

T_s = 582.2 ^oR

$P_s = P_{bar} + P_g/13.6 = 29.66 + -0.55/13.6 = 29.62$ in.Hg

M_s = 28.83 lb/lb-mole

$$V_s = (85.49)(0.80)(1.096)\sqrt{\frac{582.2}{(29.62)(28.83)}}$$

$$= (74.958)(0.8256)$$

$$= 61.89 \text{ ft/sec}$$

Volumetric Flow Rate at Gas Stream Conditions,

$$Q = A \times V_s \times 60$$

Where:

Q = Volumetric flow rate at gas stream conditions, A.C.F.M.

A = Cross sectional area of stack or duct, ft^2.

V_s = Average gas stream velocity, ft/sec.

60 = Conversion factor from seconds to minutes.

Example: Run 1

A = 7.07 ft^2

V_s = 61.89 ft/sec

$$Q = (7.07) (61.89) 60$$

$$= 26.248 \text{ ACFM}$$

8) Volumetric Flow Rate at Standard Conditions,

$$Q_{sd} = 60 \ (1 - B_{ws}) \ V_s \ A \left[\frac{T_{std}}{T_s} \right] \left[\frac{P_s}{P_{std}} \right]$$

(EPA Equation 2-10)

Where:

Q_{sd} = Dry volumetric gas flow rate corrected to standard conditions, S.C.F.M.

60 = Conversion factor from seconds to minutes.

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

V_s = Average gas stream velocity, ft/sec.

A = Cross sectional area of stack or duct, ft^2.

T_{std} = Standard absolute temperature, 528 ^{o} Rankine.

T_s = Average absolute gas stream temperature, ^{o}R.

P_s = Absolute gas stream pressure, $(P_{bar} + P_g/13.6)$ in.Hg.

P_{bar} = Barometric Pressure, in. Hg.

P_g = Pressure differential from gas stream to atmosphere, (static pressure) in.H_2O.

P_{std} = Absolute pressure at standard conditions, 29.92 in. Hg.

Example: Run 1

B_{ws} = 0.0313

V_s = 61.89 ft/sec

A = 7.07 ft^2

T_s = 582.2 ^{o}R

$P_s = P_{bar} + P_g/13.6 = 29.66 + -0.55/13.6 = 29.62$ in.Hg

$$Q_{sd} = 60 \ (1 - 0.0313) \ (61.89) \ (7.07) \ \frac{528.0}{582.2} \ \frac{29.62}{29.92}$$

= 22,829 SCFM

Gas Stream Particulate Concentration,

$$C_s = 15.43 \text{ gr./g} \left[\frac{M_n}{V_{m(std)}} \right]$$

(EPA Equation 5-6)

Where:

C_s = Concentration of particulate matter in gas stream, dry basis-corrected to standard conditions, gr/dscf.

M_n = Total amount of particulate matter collected in probe wash and on filter, g.

$V_{m(std)}$ = Volume of gas sample measured at meter box (corrected to standard conditions), ft^3.

Example: Run 1

$$M_n = (\text{probe}) 0.0071 + (\text{filter}) 0.0661 = 0.0732 \text{ g}$$

$$V_{m(std)} = 64.34 \text{ } ft^3$$

$$C_s = 15.43 \left[\frac{0.0732}{64.34} \right]$$

$$= 0.0176 \text{ gr/dscf}$$

6) Particulate Emission Rate,

$$E = Q_{sd} \; C_s \left[\frac{1 \text{ pound}}{7000 \text{ grains}}\right] \left[\frac{60 \text{ minutes}}{1 \text{ hour}}\right]$$

Where:

E = Particulate Emission Rate, lb/hr.

Q_{sd} = Dry volumetric gas flow rate corrected to standard conditions, S.C.F.M.

C_s = Concentration of particulate matter in gas stream, dry basis-corrected to standard conditions, gr/dscf.

Example: Run 1

Q_{sd} = 22,829 ft^3

C_s = 0.0176 gr/dscf

$$E = (22.829)(0.0176)\left[\frac{60}{7000}\right]$$

$$= 3.44 \text{ lb/hr}$$

11) Percent of Isokinetic Sampling.

$$I = \frac{100\ T_s \left[K_3\ V_{lc} + \left(\frac{V_m}{T_m} \right) \left(P_{bar} + \frac{\Delta H}{13.6} \right) \right]}{60\ A_n\ V_s\ P_s\ t}$$

Where: (EPA Equation 5-7)

I = Percent of Isokinetic sampling, %.

T_s = Average absolute gas stream temperature, ^{o}R.

K_3 = Constant, 0.002669 in.Hg-ft^3/ml-^{o}R.

V_{lc} = Volume of water collected in impingers & silica gel, ml.

V_m = Gas sample volume measured at meter box (meter conditions), ft^3.

T_m = Average dry gas meter temperature, ^{o}R.

P_{bar} = Barometric Pressure, in. Hg.

ΔH = Average pressure differential across orifice, in. H_2O.

t = Total sampling time, minutes.

V_s = Average gas stream velocity, ft/sec.

P_s = Absolute gas stream pressure, in.Hg.

D_n = Nominal diameter of probe nozzle tip, inches.

A_n = Cross sectional area of nozzle, ft^2.

Example: Run 1

T_s	=	582.2	^{o}R	ΔH	=	4.12	in.H_2O
V_{lc}	=	44.1	ml	t	=	60.0	min.
V_m	=	65.73	ft^3	V_s	=	61.89	ft/sec
T_m	=	540.2	^{o}R	P_s	=	29.62	in.Hg
A_n	=	0.0003408	ft^2	P_{bar}	=	29.66	in.Hg

$$I = \frac{582.2\ (\ 100\ ) \left[0.002669\ (\ 44.1\ ) + \left(\frac{65.73}{540.2} \right) \left(29.66 + \frac{-0.55}{13.6} \right) \right]}{60\ (0.0003408\ )\ (\ 61.89\ )\ (\ 29.62\ )\ (\ 60.0\ )}$$

$$= 97.4\ \%$$