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.

AP42 Section: 11.1

Reference Number: 301

Title: Source Sampling For Particulate Emissions, Thompson-McCully Co., Detroit, MI,

Ramcon Environmental Corp., Memphis, TN,

July 7, 1988.

AP-42 Section 11.1
Reference
Report Sect. 4
Reference ~~300~~ 301

RAMCON
ENVIRONMENTAL CORPORATION

SOURCE SAMPLING
for
PARTICULATE & SO_2 EMISSIONS
THOMPSON MC CULLEY
DETROIT, MICHIGAN
July 7, 1988

Byron Thomas
Thompson-McCulley

G. Sumner Buck, III
President

Allen Turner
Team Leader

RAMCON BUILDING, 223 SCOTT STREET, MEMPHIS, TENNESSEE 38112
TELEPHONE 800/458-4567 IN TENNESSEE 901/458-7000 FAX 901-458-3868

RAMCON
ENVIRONMENTAL CORPORATION

July 28, 1988

Mr. Byron Thomas
Thompson-McCulley
1785 Belleville
Belleville, MI 48111

Re: Particulate & SO_2 Emissions Test-Detroit, Michigan

Dear Mr. Thomas:

Enclosed you will find four copies of our report on the particulate and SO_2 emissions test we conducted on your plant.

You will want to sign the report covers and send two copies to:

Mr. John Baguzis
Wayne County Air Pollution Control
1311 East Jefferson
Detroit, MI 48207

You will need to keep one copy of the report at the plant.

Sincerely,

G. Sumner Buck, III
President

GSBIII/mew

Enclosures

RAMCON BUILDING, 223 SCOTT STREET, MEMPHIS, TENNESSEE 38112
TELEPHONE 800/458-4567 IN TENNESSEE 901/458-7000 FAX 901-458-3848

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I. INTRODUCTION

On July 7, 1988, personnel from RAMCON Environmental Corporation (REC) conducted a source emissions test for particulate and SO_2 emissions compliance at Thompson-McCulley's Barber-Greene drum mix asphalt plant located in Detroit, Michigan. RAMCON personnel conducting the test were Allen Turner, Team Leader, and Kevin Powell. Bruce Shrader was responsible for the particulate and SO_2 laboratory analysis including taring the beakers and filters and recording final data in the laboratory record books. Custody of the samples was limited to Mr. Turner and Mr. Shrader.

The purpose of the test was to determine if the rate of particulate and SO_2 emissions from the plant's baghouse and the total contaminants by weight (grain loading) is below the allowable emissions limit set by the State of Michigan.

II. TEST RESULTS

Table I summarizes the test results. The grain loading limitation for EPA is .04 gr/dscf and is specified in 39 FR 9314, March 8, 1974, 60.92 Standards for Particulate Matter (1), as amended. The allowable emissions for the State of Michigan are the same as those set by EPA.

Mr.Wayne Baguzi of the Wayne County APC observed the testing conducted by RAMCON.

TABLE I

SUMMARY OF TEST RESULTS

Test Run	Time	Grain Loading	SO2 Emissions	Actual Emissions
1	08:41 to 09:44	0.0184 gr/dscf	8.59 lbs/hr	6.46 lbs/hr
2	10:43 to 11:48	0.0268 gr/dscf	4.61 lbs/hr	9.20 lbs/hr
3	14:09 to 15:11	0.0165 gr/dscf	2.60 lbs/hr	5.67 lbs/hr
	Average:	0.0205 gr/dscf	5.27 lbs/hr	7.11 lbs/hr

Particulate

Particulate

On the basis of these test results, the average grain loading of the three test runs was below the .04 gr/DSCF emissions limitation set by US EPA and the State of Michigan. Therefore, the plant is operating in compliance with State and Federal Standards.

III. TEST PROCEDURES

A. Method Used: The source sampling was conducted in accordance with requirements of the U.S. Environmental Protection Agency as set forth in 39 FR 9314, March 8, 1974, 60.93, as amended.

B. Problems Encountered: No problems were encountered that affected testing.

TABLE

SUMMARY OF TEST RESULTS

Thompson-McCulley Sulfur Reduction Test

Aggregate production rate:	343 TPH
Fuel consumption rate:	1,857 gal/ton mix
Gallons of fuel consumed (343 tph)(1,857/ton)	636.95 gal
Weight of fuel consumed:*	4,735 lbs. fuel

$$*\frac{\text{(specific gravity)(pounds/ft}^3)}{\text{gallons/ft}} = \frac{(.8912)(62.4)}{(7.4805)} = \frac{7.434 \text{ pounds}}{\text{gallons}}$$

$$\frac{7.434 \text{ lbs}}{\text{gal}} \times \frac{636.95 \text{ gal}}{\text{fuel}} = 4{,}735 \text{ lbs. fuel}$$

Percent sulfur in fuel from fuel analysis:	.81%
Weight of sulfur in fuel: lbs = (.0081)(4,735 lbs.fuel)	38.35 lbs.
Weight of sulfur dioxide in fuel:**	76.71 lbs.

**Mol weight sulfur = 32

Mol weight oxygen = 16

Mol weight SO_2 = 64

38.35 lbs. sulfur with mol weight 32 =

76.71 lbs. sulfur dioxide with mol weight of 64.

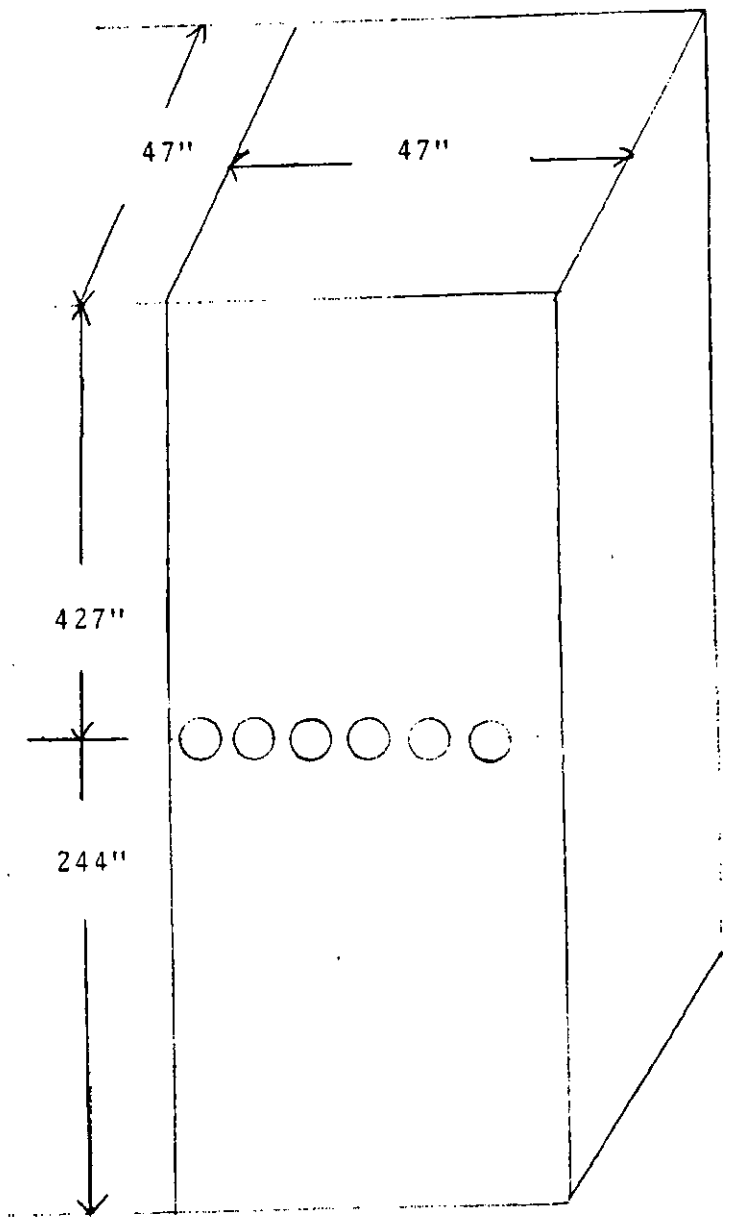
Potential sulfur dioxide emissions: 76.71 lbs/hr

Percent sulfur reduction: (potential emissions-actual emissions)/ potential emissions

Run #1	(76.71 - 8.59)/76.71	=	88.8%
Run #2	(76.71 - 4.61)/76.71	=	94.0%
Run #3	(76.71 - 2.60)/76.71	=	96.6%

C. Sampling Site: The emissions test was conducted after a baghouse on a rectangular stack measuring 47" x 47" with an equivalent diameter of 47". Six sampling ports were placed 427" down (9.1 diameters upstream) from the top of the stack and 244" up (5.2 diameters downstream) from the last flow disturbance. Thirty points were sampled, five through each port for two minutes each for a total test time of sixty minutes per test run.

Points on a Diameter	Probe Mark
1	4.7"
2	14.1"
3	23.5"
4	32.9"
5	42.3"



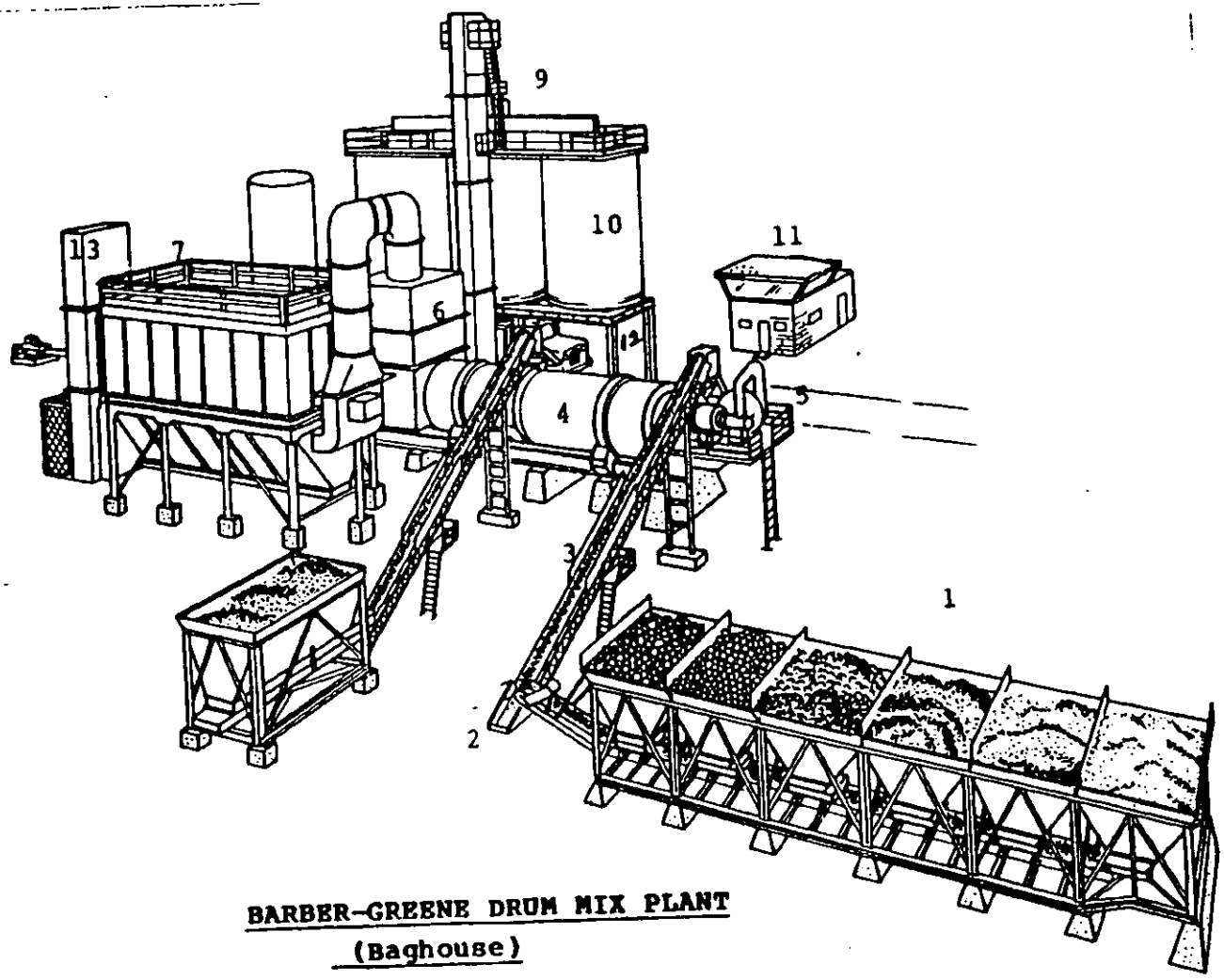
IV. THE SOURCE

IV. THE SOURCE

Thompson McCulley employs a Barber-Greene drum mix asphalt plant which is used to manufacture hot mix asphalt for road pavement. The process consists of blending prescribed portions of cold feed materials (sand, gravel, screenings, chips, etc.) uniformly and adding sufficient hot asphalt oil to bind the mixture together. After the hot asphalt mix is manufactured at the plant, it is transported to the location where it is to be applied. The hot asphalt mix is spread evenly over the surface with a paver and then compacted with a heavy roller to produce the final product.

The following is a general description of the plant's manufacturing process: The cold feed materials (aggregate) are dumped into four separate bins which in turn feed a common continuous conveyor. The aggregate is dispensed from the bins in accordance with the desired formulation onto the cold feed system conveyor to an inclined weigh conveyor then to a rotating drum for continuous mixing and drying at approximately 300°F. The dried aggregate is pulled by a bucket elevator to the top of a gradation control unit which separates and stores the aggregate by size. The required amount of each aggregate is dispensed into a weigh-hopper and from there, into a pugmill where the hot liquid asphalt is mixed thoroughly with the aggregate. The hot asphalt mix is then discharged from the storage silo through a slide gate into waiting dump trucks, which transport the material to a final destination for spreading. The rated capacity of the plant will vary with each aggregate mix and moisture content with a 5% surface moisture removal.

The drum dryer uses a burner fired with #6 fuel oil to heat air to dry the aggregate, and the motion of the rotating drum to blend the aggregate and hot asphalt oil thoroughly. The air is drawn into the system via an exhaust fan. After passing through the burner and the mixing drum, the air passes through a baghouse. The baghouse is manufactured by Barber Greene.. The exhaust gas is drawn through the baghouse and discharged to the atmosphere through the stack. The design pressure drop across the tube sheet is 1-6 inches of water. The particulate matter, which is removed by the baghouse is reinjected into the drum mixer.



BARBER-GREENE DRUM MIX PLANT
(Baghouse)

1. Aggregate bins: Virgin aggregate is fed individually into each of four bins by type. It is metered onto a conveyor belt running under the bins to a shaker screen. The proporation of each aggregate type is determined by the job mix formula and pre-set to be metered out to meet these specifications.

2. Preliminary oversize screen: The aggregate is fed through a shaker screen where oversize rocks and foreign material is screened out of the mix.

3. Weigh conveyor belt: The aggregate is conveyed to the rotary drum dryer on a conveyor belt which weighs the material. The production rate is determined by this weight reading.

4. Rotary drum dryer/mixer: The aggregate is fed into the rotary drum dryer where it is tumbled by flighting into a veil in front of a flame which drives off the moisture. Further mixing is also accomplished in this drum. Hot liquid asphalt is injected approximately one-third of the way down the inclined drum where it is mixed with the aggregate.

5. Burner: The fuel fired burner is used to provide the flame which drys the aggregate.

6. Knock off baffleing: A baffeling plate is inserted in the "dirty" side plenum as a knock out for heavy particles in the air stream. These particles fall to the bottom of the baghouse.

7. Baghouse: The hot gases are pulled through the bags into the clean air plenum. The solid particulate matter is trapped on the dust coat buildup on the bags. A bag cleaning cycle consisting of jet burst of air from the inside (or clean air side) of the bags sends a large bubble of air down the inside of the bags shaking loose buildup on the bag surface. This particulate matter is collected at the bottom of the baghouse and reinjected into the drum mixer where it is used as part of the finished project.

8. Liquid asphalt storage: The liquid asphalt is stored in this heated tank until it is needed in the mixer. The amount of asphalt content and its temperature are pre-set for each different type job.

9. Conveyor to surge/storage bin: The finished product of aggregate mixed with liquid asphalt is conveyed to a surge bin.

10. Surge/Storage bin: The asphaltic cement is dumped into this surge bin and metered out to dump trucks which pull underneath a slide gate at the bottom of the bin.

11. Control/operators house: The entire plant operation is controlled from this operator's house.

12. Truck loading scale: As the trucks receive the asphalt from the storage/surge bin they are weighed on the loading scale which tells the plant operator the amount of asphalt that is being trucked on each individual load.

13. Fuel Storage

14. Stack

V. EQUIPMENT USED

V. EQUIPMENT USED

Equipment used on conducting the particulate emissions test was:

A. The Lear Siegler PM-100 stack sampler with appropriate auxillary equipment and glassware. The train was set up according to the schematic on the nex page.

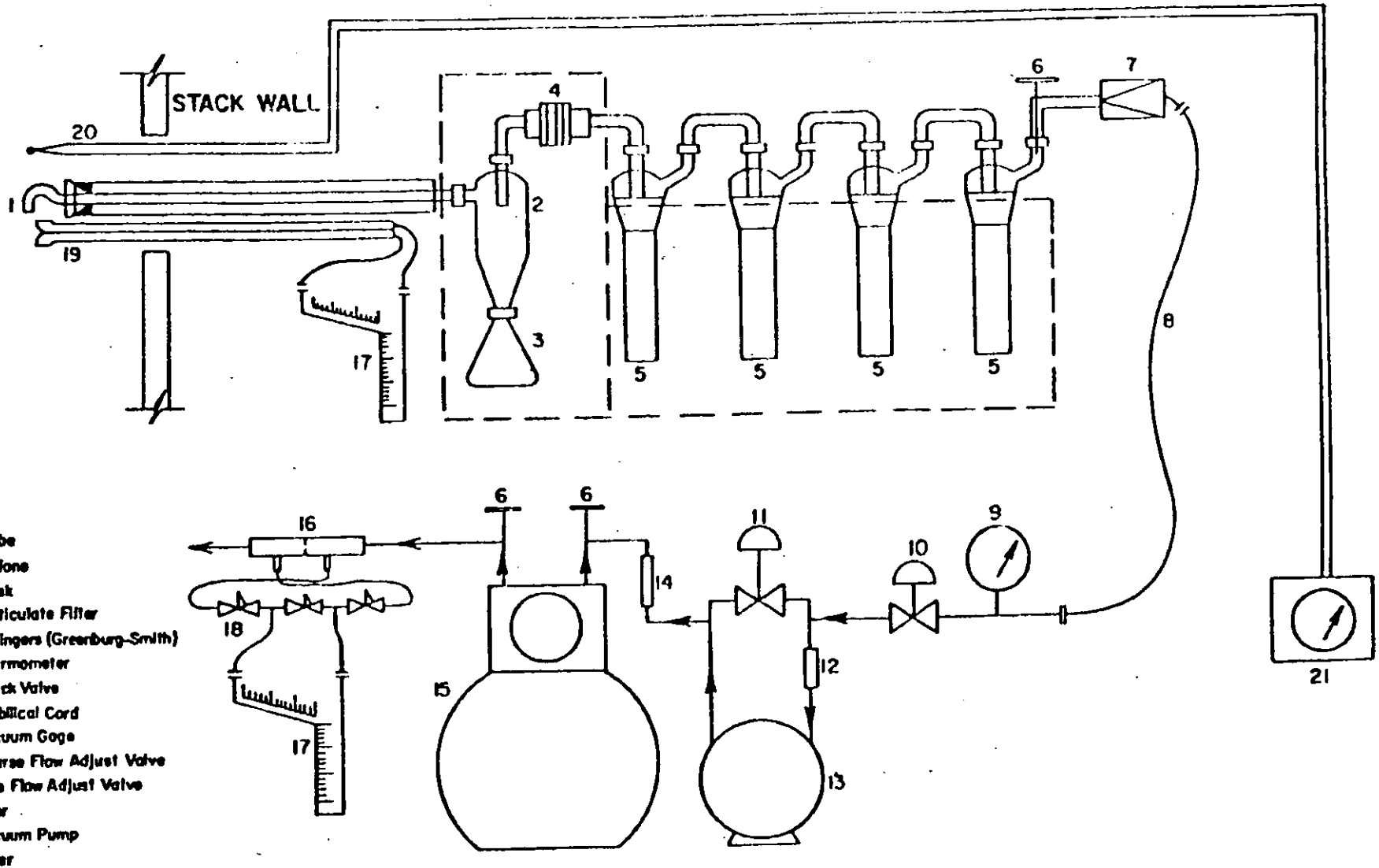
B. An Airguide Instruments Model 211-B (uncorrected) aneroid barometer was used to check the barometric pressure.

C. Weston dial thermometers are used to check meter temperatures. An Analogic Model 2572 Digital Thermocouple is used for stack temperatures.

D. A Hays 621 Analyzer was used to measure the oxygen, carbon dioxide and carbon monoxide content of the stack gases. For non-combustion sources, A Bacharach Instrument Company Fyrite is used for the gas analysis.

E. Filters are mady by Schleicher and Schuell and are type 1-HV with a porosity of .03 microns.

F. The acetone is reagent grade or ACS grade with a residue of $\leq$ .001.



1) Probe
2) Cyclone
3) Flask
4) Particulate Filter
5) Impingers (Greenburg-Smith)
6) Thermometer
7) Check Valve
8) Umbilical Cord
9) Vacuum Gage
10) Course Flow Adjust Valve
11) Fine Flow Adjust Valve
12) Oiler
13) Vacuum Pump
14) Filter
15) Dry Gas Meter
16) Orifice Tube
17) Incline Manometer
18) Solenoid Valves
19) Pitot
20) Thermocouple
21) Pyrometer

SAMPLING TRAIN
USED FOR ISOKINETIC SAMPLING

VI. LABORATORY PROCEDURES & RESULTS

LABORATORY PROCEDURES FOR PARTICULATE SAMPLING

I. Field Preparation

A. FILTERS: Fiberglass 4" sampling filters are prepared as follows:

Filters are removed from their box and numbered on the back side with a felt pen. The numbering system is continuous from job to job. The filters are placed in a dessicator to dry for at least 24 hours. Clean plastic petri dishes, also numbered, top and bottom, are placed in the dessicator with the filters. After dessication, the filters are removed one at a time and weighed on the Sartorius analytical balance, then placed in the correspondingly numbered petri dish. Weights are then recorded in the lab record book. Three filters are used for each complete particulate source emissions test and there should be several extra filters included as spares.

B. SILICA GEL: Silica Gel used for the test is prepared as follows:

Approximately 200 g of silica gel is placed in a wide mouth "Mason" type jar and dried in an oven (175°C for two hours). The open jars are removed and placed in a dessicator until cool (2 hours) and then tightly sealed. The jars are then numbered and weighed on the triple beam balance to the closest tenth of a gram, and this weight is recorded for each sealed jar. The number of silica gel jars used is the same as the number of filters. Silica gel should be indicating type, 6-16 mesh.

II. Post-Testing Lab Analysis

A. FILTERS: The filters are returned to the lab in their sealed petri dishes. In the lab, the dishes are opened and placed into a dessicator for at least 24 hours. Then, the filters are weighed continuously every 6 hours until a constant weight is achieved. All data is recorded on the laboratory forms that will be bound in the test report.

Alternately, the test team may opt to oven dry the filters at 220°F for two to three hours, weigh the sample, and use this weight as a final weight.

B. SILICA GEL: The silica gel used in the stack test is returned to the appropriate mason jar and sealed for transport to the laboratory where it is reweighed to a constant weight on a triple-beam balance to the nearest tenth of a gram.

C. PROBE RINSINGS: In all tests, where a probe washout analysis is necessary, this is accomplished in accordance with procedures specified in "EPA Reference Method 5". These samples are returned in sealed mason jars to the laboratory for analysis. The front half of the filter holder is washed in accordance with the same procedures and included with the probe wash. Reagent or ACS grade acetone is used as the solvent. The backhalf of the filter holder is washed with deionized water into the impinger catch for appropriate analysis.

D. IMPINGER CATCH: In some testing cases, the liquid collected in the impingers must be analyzed for solid content. This involves a similar procedure to the probe wash solids determination, except that the liquid is deionized water.

E. ACETONE: Conduct a blank analysis of acetone from the one gallon glass container. This acetone will be used in the field for rinsing the probe, nozzle, and top half of the filter holder. Performing such a blank analysis prior to testing will insure that the quality of the acetone to be used will not exceed the .001% residual purity standard.

SPECIAL NOTE

When sampling sources high in moisture content, (such as asphalt plants) the filter paper sometimes sticks to the filter holder. When removing the filter, it may tear. In order to maintain control of any small pieces of filter paper which may be easily lost, they are washed with acetone into the probe washing. This makes the filter weight light (sometimes negative) and the probe wash correspondingly heavier. The net weight is the same and no particulate is lost. This laboratory procedure is taught by EPA in the Quality Assurance for Source Emissions Workshop at Research Triangle Park and is approved by EPA.

WEIGHING PROCEDURE - SARTORIUS ANALYTICAL BALANCE

The Sartorius balance is accurate to 0.1 mg and has a maximum capacity of 200 grams. The balance precision (standard deviation) is 0.05 mg. Before weighing an item, the balance should first be zeroed. This step should be taken before every series of weighings. To do this, the balance should have all weight adjustments at "zero" position. The beam arrest lever (on the lower left hand side toward the rear of the balance) is then slowly pressed downward to full release position. The lighted vernier scale on the front of the cabinet should align the "zero" with the mark on the cabinet. If it is not so aligned, the adjustment knob on the right hand side (near the rear of the cabinet) should be turned carefully until the marks align. Now return the beam arrest to horizontal arrest position. The balance is now "zeroed".

To weigh an item, it is first placed on the pan. And the sliding doors are closed to avoid air current disturbance. The weight adjustment knob on the right hand side must be at "zero". The beam arrest is then slowly turned upward. The lighted scale at the front of the cabinet will now indicate the weight of the item in grams. If the scale goes past the divided area, the item then exceeds 100 g weight (about 3-1/2 ounces) and it is necessary to arrest the balance (beam arrest lever) and move the lever for 100 g weight away from you. It is located on the left hand side of the cabinet near the front, and is the knob closest to the side of the cabinet. The balance will not weigh items greater than 200 grams in mass, and trying to do this might harm the balance. Remember -- this is a delicate precision instrument.

After the beam is arrested, in either weight range, the procedure is the same. When the weight of the item in grams is found, "dial in" that amount with the two knobs on the left hand side (near the 100 g lever) color coded yellow and green. As you dial the weight, the digits will appear on the front of the cabinet. When the proper amount is dialed, carefully move the arrest lever down with a slow, steady turn of the wrist. The lighted dial will appear, and the right hand side knob (front of cabinet) is turned to align the mark with the lower of the two lighted scale divisions which the mark appears between. When these marks are aligned, the two lighted digits along with the two indicated on the right hand window on the cabinet front are the fractional weight in grams (the decimal would appear before the lighted digits) and the whole number of grams weight is the amount "dialed in" on the left.

In general, be sure that the beam is in "arrest" position before placing weight on or taking weight off of the pan. Don't "dial in" weight unless the beam is arrested. The balance is sensitive to even a hand on the table near the balance, so be careful and painstaking in every movement while weighing.

Form REC#8

SAMPLE ANALYTICAL DATA FORM

Plant Location Thompson McCully — Relative humidity in lab 45 %

Sample Location hot mix asphalt plant — Density of Acetone (pa) .7853 mg/ml

Blank volume (V_a) 200 ml

Date/Time wt. blank 7-18-88 — Gross wt. 104.4682 mg

Date/Time wt. blank 7-19-88 — Gross wt. 104.4678 mg

Ave. Gross wt. 104.4680 mg

Tare wt. 104.4678 mg

Weight of blank (m_{ab}) .0002 mg

Acetone blank residue concentration (C_a) $(C_a) = (M_{ab}) / (V_a)(p_a) = (.000003$ mg/g)

Weight of residue in acetone wash: $W_a = C_a V_{aw} p_a = (.000003)(200)(.7853) = (.0002)$

			Run # 1	Run # 2	Run # 3
Acetone rinse volume (V_{aw})		ml	200	200	200
Date/Time of wt 7-18-88	Gross wt	g	101.0971	99.9787	98.5745
Date/Time of wt 7-19-88	Gross wt	g	101.0968	99.9782	98.5743
	Average Gross wt	g	101.0970	99.9785	98.5744
	Tare wt	g	101.0653	99.9302	98.5460
	Less acetone blank wt (W_a)	g	.0002	.0002	.0002
Wt of particulate in acetone rinse (m_a)		g	.0315	.0481	.0282

	Filter Numbers	#	SG-2700	SG-2701	SG-2699
Date/Time of wt 7-18-88	Gross wt	g	.5456	.5423	.5410
Date/Time of wt 7-19-88	Gross wt	g	.5454	.5420	.5409
	Average Gross wt	g	.5455	.5422	.5410
	Tare wt	g	.5283	.5263	.5292

Weight of particulate on filters(s) (m_f)	g	.0172	.0159	.0118
Weight of particulate in acetone rinse	g	.0315	.0481	.0282
Total weight of particulate (m_n)	g	.0487	.0640	.0400

Note: In no case should a blank residue greater than 0.01 mg/g (or 0.001% of the blank weight) be subtracted from the sample weight.

Remarks

Signature of analyst [signature] Signature of reviewer [signature]

SO_2 ANALYSIS

(Method 8)

Plant McCulley Date 7/1/85

Audit Samples

Audit Number									
		A	B	A	B	A	B	A	B
V_{soln}	(ml)	1000	1000						
V_a	(ml)	10	10						
N	(N)	0.0091	0.0091						
V_t	(ml)	2.0	1.95						
$V_{m(std)}$	(dscm)								
C_{SO_2}	(mg/dscm)								

K_2 = 32.03 mg/meq

SO_2 Analysis for Impinger 2 & 3 Combined.

Run Number		1		2		3		Blank	
		A	B	A	B	A	B	A	B
V_{soln}	(ml)	1000	1000	1000	1000	1000	1000		
V_a	(ml)	10	10	10	10	10	10		
N	(N)	0.0102	0.0102	0.0102	0.0102	0.0102	0.0102		
V_t	(ml)	2.0	2.0	1.0	1.0	0.55	0.60	0.02	0.02
$V_{m(std)}$	(dscf)								
C_{SO_2}	(lb/dscf)								

K_3 = 7.061×10^{-5} lb/meq

Analysis performed by: [illegible] Approved by: [illegible]

COMMERCIAL TESTING & ENGINEERING CO.
GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • (312) 953-9300

Member of the SGS Group (Société Générale de Surveillance)

PLEASE ADDRESS ALL CORRESPONDENCE TO:
216 OXMOOR CIRCLE, BIRMINGHAM, AL 35209
TELEPHONE: (205) 942-3120
TELEX: 782071 COMTECO BHM
FAX: (205) 942-0914

Ramcon, Inc.

Memphis, Tennessee

August 5, 1988

Sample identification
by Ramcon, Inc.

Kind of sample reported to us	Thompson-McCully-#6 Fuel Oil
Sample taken at	------
Sample taken by	Ramcon, Inc.
Date sampled	July 7, 1988
Date received	August 3, 1988

Analysis report no. 73-11767

As Run Sulfur = 0.81

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Manager, Birmingham Laboratory

Original Copy Watermarked
For Your Protection

F-464

ENVIRONMENTAL TESTING & CONSULTING INC.
2924 WALNUT GROVE RD. • MEMPHIS, TENN. 38111 • PHONE (901) 327-2750

August 29, 1988

Mr. Sumner Buck
Ramcon
223 Scott
Memphis, Tenn. 38112

REF: ANALYTICAL TESTING
SAMPLE(S) DATE: 8/9/88
THOMPSON McCULLY - AGGREGATE SAMPLES

Dear Mr. Buck:

The above referenced samples have been analyzed per your instructions. The tests were performed in our laboratory (#00210) in accordance with Standard Methods, 16th Edition, and the results are shown below.

Sample I.D.	Date	Time	*pH	Standard Methods Page #	By	Date
#1 Baghouse	7/7/88	9:50 a.m.	11.2	429	JS	8/9
#2	7/7/88	7:47 a.m.	11.4	429	JS	8/9
#3	7/7/88	9:45 a.m.	10.8	429	JS	8/9
#4 Limestone Sand	7/7/88	11:45 a.m.	9.0	429	JS	8/9
#5 Limestone Baghouse	7/7/88	11:50 a.m.	11.3	429	JS	8/9

If you have any questions please call me.

Very truly yours,

Michael J. Cimbalo
President

MJC/mg

* 10 grams/100 ml of DI

VII. CALCULATIONS

THOMPSON MCCULLEY
DETROIT, MICHIGAN
7/7/88

SUMMARY OF TEST DATA

		RUN #1	RUN #2	RUN #3
SAMPLING TRAIN DATA				
	start	08:41	10:43	14:09
	finish	09:44	11:48	15:11
1. Sampling time, minutes	θ	60.0	60.0	60.0
2. Sampling nozzle diameter, in.	D_n	.2100	.2100	.2100
3. Sampling nozzle cross-sect. area, ft^2	A_n	.000241	.000241	.000241
4. Isokinetic variation	I	105.5	97.3	98.8
5. Sample gas volume - meter cond., cf.	V_m	42.800	39.642	40.194
6. Average meter temperature, ^oR	T_m	566	581	580
7. Avg. oriface pressure drop, in. H_2O	dH	1.72	1.50	1.46
8. Total particulate collected, mg.	M_n	48.70	64.00	40.00
VELOCITY TRAVERSE DATA				
9. Stack area, ft^2	A	15.34	15.34	15.34
10. Absolute stack gas pressure, in. Hg.	P_s	30.75	30.75	30.75
11. Barometric pressure, in. Hg.	P_{bar}	30.75	30.75	30.75
12. Avg. absolute stack temperature, R^o	T_s	697	700	700
13. Average $-\sqrt{\text{vel. head}}$, (C_p= .80)	$-\sqrt{dP}$	1.14	1.11	1.10
14. Average stack gas velocity, ft./sec.	V_s	71.58	69.75	68.99
STACK MOISTURE CONTENT				
15. Total water collected by train, ml.	V_{ic}	217.00	188.00	180.00
16. Moisture in stack gas, %	B_{ws}	20.17	19.49	18.54
EMISSIONS DATA				
17. Stack gas flow rate, dscf/hr.(000's)	Q_{sd}	2456	2404	2405
18. Stack gas flow rate, cfm	acfm	65882	64198	63498
19. Particulate concentration, gr/dscf	C_s	0.0184	0.0268	0.0165
20. Particulate concentration, lb/hr	E	6.46	9.20	5.67
21. Total SO_2 concentration, lb/dscf	C'	3.5 EE - 6	1.9 EE --6	1.1 EE - 6
22. Total SO_2 emissions, lbs/hr	ESO_2	8.59	4.61	2.60
ORSAT DATA				
23. Percent CO_2 by volume	CO_2	4.00	4.00	4.00
24. Percent O_2 by volume	O_2	12.50	12.50	12.30
25. Percent CO by volume	CO	.00	.00	.00
26. Percent N_2 by volume	N_2	83.50	83.50	83.70

Format: sumry4R3

NAME: THOMPSON MCCULLEY
LOCATION: DETROIT, MICHIGAN
TEST DATE: 7/7/88

Dry Gas Volume

$$V_{m(std)} = V_m \left[\frac{T_{(std)}}{T_m}\right]\left[\frac{P_{bar} + \frac{dH}{13.6}}{P_{(std)}}\right] = 17.64 \frac{^oR}{in.Hg} \; Y \; V_m \left[\frac{P_{bar} + \frac{dH}{13.6}}{T_m}\right]$$

Where:

$V_{m(std)}$ = Dry Gas Volume through meter at standard conditions, cu. ft.

V_m = Dry Gas Volume measured by meter, cu. ft.

P_{bar} = Barometric pressure at oriface meter, in. Hg.

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

T_m = Absolute temperature at meter ^oR.

T_{std} = Standard absolute temperature (528^oR).

dH = Average pressure drop across oriface meter, in. H_2O.

Y = Dry gas meter calibration factor.

13.6 = Inches water per inches Hg.

RUN 1:

$$V_{m(std)} = (17.64)(.990)(42.800)\left[\frac{(30.75) + \frac{1.72}{13.6}}{566}\right] = 40.775 \text{ dscf}$$

RUN 2:

$$V_{m(std)} = (17.64)(.990)(39.642)\left[\frac{(30.75) + \frac{1.50}{13.6}}{581}\right] = 36.772 \text{ dscf}$$

RUN 3:

$$V_{m(std)} = (17.64)(.990)(40.194)\left[\frac{(30.75) + \frac{1.46}{13.6}}{580}\right] = 37.344 \text{ dscf}$$

Format: dgmR3

THOMPSON MCCULLEY
DETROIT, MICHIGAN
7/7/88

Emissions of SO_2 PPM (Parts Per Million)

$$E = CSO_2 \left| \frac{453.593g}{1\ lb} \right| \frac{MOL\ SO_2}{64g\ SO_2} \left| \frac{22.4\ l}{MOL} \right| \frac{293^oK}{273^oK} \left| \frac{ft^3}{28.317\ l} \right| 1,000,000$$

Where; CSO_2 = Concentration of SO_2 in lbs/dscf.

453.593 = Conversion to grams.

64/MOL SO_2 = Molar conversion of SO_2.

22.4 l/MOL = Volumetric molar conversion 273^oK.

$293^oK/273^oK$ = Temperature correction to std. conditions.

28.317 l = Conversion of liters to cubic feet.

1,000,000 = Conversion to parts per million.

Run # 1:

$$E = 40.775 \frac{lbs}{dscf} \left| \frac{453.593g}{1\ lb} \right| \frac{MOL\ SO_2}{64g\ SO_2} \left| \frac{22.4\ l}{MOL} \right| \frac{293^oK}{273^oK} \left| \frac{ft^3}{28.317\ l} \right| 1,000,000 = 21.04ppm$$

Run # 2:

$$E = 36.772 \frac{lbs}{dscf} \left| \frac{453.593g}{1\ lb} \right| \frac{MOL\ SO_2}{64g\ SO_2} \left| \frac{22.4\ l}{MOL} \right| \frac{293^oK}{273^oK} \left| \frac{ft^3}{28.317\ l} \right| 1,000,000 = 11.55ppm$$

Run # 3:

$$E = 37.344 \frac{lbs}{dscf} \left| \frac{453.593g}{1\ lb} \right| \frac{MOL\ SO_2}{64g\ SO_2} \left| \frac{22.4\ l}{MOL} \right| \frac{293^oK}{273^oK} \left| \frac{ft^3}{28.317\ l} \right| 1,000,000 = 6.50ppm$$

Format:ppmso2R3

NAME: THOMPSON MCCULLEY
LOCATION: DETROIT, MICHIGAN
TEST DATE: 7/7/88

Total Contaminants by Weight: GRAIN LOADING

Particulate concentration C_s' gr./dscf.

$$C_s' = \left[0.0154 \frac{gr}{mg}\right] \left[\frac{M_n}{V_{m(std)}}\right]$$

Where:

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

M_n = Total amount of particulate matter collected, mg.

$V_{m(std)}$ = Dry gas volume through meter at standard conditions, cu. ft.

Run 1:

$$C_s' = \left[0.0154 \frac{gr}{mg}\right] \left[\frac{48.70}{40.775}\right] = 0.0184 \text{ gr./dscf.}$$

Run 2:

$$C_s' = \left[0.0154 \frac{gr}{mg}\right] \left[\frac{64.00}{36.772}\right] = 0.0268 \text{ gr./dscf.}$$

Run 3:

$$C_s' = \left[0.0154 \frac{gr}{mg}\right] \left[\frac{40.00}{37.344}\right] = 0.0165 \text{ gr./dscf.}$$

Format: csR3

NAME: THOMPSON MCCULLEY
LOCATION: DETROIT, MICHIGAN
TEST DATE: 7/7/88

Dry Molecular Weight

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

Where:

M_d = Dry molecular weight, lb./lb.-mole.

$\%CO_2$ = Percent carbon dioxide by volume (dry basis).

$\%O_2$ = Percent oxygen by volume (dry basis).

$\%N_2$ = Percent nitrogen by volume (dry basis).

$\%CO$ = Percent carbon monoxide by volume (dry basis).

0.264 = Ratio of O_2 to N_2 in air, v/v.

0.28 = Molecular weight of N_2 or CO, divided by 100.

0.32 = Molecular weight of O_2 divided by 100.

0.44 = Molecular weight of CO_2 divided by 100.

Run 1:

$$M_d = 0.44(\ 4.00\%) + 0.32(12.50\%) + 0.28(\ .00\% + 83.50\%) = 29.14\ \frac{lb}{lb\text{-}mole}$$

Run 2:

$$M_d = 0.44(\ 4.00\%) + 0.32(12.50\%) + 0.28(\ .00\% + 83.50\%) = 29.14\ \frac{lb}{lb\text{-}mole}$$

Run 3:

$$M_d = 0.44(\ 4.00\%) + 0.32(12.30\%) + 0.28(\ .00\% + 83.70\%) = 29.13\ \frac{lb}{lb\text{-}mole}$$

Format: mdR3

NAME: THOMPSON MCCULLEY
LOCATION: DETROIT, MICHIGAN
TEST DATE: 7/7/88

Water Vapor Condensed

$$V_{wc_{std}} = \left[V_f - V_i \right] \left[\frac{p_w \; R \; T_{(std)}}{M_w \quad P_{(std)}} \right] = 0.04707 \left[V_f - V_i \right]$$

$$V_{wsg_{std}} = \left[W_f - W_i \right] \left[\frac{R \quad T_{(std)}}{M_w \quad P_{(std)}} \right] = 0.04715 \left[W_f - W_i \right]$$

Where:

0.04707 = Conversion factor, ft.^{3}/ml.

0.04715 = Conversion factor, ft.^{3}/g.

$V_{wc_{std}}$ = Volume of water vapor condensed (standard conditions), scf.

$V_{wsg_{std}}$ = Volume of water vapor collected in silica gel (standard conditions), ml.

$V_f - V_i$ = Final volume of impinger contents less initial volume, ml.

$W_f - W_i$ = Final weight of silica gel less initial weight, g.

p_w = Density of water, 0.002201 lb/ml.

R = Ideal gas constant, 21.85 in.Hg. (cu.ft./lb.-mole)(^{o}R).

M_w = Molecular weight of water vapor, 18.0 lb/lb-mole.

T_{std} = Absolute temperature at standard conditions, 528°R.

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

Run 1:

$V_{wc(std)}$ = (0.04707) (203.0) = 9.6 cu.ft
$V_{wsg(std)}$ = (0.04715) (14.0) = 0.7 cu.ft

Run 2:

$V_{wc(std)}$ = (0.04707) (176.0) = 8.3 cu.ft
$V_{wsg(std)}$ = (0.04715) (12.0) = 0.6 cu.ft

Run 3:

$V_{wc(std)}$ = (0.04707) (169.0) = 8.0 cu.ft
$V_{wsg(std)}$ = (0.04715) (11.0) = 0.5 cu.ft

NAME: THOMPSON MCCULLEY
LOCATION: DETROIT, MICHIGAN
TEST DATE: 7/7/88

Moisture Content of Stack Gases

$$B_{ws} = \frac{V_{wc_{std}} + V_{wsg_{std}}}{V_{wc_{std}} + V_{wsg_{std}} + V_{m_{std}}} \times 100$$

Where:

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

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

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

$V_{wsg_{std}}$ = Volume of water vapor collected in silica gel corrected to standard conditions (scf).

Run 1:

$$B_{ws} = \frac{9.6 + 0.7}{9.6 + 0.7 + 40.775} \times 100 = 20.17\ \%$$

Run 2:

$$B_{ws} = \frac{8.3 + 0.6}{8.3 + 0.6 + 36.772} \times 100 = 19.49\ \%$$

Run 3:

$$B_{ws} = \frac{8.0 + 0.5}{8.0 + 0.5 + 37.344} \times 100 = 18.54\ \%$$

Format: bwsR3

NAME: THOMPSON MCCULLEY
LOCATION: DETROIT, MICHIGAN
TEST DATE: 7/7/88

Molecular Weight of Stack Gases

$$M_s = M_d (1 - B_{ws}) + 18 (B_{ws})$$

Where:

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

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

Run 1:

M_s = 29.14 (1 - 20.17) + 18 (20.17) = 26.89 (lb./lb.-mole)

Run 2:

M_s = 29.14 (1 - 19.49) + 18 (19.49) = 26.97 (lb./lb.-mole)

Run 3:

M_s = 29.13 (1 - 18.54) + 18 (18.54) = 27.07 (lb./lb.-mole)

NAME: THOMPSON MCCULLEY
LOCATION: DETROIT, MICHIGAN
TEST DATE: 7/7/88

Stack Gas Velocity

$$V_s = K_p\ C_p \left[\sqrt{dP} \right]_{avg.} \sqrt{\frac{T_{s(avg.)}}{P_s\ M_s}}$$

Where:

V_s	=	Average velocity of gas stream in stack, ft./sec.
K_p	=	85.49 ft/sec $\left[(g/g\text{-mole})\text{-}(mm\ Hg)\ /\ (^oK)(\ mm\ H_2O\right]^{1/2}$
C_p	=	Pitot tube coefficient, (dimensionless).
dP	=	Velocity head of stack gas, in. H_2O.
P_{bar}	=	Barometric pressure at measurement site, (in. Hg).
P_g	=	Stack static pressure, (in. Hg).
P_s	=	Absolute stack gas pressure, (in. Hg) = $P_{bar} + P_g$
P_{std}	=	Standard absolute pressure, (29.92 in. Hg).
t_s	=	Stack temperature, (^of).
T_s	=	Absolute stack temperature, (^oR). = 460 + t_s.
M_s	=	Molecular weight of stack gas, wet basis, (lb/lb-mole).

Run 1:

$$V = (85.49)\ (\ .80)\ (\ 1.14)\ \sqrt{\frac{697}{(30.75)(26.89)}} = 71.58\ ft/sec.$$

Run 2:

$$V = (85.49)\ (\ .80)\ (\ 1.11)\ \sqrt{\frac{700}{(30.75)(26.97)}} = 69.75\ ft/sec.$$

Run 3:

$$V = (85.49)\ (\ .80)\ (\ 1.10)\ \sqrt{\frac{700}{(30.75)(27.07)}} = 68.99\ ft/sec.$$

Format: vsR3

NAME: THOMPSON MCCULLEY
LOCATION: DETROIT, MICHIGAN
TEST DATE: 7/7/88

Stack Gas Flow Rate

$$Q_{sd} = 3600 \left[1 - B_{wc} \right] V_s \; A \left[\frac{T_{std}}{T_{stk}} \right] \left[\frac{P_s}{P_{std}} \right]$$

Where:

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

A = Cross sectional area of stack, (ft.^{2}).

3600 = Conversion factor, (sec./hr.).

t_s = Stack temperature, (^{o}f).

T_s = Absolute stack temperature, (^{o}R).

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

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

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

P_s = Absolute stack gas pressure, (in.Hg.); = $P_{bar} + P_g$

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

Run 1:

$$Q_{sd}=3600(1-\ .2017\ )(\ 71.58)(\ 15.34)\left[\frac{528}{697}\right]\left[\frac{30.75}{29.92}\right]=\ 2456803.2\ \frac{dscf}{hr}$$

Run 2:

$$Q_{sd}=3600(1-\ .1949\ )(\ 69.75)(\ 15.34)\left[\frac{528}{700}\right]\left[\frac{30.75}{29.92}\right]=\ 2404037.9\ \frac{dscf}{hr}$$

Run 3:

$$Q_{sd}=3600(1-\ .1854\ )(\ 68.99)(\ 15.34)\left[\frac{528}{700}\right]\left[\frac{30.75}{29.92}\right]=\ 2405901.4\ \frac{dscf}{hr}$$

Format: qR3

NAME: THOMPSON MCCULLEY
LOCATION: DETROIT, MICHIGAN
TEST DATE: 7/7/88

Emissions Rate from Stack

$$E = \frac{(C_s)\ (Q_{sd})}{7000\ gr./lb.} = lb. / hr.$$

Where:

E = Emissions rate, lb./hr.

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

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

Run 1:

$$E = \frac{(0.0184)\ (2456803.2)}{7000} = 6.46\ lb. / hr.$$

Run 2:

$$E = \frac{(0.0268)\ (2404037.9)}{7000} = 9.20\ lb. / hr.$$

Run 3:

$$E = \frac{(0.0165)\ (2405901.4)}{7000} = 5.67\ lb. / hr.$$

NAME: THOMPSON MCCULLEY
LOCATION: DETROIT, MICHIGAN
TEST DATE: 7/7/88

Isokinetic Variation

$$I = 100\ T_s \left[\frac{0.002669\ \frac{V_{ic}}{60} + \frac{(V_m / T_m)}{\theta} \frac{(P_{bar} + dH / 13.6)}{V_s\ P_s\ A_n}}{} \right]$$

Where:

I	=	Percent isokinetic sampling.
100	=	Conversion to percent.
T_s	=	Absolute average stack gas temperature, ^oR.
0.002669	=	Conversion factor, Hg - ft^3/ml - ^oR.
V_{ic}	=	Ttl vol of liquid collected in impingers and silica gel, ml.
T_m	=	Absolute average dry gas meter temperature, ^oR.
P_{bar}	=	Barometric pressure at sampling site, (in. Hg).
dH	=	Av pressure differential across the oriface meter, (in.H_2O).
13.6	=	Specific gravity of mercury.
60	=	Conversion seconds to minutes.
θ	=	Total sampling time, minutes.
V_s	=	Stack gas velocity, ft./sec.
P_s	=	Absolute stack gas pressure, in. Hg.
A_n	=	Cross sectional area of nozzle, ft^2.

Run 1:

$$I = (100)(\ 697\ ) \left[\frac{(0.002669)(217.00) + \frac{42.800}{566} \left[30.75 + \frac{1.72}{13.6} \right]}{60\ (\ 60.0\ )\ (\ 71.58\ )\ (\ 30.75\ )\ (\ .000241\ )} \right] = 105.5\%$$

Run 2:

$$I = (100)(\ 700\ ) \left[\frac{(0.002669)(188.00) + \frac{39.642}{581} \left[30.75 + \frac{1.50}{13.6} \right]}{60\ (\ 60.0\ )\ (\ 69.75\ )\ (\ 30.75\ )\ (\ .000241\ )} \right] = 97.3\%$$

Run 3:

$$I = (100)(\ 700\ ) \left[\frac{(0.002669)(180.00) + \frac{40.194}{580} \left[30.75 + \frac{1.46}{13.6} \right]}{60\ (\ 60.0\ )\ (\ 68.99\ )\ (\ 30.75\ )\ (\ .000241\ )} \right] = 98.8\%$$

Format: iR3

Concentration of Sulfur Dioxide

$$CSO_2 = \frac{K_3 N\ (V_t - V_{tb})\ \left(\frac{V_{soln}}{V_a}\right)}{V_{m(std)}}$$

Where:

CSO_2	=	Sulfur dioxide concentration, lbs/dscf.
K_3	=	7.061×10^{-5}, lbs/meq.
N	=	Normality of barium perchlorate titrant, g. equivalent/liter.
V_t	=	Volume of barium perchlorate titrant used for the sample, ml.
V_{tb}	=	Volume of barium perchlorate titrant used for the blank, ml.
V_{soln}	=	Total volume of solution in which the sulfur dioxide sample is contained, ml.
$V_{m(std)}$	=	Volume of gas sample measured by the dry gas meter corrected to std. conditions, dscf.
V_a	=	Volume of sample aliquot titrated, ml.

Run # 1:

$$CSO_2 = 7.061 \times 10^{-5} \frac{[\ .01020(\ 2.00 - .02\ )(\frac{1000.0}{10.00})]}{(\ 40.775\ )} = .000003497 \text{ lbs/dscf}$$

Run # 2:

$$CSO_2 = 7.061 \times 10^{-5} \frac{[\ .01020(\ 1.00 - .02\ )(\frac{1000.0}{10.00})]}{(\ 36.772\ )} = .000001919 \text{ lbs/dscf}$$

Run # 3:

$$CSO_2 = 7.061 \times 10^{-5} \frac{[\ .01020(\ .58 - .02\ )(\frac{1000.0}{10.00})]}{(\ 37.344\ )} = .000001080 \text{ lbs/dscf}$$

Sulfur Dioxide Emissions

$$E = CSO_2 \times Q_{sd}$$

Where:

	E	= Emissions of sulfur dioxide, lbs/hr.
	Q_{sd}	= Stack gas flow rate, dscf/hr.
	CSO_2	= Sulfur dioxide concentration, lbs/dscf.

Run # 1:

E = (.000003497 lbs/dscf)(2456803.2 dscf/hr) = 8.59 lbs/hr

Run # 2:

E = (.000001919 lbs/dscf)(2404037.9 dscf/hr) = 4.61 lbs/hr

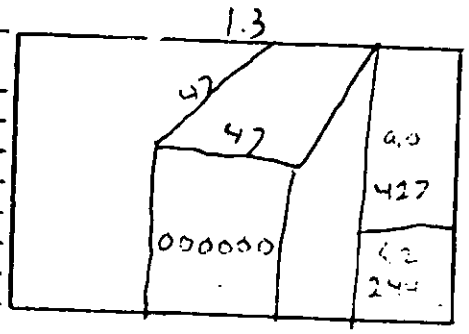
Run # 3:

E = (.000001080 lbs/dscf)(2405901.4 dscf/hr) = 2.60 lbs/hr

VIII. FIELD DATA

RAMCON ENVIRONMENTAL CORPORATION

Plant Stamper Railway
Location Detroit
Operator Adam Turner
Date 7-7-88
Run No. 1
Sample Box No. 1
Meter Box No. 004
Meter H @ 2.1
C Factor ~~.955~~ .995
Pitot Tube Coefficient Cp .797



Schematic of Stack Cross Section

Ambient Temperature 90
Barometric Pressure 30.75
Assumed Moisture, % 18
Probe Length, m(ft) 5
Nozzle Identification No. 0002405
Avg. Calibrated Nozzle Dia., (in.) .210/.210/.210
Probe Heater Setting 4
Leak Rate, m³/min. (cfm) Not Tested
Probe Liner Material Pyrex
Static Pressure, mm Hg (in. Hg) .05
Filter No. 56-2200

	IMPINGER VOLUME, ml	SILICA GEL WEIGHT, g
FINAL	803	526
INITIAL	300	512
DIFFERENCE	203	14

TRAV. PT NO.	SAMPLING TIME (θ) min.	VACUUM in. Hg	STACK TEMP (T_s) °F	VELOCITY HEAD (P_s) in H_2O	PRESSURE DIFF. ORF. MTR in H_2O	GAS SAMPLE VOLUME ft^3	GAS SAMPLE TEMP. AT DRY GAS METER °F Inlet	Outlet	FILTER HOLDER TEMP °F	GAS TEMP LVG CONDENSER OR LAST IMPINGER °F
1	~~9:41~~ 9:43	5	225	1.4	1.8	~~479.2~~ 480.1	100	90	225	60
2	9:45	5	225	1.4	1.8	482.5	100	90	225	60
3	9:47	5	225	1.4	1.8	483.9	108	90	250	60
4	9:49	6	225	1.4	1.8	484.4	108	90	250	60
5	9:51	6	225	1.4	1.8	486.3	108	90	250	60
1	~~9:52~~ 9:54	6	229	1.2	1.6	487.7	110	90	250	60
2	9:56	6	235	1.2	1.6	489.0	110	90	250	60
3	9:58	6	235	1.4	1.8	490.5	110	90	250	60
4	900	6	235	1.6	2.0	492.4	110	90	250	60
5	9:02	6	236	1.4	1.8	493.6	110	90	250	60
1	~~9:02:30~~ 9:04:30	6	236	1.2	1.6	495.1	115	94	250	60
2	9:06:30	5	236	1.2	1.6	496.4	115	94	250	60
3	9:08:30	5	237	1.4	1.8	497.8	115	94	250	60

O_2 = 12.5 O_2 = 12.5

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Form #REC-06

RAMCON emissions test log sheet, cont. DATE 7-7-88 LOCATION Detroit TEST NO. 1

TRAVERSE POINT	SAMPLING TIME θ (min)	VACUUM mm Hg (in. Hg)	STACK TEMP T_s (°F)	VELOCITY HEAD ΔP_s (in. H_2O)	ORFICE DIFF. PRESSURE ΔH (in. H_2O)	GAS VOLUME Vm ($ft.^3$)	GAS SAMPLE TEMP. (°F) in	GAS SAMPLE TEMP. (°F) out	SAMPLE BOX TEMP. (°F)	IMPINGER TEMP (°F)
4	9:10-30	6	236	1.4	1.8	499.5	120	100	250	60
5	9:12-30	6	237	1.2	1.6	500.9	120	100	250	60
1	~~9:13~~ 9:15	~~6~~ 5	239	1.2	1.6	502.1	120	100	250	60
2	9:17	5	240	1.2	1.6	503.6	120	100	250	60
3	9:19	5	240	1.2	1.6	504.9	120	100	250	60
4	9:21	6	241	1.6	2.1	506.6	120	100	250	60
5	9:23	5	241	1.3	1.7	508.1	120	100	250	60
1	~~9:23:30~~ 9:25:30	5	240	1.0	1.3	509.5	120	100	250	60
2	9:27-30	5	240	1.2	1.6	510.8	125	100	255	60
3	9.29-30	5	245	1.4	1.8	512.0	125	100	255	60
4	9.31-30	6	244	1.6	2.1	513.6	125	100	255	60
5	9:33-30	6	243	1.5	2.0	515.2	125	100	255	60
1	~~9:34~~ 9:36	5	242	.90	1.2	516.5	125	100	255	60
2	9:38	5	243	1.0	1.3	517.7	125	100	255	60
3	9:40	5	243	1.4	1.8	519.0	125	100	255	60
4	9:42	5	243	1.4	1.8	520.6	125	100	255	60
5	9:44	5	243	1.4	1.8	522.0	125	100	255	60

RAMCON ENVIRONMENTAL CORPORATION

Plant Thompson Machinery

Location Detroit
Operator [illegible]
Date 7-7-99
Run No. 2
Sample Box No. 1
Meter Box No. 004
Meter H @ 2.1
C Factor .958
Pitot Tube Coefficient Cp .797

1.2

Ambient Temperature 90
Barometric Pressure 30.25
Assumed Moisture, % 18
Probe Length, m(ft) 5

	IMPINGER VOLUME, ml	SILICA GEL WEIGHT, g
FINAL	776	512
INITIAL	300	510
DIFFERENCE	176	12

Nozzle Identification No. .010 2405
Avg. Calibrated Nozzle Dia., (in.) .210/.210/.210
Probe Heater Setting 4
Leak Rate, m³/min. (cfm) .01 at 6 inHg
Probe Liner Material [illegible]
Static Pressure, mm Hg (in Hg) .05
Filter No. SG-2201

Schematic of Stack Cross Section

TRAV. PT NO.	SAMPLING TIME (θ)min.	VACUUM in. Hg	STACK TEMP (T_s) °F	VELOCITY HEAD (P_s) in H20	PRESSURE DIFF. ORF. MTR in H20	GAS SAMPLE VOLUME ft³	GAS SAMPLE TEMP. AT DRY GAS METER °F Inlet	Outlet	FILTER HOLDER TEMP °F	GAS TEMP LVG CONDENSER OR LAST IMPINGER °F
1	10:43 / 10:45	4	227	.60	.72	522.2 / 523.3	120	110	230	55
2	10:47	4	229	.70	.84	524.7	120	110	230	55
3	10:49	4	232	1.2	1.4	525.2	120	110	230	55
4	10:51	4	234	1.2	1.4	526.7	130	110	230	55
5	10:53	4	235	1.5	1.8	527.6	130	110	230	55
1	10:55:30 / 10:56:30	5	237	1.0	1.2	528.9	130	110	230	55
2	10:58:30	5	237	1.0	1.2	529.9	130	110	230	55
3	11:00:30	5	239	1.0	1.2	531.5	130	110	230	55
4	11:02:30	5	240	1.5	1.8	532.8	130	110	230	55
5	11:04:30	5	240	1.5	1.8	534.2	130	110	230	55
1	11:06 / 11:07	5	240	1.0	1.2	535.6	130	110	230	55
2	11:09	5	240	1.1	1.3	536.9	130	110	230	55
3	11:11	5	241	1.1	1.3	538.2	130	110	230	55

O2 = 12.5% O2 = 12.5%

Form #REC-06

RAMCON emissions test log sheet, cont. DATE 7-7-88 LOCATION Detroit TEST NO. 2

TRAVERSE POINT	SAMPLING TIME θ (min)	VACUUM mm Hg (in. Hg)	STACK TEMP T_s (°F)	VELOCITY HEAD ΔP_s (in. H_2O)	ORFICE DIFF. PRESSURE ΔH (in. H_2O)	GAS VOLUME Vm ($ft.^3$)	GAS SAMPLE TEMP. (°F) in	GAS SAMPLE TEMP. (°F) out	SAMPLE BOX TEMP. (°F)	IMPINGER TEMP (°F)
4	11:13	5	241	1.2	1.4	539.6	130	110	240	60
5	11:15	5	241	1.5	1.8	540.9	130	110	240	60
1	11:15-30 / 11:17-30	5	241	1.3	1.6	542.5	130	110	240	60
2	11:19-30	5	242	1.3	1.6	543.6	130	110	240	60
3	11:21-30	5	242	1.5	1.8	545.2	130	115	240	60
4	11:23-30	5	242	1.4	1.7	546.6	130	115	240	60
5	11:25-30	5	242	1.4	1.7	548.0	130	115	240	60
1	11:26 / 11:28	5	242	1.3	1.6	549.4	130	115	240	60
2	11:30	5	242	1.3	1.6	550.6	130	115	240	60
3	11:32	5	242	1.3	1.6	552.1	130	115	240	60
4	11:34	5	242	1.4	1.7	553.4	130	115	240	60
5	11:36	5	243	1.5	1.8	555.1	130	115	240	60
1	11:36-30 / 11:38-30	5	243	1.3	1.6	556.2	130	115	250	60
2	11:40-30	5	243	1.3	1.6	557.7	130	115	250	60
3	11:42-30	5	243	1.3	1.6	559.1	130	115	250	60
4	11:44-30	5	243	1.3	1.6	560.8	130	115	250	60
5	11:46-30	5	246	1.2	~~1.4~~ 1.6	561.842	130	115	250	60

Form #REC-06

RAMCON emissions test log sheet, cont. DATE 7-7-88 LOCATION [illegible] TEST NO. 3

TRAVERSE POINT	SAMPLING TIME θ (min)	VACUUM mm Hg (in. Hg)	STACK TEMP T_s (°F)	VELOCITY HEAD ΔP_s (in. H_2O)	ORFICE DIFF. PRESSURE ΔH (in. H_2O)	GAS VOLUME Vm (ft^3)	GAS SAMPLE TEMP. (°F) in	GAS SAMPLE TEMP. (°F) out	SAMPLE BOX TEMP. (°F)	IMPINGER TEMP (°F)
4	2:38	5	243	1.5	1.8	582.9	130	115	250	60
5	2:40	5	243	1.5	1.8	584.3	130	115	250	60
1	~~2:40-30~~ 2:42-30	5	243	1.1	1.3	585.8	130	115	250	60
2	2:44-30	5	243	1.1	1.3	586.9	130	115	250	60
3	2:46-30	4	243	1.0	1.2	588.3	130	115	250	60
4	2:48-30	4	243	1.0	1.2 ~~588.3~~	589.7	130	115	250	60
5	2:50-30	~~5~~ 4	~~250~~ 240	1.5	1.8	590.8	130	115	250	60
1	~~2:51~~ 2:53	4	243	.90	1.1	592.1	130	115	250	60
2	2:55	4	243	.90	1.1	593.4	130	115	250	60
3	2:57	4	245	.90	1.1	594.4	130	115	250	60
4	2:59	4	245	1.0	1.2	595.5	130	115	250	60
5	3:01	4	245	1.0	1.2	597.6	130	115	250	60
1	~~3:01-30~~ 3:03-30	4	245	.70	.84	598.1	130	115	250	60
2	3:05-30	4	245	.70	.84	599.0	130	115	250	60
3	3:07-30	4	245	.70	.84	600	130	115	250	60
4	3:09-30	4	245	1.2 ~~1.0~~	1.4	601.1	130	115	250	60
5	3:11-30	4	240	1.2	1.4	602.494	130	115	250	60

RAMCON ENVIRONMENTAL CORPORATION

Plant Thompson Meadows

Location Detroit
Operator Alan Turner
Date 7-7-87
Run No. 3
Sample Box No. 1
Meter Box No. 004
Meter H @ 2.1
C Factor .958
Pitot Tube Coefficient Cp .297

1.2

Schematic of Stack Cross Section

÷30 4382

Ambient Temperature 90
Barometric Pressure 30.75
Assumed Moisture, % 18
Probe Length, m(ft) 4
Nozzle Identification No. .000 2405
Avg. Calibrated Nozzle Dia., (in.) .210/.210/.210
Probe Heater Setting 4
Leak Rate, m³/min. (cfm) .005
Probe Liner Material Stainless Steel
Static Pressure, mm Hg (in. Hg) .05
Filter No. SG-2699

	IMPINGER VOLUME, ml	SILICA GEL WEIGHT, g
FINAL	469	524
INITIAL	300	513
DIFFERENCE	169	11

÷60 ÷66

TRAV. PT NO.	SAMPLING TIME (θ) min.	VACUUM in. Hg	STACK TEMP (T_s) °F	VELOCITY HEAD (P_s) in H_2O	PRESSURE DIFF. ORF. MTR in H_2O	GAS SAMPLE VOLUME ft^3	GAS SAMPLE TEMP. AT DRY GAS METER °F 3820 Inlet	3406 Outlet	FILTER HOLDER TEMP °F	GAS TEMP LVG CONDENSER OR LAST IMPINGER °F
1	2:09 / 2:11	5	229	1.6	1.9 / 2.0	562.3 / 563.9	120	110	250	60
2	2:13	5	229	1.6	1.9	565.0	120	110	250	60
3	2:15	5	229	1.6	1.9	566.6	120	110	250	60
4	2:17	5	230	1.6	1.9	568.4	120	110	250	60
5	2:19	5	230	1.6	1.9	569.7	120	110	250	60
1	2:19-30 / 2:21-30	5	235	1.4	1.7	571.3	120	110	250	60
2	2:23-30	5	235	1.4	1.7	572.7	120	110	250	60
3	2:25-30	5	235	1.4	1.7	573.9	125	110	250	60
4	2:27-30	5	239	1.4	1.7	575.5	125	110	250	60
5	2:29-30	5	239	1.4	1.7	577.1	130	115	250	60
1	2:30 / 2:32	5	240	1.3	1.6	578.6	130	115	250	60
2	2:34	5	240	1.2	1.4	579.6	130	115	250	60
3	2:36	5	240	1.2	1.4	581.5	130	115	250	60

Δ2 = 12.5 O2 = 12.0

IX. CALIBRATIONS

METER BOX CALIBRATION DATA AND CALCULATION FORM

(English units)

Date 2-19-89 Meter box number 004-639809

Barometric pressure, P_b = 30.01 in. Hg Calibrated by [illegible]

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_{d_i}), °F	Temperature: Dry gas meter: Outlet (t_{d_o}), °F	Temperature: Dry gas meter: Avg[a] (t_d), °F	Time (Θ), min	Y_i	$\Delta H@_i$ in. H_2O
0.5	5								
1.0	5	68.982 / 75.2005	72	100 / 101	82 / 82	91.25	9.56	.991	1.98
1.5	10								
2.0	10	58.158 / 65.883	72	102 / 104	82 / 82	92.5	13.20	.964	2.0
3.0	10	47.425 / 58.006	72	102 / 104	82 / 82	92.5	11.37	.975	2.1
4.0	10								
							Avg	.977	2.0

ΔH, in. H_2O	$\frac{\Delta H}{13.6}$	$Y_i = \frac{V_w P_b (t_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6})(t + 460)}$	$\Delta H@_i = \frac{0.0317\ \Delta H}{P_b\ (t_d + 460)} \left[\frac{(t_w + 460)\ \Theta}{V_w}\right]^2$
0.5	0.0368	165805.25 / 172753.88	10.58
1.0	0.0737		
1.5	0.110	165805.25 / 172667.13	10.725
2.0	0.147		
3.0	0.221	82715.063 / 83439.136	5.2135
4.0	0.294		

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

Quality Assurance Handbook M4-2.3A (front side)

Form #REC-02

METER BOX CALIBRATION DATA AND CALCULATION FORM

(English units)

Date 7-1-88 Meter box number 004-638809

Barometric pressure, P_b = 29.99 in. Hg Calibrated by [illegible]

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_{d_i}), °F	Temperature: Dry gas meter: Outlet (t_{d_o}), °F	Temperature: Dry gas meter: Avg[a] (t_d), °F	Time (θ), min	Y_i	$\Delta H@_i$ in. H_2O
0.5	5								
1.0	5	492.22 / 497.39	77	102 / 106	86 / 86	95	9.20	.998	1.86
1.5	10								
2.0	10	481.432 / 492.029	77	104 / 110	86 / 86	96.5	13.26	.975	2.1
3.0	10	470.225 / 481.252	77	102 / 110	86 / 86	96	11.44	.981	2.15
4.0	10								
	10.477		10.577	5.167			Avg	.985	2.0

ΔH, in. H_2O	$\frac{\Delta H}{13.6}$	$Y_i = \frac{V_w P_b (t_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6}) (t + 460)}$	$\Delta H@_i = \frac{0.0317 \Delta H}{P_b (t_d + 460)} \left[\frac{(t_w + 460)\theta}{V_w}\right]^2$
0.5	0.0368		
1.0	0.0737	~~168~~ 1[illegible].95 / 83416.644	83222.25 / 83416.644
1.5	0.110		
2.0	0.147	166894.35 / 12422.94	
3.0	0.221	~~168~~ 166749.4 / 169969.22	
4.0	0.294		

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

Quality Assurance Handbook M4-2.3A (front side)

Form #REC-02

RAMCON ENVIRONMENTAL CORPORATION

Lear Siegler Stack Sampler

Nozzle Diameter Calibration

Date _____ Signature _____

Nozzle No.	Average Diameter	Nozzle No.	Average Diameter
1		7	
2		8	
3		9	
4		10	
5		11	
6		12	

Pitot Tube Calibration (S Type)

Pitot Tube Identification No. 51 Date 2-3-88

Calibrated by: Sam T. Turner

"A" SIDE CALIBRATION

Run No.	Δp std cm H_2O (in. H_2O)	Δp (s) cm H_2O (in. H_2O)	$C_p(s)$	DEVIATION $C_{p(s)}-\bar{C}_p(A)$
1	0.90	1.41	.799	< .01
2	0.60	.94	.799	< .01
3	0.41	.65	.794	< .01
		$\bar{C}_p$ (SIDE A)	.797	

"B" SIDE CALIBRATION

Run No.	Δp std cm H_2O (in. H_2O)	Δp(s) cm H_2O in. H_2O)	$C_p(s)$	DEVIATION $C_{p(s)}-\bar{C}_p(B)$
1	[illegible]	1.4	.802	< .01
2	0.60	.95	.795	< .01
3	0.41	.64	.800	< .01
		$\bar{C}_p$ (SIDE B)	.799	

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

$$|\bar{C}_p(\text{SIDE A})-\bar{C}_p(\text{SIDE B})| \leftarrow \text{MUST BE} \leq 0.01$$

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

Form No. EED-17-1

RAMCON ENVIRONMENTAL CORPORATION

Date 2/9/88 Thermocouple number 51

Ambient temperature 54°F ~~°C~~ Barometric pressure 29.95 in. Hg

Calibrator S. Greenwood Reference: mercury-in-glass ✓

other _____

Reference point number[a]	Source[b] (specify)	Reference Thermometer Temperature, °~~C~~	Thermocouple Potentiometer Temperature, ~~°C~~	Temperature Difference,[c] %
A	ICE WATER	32°F	32°F	0%
B	BOILING WATER	212°F	211°F	.005%
C	OIL	380°F	382°F	.005%
D	AMBIENT 7-7-88	54°F 70°F	55°F 70°F	.01% 0%

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

[b]Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °C} + 273) - (\text{test thermom temp, °C} + 273)}{\text{ref temp, °C} + 273}\right] 100 \leq 1.5\%.$

Figure 2.5 stack temperature sensor calibration data form.

RAMCON

Lear Siegler Stack Sampler

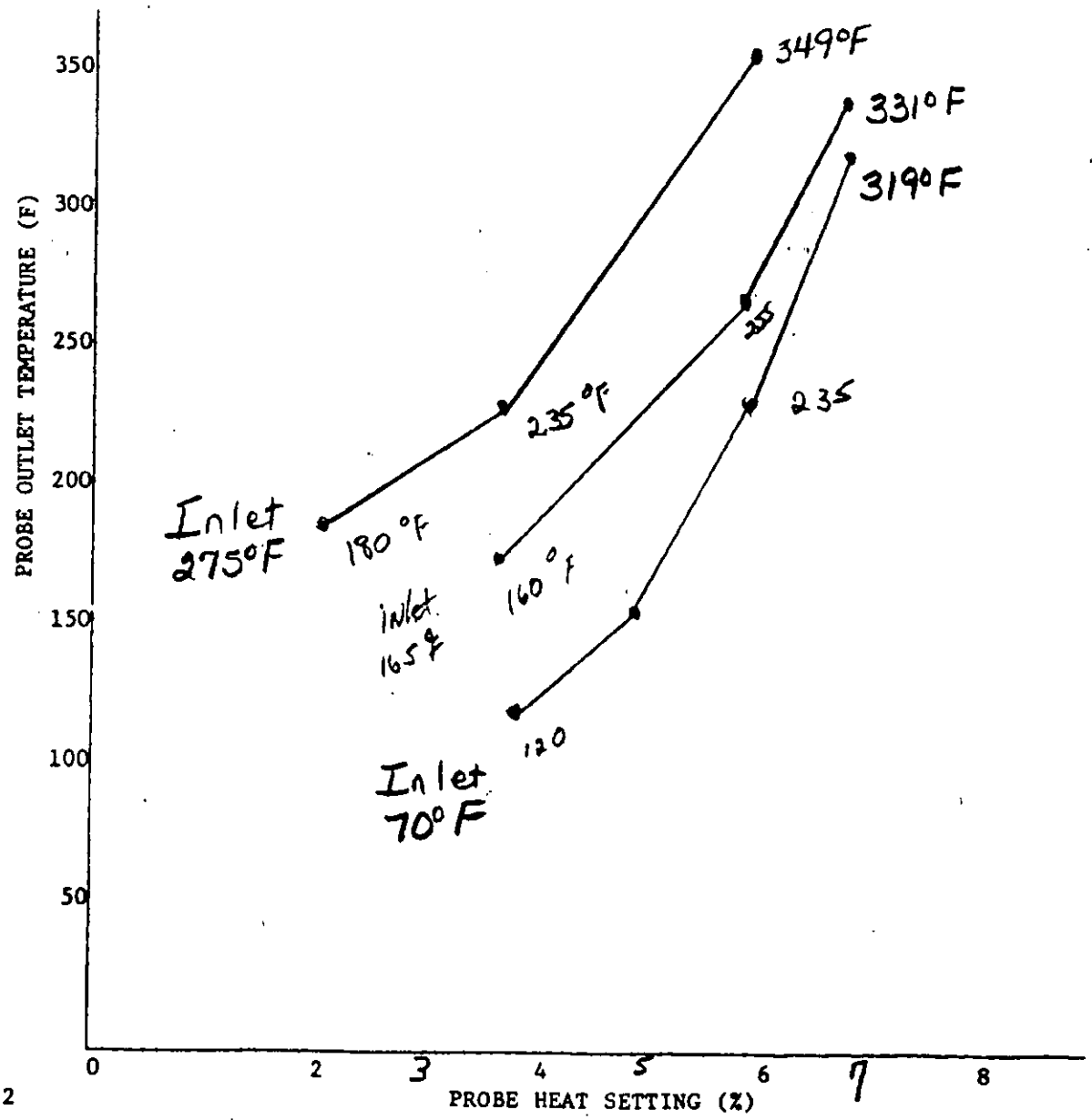
Heating Probe Calibration

Probe No. 51 Probe Length 5'

Date of Calibration 2-10-88 Signature Sam T. Tuney

Name of Company to be tested _____

Note: 3 ft. probe - 5 min. warmup
6 ft. probe - 15 min. warmup
10 ft. probe - 30 min. warmup
Calibration flow rate = .75 CFM



Form No. EED-17-2

Date 2-10-88 Thermocouple number Outlet

Ambient temperature 55°F °C Barometric pressure 29.96 in. Hg

Calibrator S. Greenwood Reference: mercury-in-glass ✓

other _____

Reference point number[a]	Source[b] (specify)	Reference Thermometer Temperature, °C	Thermocouple Potentiometer Temperature, °C	Temperature Difference,[c] %
A	ICE BATH	33°F	32°F	.03%
B	OVEN	152°F	150°F	.01%
C	OVEN	175°F	175°F	0%
D	Ambient	55°F	55°F	0%
	7-7-88	90°F	90°F	0%

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

[b]Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °C} + 273) - (\text{test thermom temp, °C} + 273)}{\text{ref temp, °C} + 273}\right] 100 \leq 1.5\%.$

Figure 2.5 stack temperature sensor calibration data form.

Date 2-10-88 Thermocouple number Inlet

Ambient temperature 55°F °C Barometric pressure 29.96 in. Hg

Calibrator S. Greenwood Reference: mercury-in-glass ✓

other _____

Reference point number[a]	Source[b] (specify)	Reference Thermometer Temperature, °C	Thermocouple Potentiometer Temperature, °C	Temperature Difference,[c] %
A	ICE BATH	33°F	33°F	0%
B	OVEN	150°F	151°F	.007%
C	OVEN	175°F	173°F	.01%
D	AMBIENT	55°F	54°F	.02%
	7-7-88	90°F	90°F	0%

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

[b]Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °C} + 273) - (\text{test thermom temp, °C} + 273)}{\text{ref temp, °C} + 273}\right] 100 \leq 1.5\%.$

Figure 2.5 stack temperature sensor calibration data form.

X. RAMCON PERSONNEL

RAMCON Environmental Stack Test Team

Sumner Buck - President

Sumner Buck is the President of RAMCON Environmental. He is a graduate of the EPA 450 "Source Sampling for Particulate Pollutants" course and the 474 "Continuous Emissions Monitoring" course all given at RTP. Mr. Buck is a qualified V.E. reader with current certification. Mr. Buck has personally sampled over 300 stacks including over 200 asphalt plants. He is 43 years old and a graduate of the University of Mississippi with graduate studies at Memphis State University and State Technical Institute of Memphis.

Allen Turner - Team Leader

Allen Turner has been employed by RAMCON for three years. He has undergone extensive training in Methods 1 through 9. He is qualified as a team leader and is currently certified as a V.E. reader.