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: 300

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

Ramcon Environmental Corp., Memphis, TN,

July 17, 1987.

AP-42 Section 11.1
Reference
Report Sect. 4
Reference ~~299~~ 300

RAMCON
ENVIRONMENTAL CORPORATION

SOURCE SAMPLING
for
SULFUR REDUCTION
THOMPSON-MCCULLY COMPANY
BELLEVILLE, MICHIGAN
July 17, 1987

Alan Sandell
Thompson-McCully Company

G. Sumner Buck, III
President

Sam T. Turner
Field Supervisor

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

RAMCON
ENVIRONMENTAL CORPORATION

August 25, 1987

Mr. Alan Sandell
Thompson-McCully Company
1785 Rawsonville Road
Belleville, MI 48111

Re: Sulfur Reduction Test

Dear Mr. Sandell:

Enclosed you will find four copies of our report on the sulfur reduction test we conducted at your Belleville, Michigan plant.

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

Mr. Carl Vogt
Michigan DNR
Air Quality Division
P.O. Box 30028
Lansing, MI 48909

?

We certainly have enjoyed working with you and look forward to serving you again in the future.

Sincerely,

G. Sumner Buck, III
President

GSBIII:kr

Enclosures

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

TABLE OF CONTENTS

I.	INTRODUCTION	1
II.	TEST RESULTS	1
III.	TEST PROCEDURES	3
IV.	THE SOURCE	5
V.	EQUIPMENT USED	10
VI.	LABORATORY PROCEDURES & RESULTS	11
VII.	CALCULATIONS	19
VIII.	FIELD DATA	31
IX.	CALIBRATIONS	34
X.	RAMCON PERSONNEL	41

I. INTRODUCTION

On July 17, 1987, personnel from RAMCON Environmental Corporation (REC) conducted a source emissions test for sulfur reduction compliance at Thompson-McCully Company's Barber-Greene drum mix asphalt plant located in Belleville, Michigan. RAMCON personnel conducting the test were Sam Turner, Field Supervisor and Bill Turner. John Biggs was responsible for the laboratory analysis and recording final data in the laboratory record books. Custody of the samples were limited to Mr. Turner and Mr. Biggs.

The purpose of the test was to determine the rate of sulfur reduction emissions from the plant's baghouse through neutralizing in the rotary kiln (drum) with aggregate being dried for use as road surface paving.

II. TEST RESULTS

Table I summarizes the test results. Mr. Carl Vogt of Wayne County's Air Pollution Control Division observed the testing conducted by RAMCON.

TABLE I

SUMMARY OF TEST RESULTS

Thompson McCully Sulfur Reduction Test

Aggregate production rate:	**350 TPH**
Fuel consumption rate:	**1.7 gal/ton mix**
Gallons of fuel consumed:	**595 gal**
Weight of fuel consumed:*	**4,760 lbs/fuel**

$$*\frac{\text{(specific gravity)(pounds/ft}^3)}{\text{gallons/ft}^3} = \frac{(.959)(62.4)}{(7.4805)} = \frac{8 \text{ pounds}}{\text{gallons}}$$

$$\frac{8 \text{ lbs}}{\text{gal}} \times \frac{595 \text{ gal}}{\text{fuel}} = 4{,}760 \text{ lbs fuel}$$

Percent sulfur in fuel:	**1.05%**
Weight of sulfur in fuel:	**49.98 lbs = (.0105)(4,760 lbs/fuel)**
Weight of sulfur dioxide in fuel:**	(.0097)(4760) = 46.172

**Mol weight sulfur = 32
Mol weight oxygen = 16
Mol weight SO_2 = 64

**49.98 lbs sulfur with mol weight of 32 =
99.96 lbs sulfur dioxide with mol weight of 64.** 92.344

Potential sulfur dioxide emissions: 99.96 lbs/hr

Percent sulfur reduction:

Run #1	**47%**	
Run #2	**42%**	.368
Run #3	**42%**	

ALLOWED = #1, 2 OIL @ .30% S

ALLOWED #6 F.O. = $\frac{0.30}{1 - .368}$ = 0.475% S

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.

The actual testing was by modified EPA Reference Method 6 using large impingers. Testing time was 3 sixty minute proportional runs. Methods 1, 2 & 4 were used for sample site location, gas velocity and flow and moisture content.

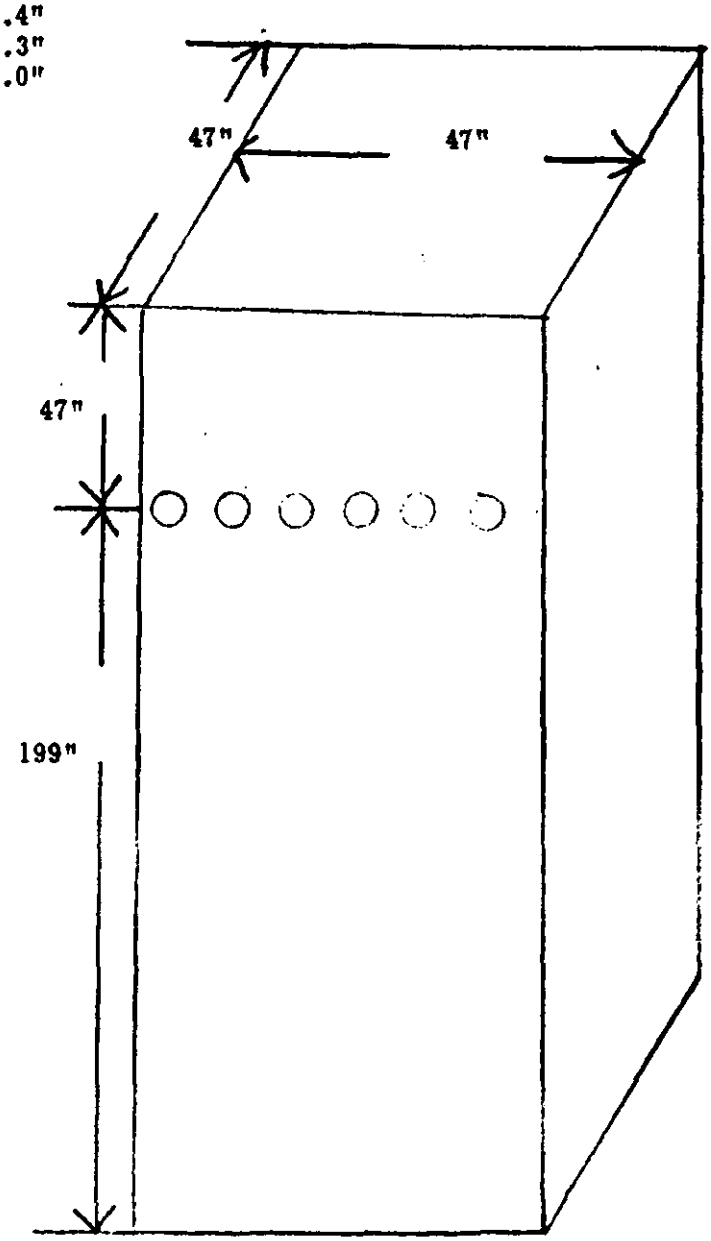
The plant attempted to simulate worst conditions by operating near capacity for the testing. A sieve analysis of the mix being used is in the Source section of this report. Two fuel analysis were made. One from the supplier and a second from an independent laboratory. Both labs attained close agreement on the sulfur content.

Our lab conducted repeated pH analysis of the aggregate and the fines captured in the baghouse hopper. The aggregate registered 9.1 and the baghouse fines registered 10.5.

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

C. Sampling Site: The emissions test was conducted after a baghouse on a square stack measuring 47" x 47" with an equivalent diameter of 47.0". Six sampling ports were placed 47" down (1.0 diameters upstream) from the top of the stack and 199" up (4.2 diameters downstream) from the last flow disturbance.

Points on a Diameter	Probe Mark
1	*3.9"
2	11.8"
3	19.6"
4	27.4"
5	35.3"
6	43.0"



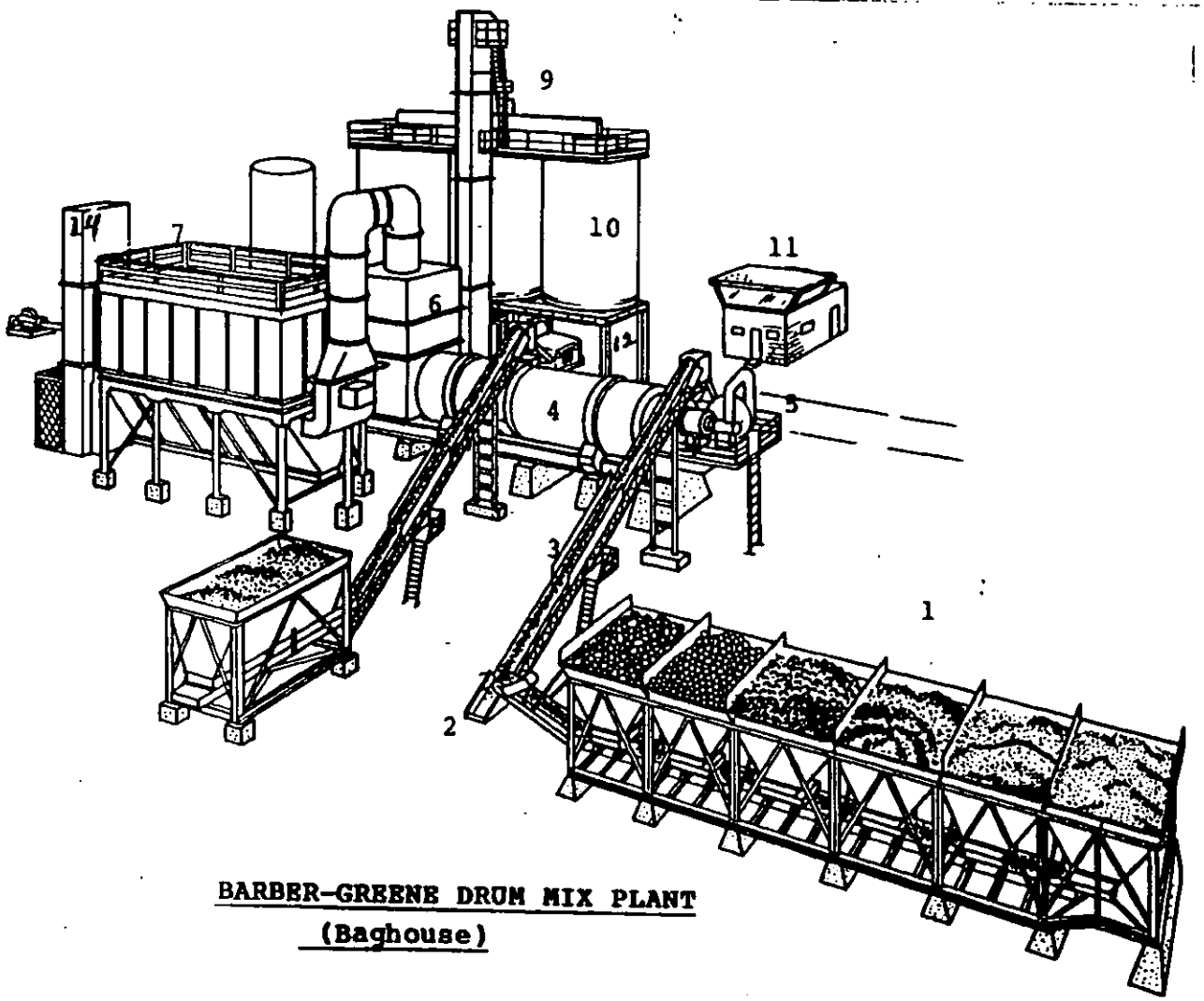
IV. THE SOURCE

IV. THE SOURCE

Thompson-McCully Company 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. When recycled asphalt mix is used, it is added to the mix halfway down the drum through a separate weigh conveyor. The required amount of hot asphalt oil is then injected onto and mixed into the dried aggregate. The now newly formed hot asphalt mix is pulled to the top of a storage silo by conveyor. 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 mixer 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 exhaust gasses pass through a baghouse. The baghouse is manufactured by Barber-Greene. The exhaust gasses are drawn through the baghouse and discharged to the atmosphere through a 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

DATA SUMMARY

Plant

1. Manufacturer of plant BARBER GREENE.
2. Designed maximum operating capacity 600 TPH @ 4 % moisture.
3. Actual operation rate 350 TPH @ 4 % moisture.
4. Startup date MAY 1978.
5. Type of fuel used in dryer #6 Fuel Oil.
6. Quanity of fuel consumption 0.76 gallons/ton mix. gallons/ton

Aggregate

7. Name/type of mix 20-AAA-[redacted].
8. Percent asphalt in mix 5.8 %.
9. Temperature of asphalt 300.
10. Sieve/Screening analysis: % Passing;

1"	100	3/8"	93.5	#30	27.5
3/4"	100	#4	70.1	#	[redacted]
1/2"	98.5	#8	53.1	#200	6.3

43% Fine Aggreg.
15% Coarse Crs.
22% Fine Crs.
20% Recycle

Baghouse

11. Manufacturer BARBER GREENE.
12. No. of bags 1200. Type of bags BHA.
13. Air to cloth ratio 14.4. Designed ACFM 82,000 CFM
14. Square feet of bags 150,000 SFT Each bag is 8' long and 5" diameter
15. Type of cleaning; pulse jet X, reverse air ____, plenum pulse ____, other ____.
16. Cleaning cycle time [redacted] 1/5 second.
17. Interval between cleaning cycle 9 seconds.
18. Pressure drop across baghouse 7 psi.
19. Pulse pressure on cleaning cycle 100 psi.

COMPANY NAME THOMPSON McCULLY DATE 7-17-87

COMPANY REPRESENTATIVE Pete [illegible]

Form #REC-03

PLANT DATA

COMPANY NAME Thompson - McCully Company

COMPANY REP. _____ DATE 7-17-87 PHONE # 485 1717

DATA SOURCE Alan Sandell / Pete Mott

PLANT LOCATION 1785 Ransorville Rd - Belleville Mich 48111

PLANT MFG. Barber Greene PLANT MODEL # DM 75 PLANT TYPE Drum Mix

MIX SPECIFICATION # MDOT 2000AA OIL SPECIFICATION # #6 Fuel Oil

Time 24 Hour	Fuel Oil / Nat. Gas / Propane / Coal	Burner Setting	Aggregate TPH	Recycle TPH	Liquid Asphalt TPH	Mix Temp. °F	Venturi / Baghouse Pressure Drop Inches Water
7:15 AM	#6 FUEL	52%	260	65	17.2	310	7
7:30 AM	#6 FUEL	54%	260	65	17.2	310	7
7:45 AM	#6 FUEL	53%	260	65	17.4	310	7
8:00 AM	#6 FUEL	52%	260	70	17.5	310	7
8:15 AM	#6 FUEL	53%	264	72	17.8	310	7
9:20-AM	#6 FUEL	52%	262	72	17.0	310	7
9:35-AM	#6 FUEL	52%	261	72	17.3	310	7
9:50-AM	#6-FUEL	50%	260	73	17.2	310	7
10:05-AM	#6-FUEL	52%	259	72	16.8	310	7
10:20-AM	#6-FUEL	51%	261	72	17.1	310	7
11:10-AM	#6-FUEL	51%	260	72	17.2	310	7
11:25 AM	#6-FUEL	52%	264	72	17.1	310	7
11:40 AM	#6-FUEL	51%	260	72	17.2	310	7
12:05 PM	#6-FUEL	50%	260	71	17.2	310	7
12:20-PM	#6-FUEL	51%	260	73	17.2	310	7

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.

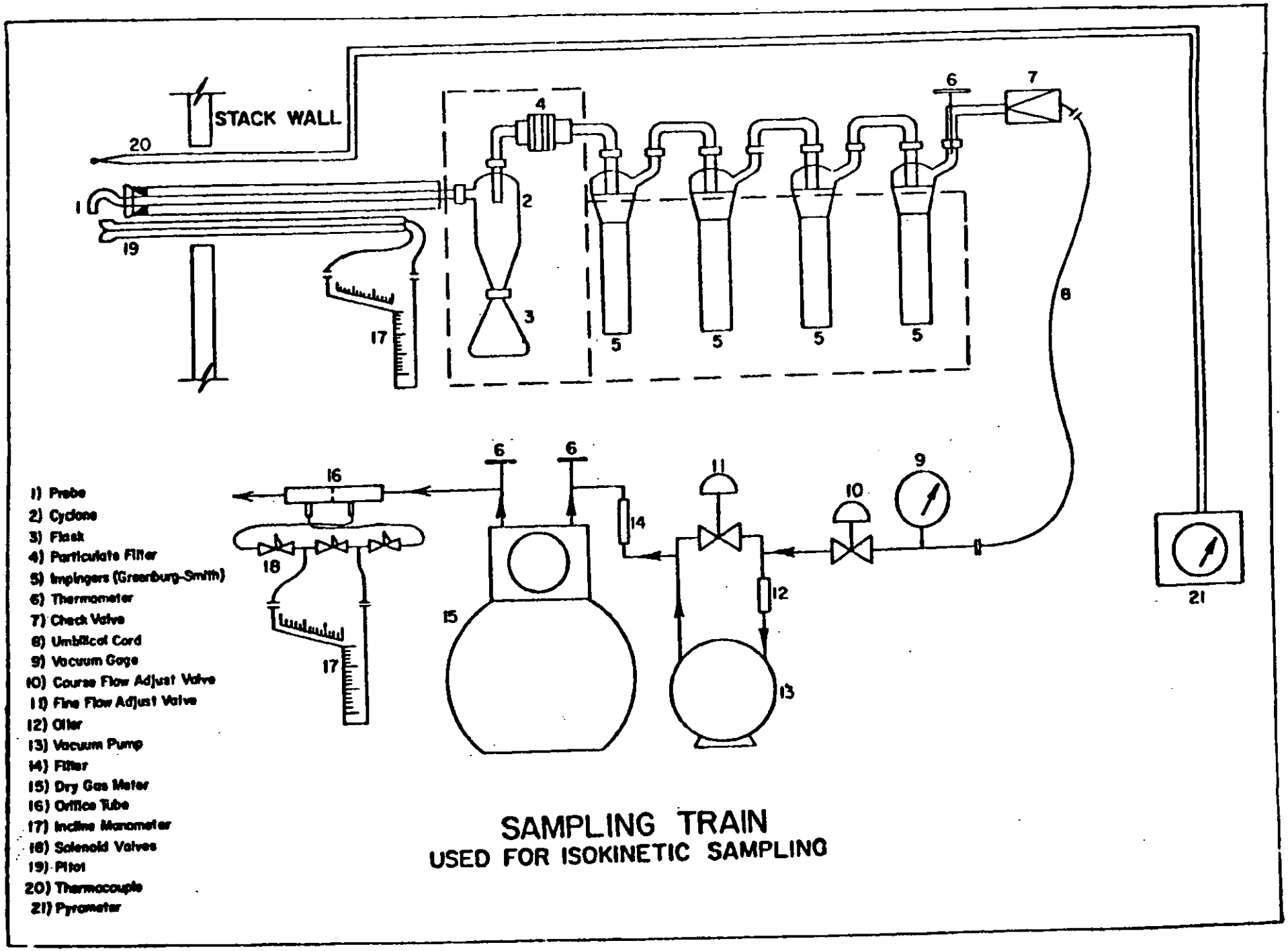
B. An Airguide Instruments Model 211-B (uncorrected) aneroid barometer was used to check the barometric pressure.

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.



SAMPLING TRAIN
USED FOR ISOKINETIC SAMPLING

VI. LABORATORY PROCEDURES & RESULTS

LABORATORY PROCEDURES FOR SO_2

Pour the catch from impingers two and three into a 1000 ml volumetric flask. Bring the solution in the flask up to the required 1000 ml volume by mixing it with deionized distilled water, then mix thoroughly. Pipette a 10 ml aliquot of sample into a 250 ml Erlenmeyer flask. Add 40 ml of isopropanol, 2 to 4 drops of thorin indicator and titrate to a pink endpoint using 0.0100 N barium perchlorate. Repeat the titration with a second aliquot of sample and average the titration values. Replicate titrations must agree within 1 percent or 0.2 ml, whichever is greater.

Prepare the blanks by adding 2 to 4 drops of thorin indicator to 100 ml of 80 percent isopropanol. Titrate the blanks in the same manner as the samples.

LABORATORY PROCEDURES FOR H_2SO_4

Pour the contents of the first impinger into a 250 ml graduated cylinder and bring the volume up to 250 ml with 80% isopropanol. Transfer the contents to a storage container and add the filter. Shake the container to coat the isopropanol solution on the filter. If the filter tears, allow the fragments to settle before taking a sample. Pipette a 25 ml aliquot (100 ml aliquot is too large for these particular samples because of the strength of the solution) of this solution into a 250 ml Erlenmeyer flask, add 2 to 4 drops of thorin indicator and titrate to a pink endpoint using 0.0100 N barium perchlorate. Repeat the titration with a second aliquot and average the titration values.

SO_2 ANALYSIS
(Method 8)

Plant Thompson McCulley Detroit, MI. Date 7/24/87

Audit Samples

Audit Number								
	A	B	A	B	A	B	A	B
V_{soln} (ml)								
V_a (ml)								
N (N)								
V_t (ml)								
$V_{m(std)}$ (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)	0.0099	0.0099	0.0099	0.0099	0.0099	0.0099		
V_t (ml)	12.9	12.9	13.8	13.8	14.1	14.1	0	0
$V_{m(std)}$ (dscf)								
C_{SO_2} (lb/dscf)								

K_3 = 7.061×10^{-5} lb/meq

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

H_2SO_4 ANALYSIS
(Method 8)

Plant Thompson McCulloy Date 7/24/87

Audit Samples

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

K_2 = 32.03 mg/meq

H_2SO_4 Analysis for Impinger 1 [redacted]

Run Number	1		2		3		Blank	
	A	B	A	B	A	B	A	B
V_{soln} (ml)	250	250	250	250	250	250		
V_a (ml)	20	20	20	20	20	20		
N (N)	0.0099	0.0099	0.0099	0.0099	0.0099	0.0099		
V_t (ml)	1.6	1.6	1.2	1.2	1.3	1.3	0	0
$V_{m(std)}$ (dscf)								
C_{SO_2} (lb/dscf)								

K_3 = 7.061 x 10^{-5} lb/meq

Analysis performed by: GRB Approved by: [signature]

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

SINCE 1908

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

Ramcon Environmental Corp.

Memphis, Tennessee

August 6, 1987

Sample identification
by Ramcon Environmental Corp.

Kind of sample reported to us	No. 6 Fuel Oil
Sample taken at	------
Sample taken by	Ramcon Environmental Corp.
Date sampled	------
Date received	August 3, 1987

Analysis report no. 73-08085

Ash = 0.06
Btu/lb. = 18,208
Sulfur = 1.05

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

John T. Burt

Manager, Birmingham Laboratory

Original Copy Watermarked
For Your Protection

F-464

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

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Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

John T. Burt

Manager, Birmingham Laboratory

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OVER 40 BRANCH LABORATORIES STRATEGICALLY LOCATED IN PRINCIPAL COAL MINING AREAS,
TIDEWATER AND GREAT LAKES PORTS, AND RIVER LOADING FACILITIES

ENVIROCO
FUELS AND LUBRICANTS

27140 Princeton Avenue • P.O. Box 431 • Inkster, Michigan 48141 • 313 [illegible]

July 20, 1987

THOMPSON MCCULLY
1785 Rawsonville Road
Belleville, MI 48111

Attn: Mr. Alan Sandell

Dear Alan,

Thank you for the opportunity to supply your fuel requirement for Rawsonville. Below are the specifications for the fuel we are delivering.

API Gravity	16
VIS 100F	220
Flash	200
Pour	35
Sulfur	.97
BTU	148,000

If I can be of further assistance, please do not hesitate to contact me.

Sincerely,

ENVIROCO FUELS AND LUBRICANTS

John A. Turner
Sales Manager
EF&L

JAT/LAB

Ann Arbor Technical Services, Inc.
6540 Jackson Road • Ann Arbor, Michigan 48103 • 313-995-0995

99000

Data Summary Sheet

Date June 30, 1987

Project Thompson - McCully

Sample I.D./Sample Date

Parameter	Units		Rawsonville Coarse Crush 6-18-87	Fine Crush 6-18-87	3 cs. Sand 6-18-87	Fine Aggregate 6-18-87	Rap 6-18-87		
pH	S.U.		8.76	8.68	8.55	8.63	9.78		
		NOTE: pH in these samples was determined following an ASTM Neutral Water Leachate extraction (ASTM D-3987-81) of each sample.							

Sheet 1 of 1

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

August 12, 1987

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

REF: ANALYTICAL TESTING
SAMPLE(S) DATE: 8/12/87
BAGHOUSE DUST & SOIL

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.

	Results		Standard Methods		
Test	Baghouse Dust	Soil	Page #	By	Date
*pH	10.5	9.1	429	JL	8/12

* 10 grams of sample was put into 100 ml's of DI and stirred for one hour.

If you have any questions please feel free to contact me.

Very truly yours,

Michael J. Cimbalo
President

MJC/mg

Attachment

VII. CALCULATIONS

NAME: THOMPSON-MCCULLY COMPANY

LOCATION: BELLEVILLE, MICHIGAN

		date	7/17/87	7/17/87	7/17/8
	SUMMARY OF TEST DATA		RUN # 1	RUN # 2	RUN #
	SAMPLING TRAIN DATA	start	07:20	09:23	11:15
		finish	08:20	10:23	12:15
1	Sampling time, minutes	θ	60	60	60
2	Sampling nozzle diameter, in.				
3	Sampling nozzle cross-sectional area, ft^2				
4	Isokinetic variation				
5	Sample gas volume - meter conditions, cf.	Vm	39.91	40.29	41.83
6	Average meter temperature, °R	Tm	530	546	561
7	Average oriface pressure drop, in.H_2O	ΔH	1.60	1.60	1.60
8	Total particulate collected mg.	Mn	.0	.0	.0
	VELOCITY TRAVERSE DATA				
9	Stack area, ft^2	A	15.3	15.3	15.3
10	Absolute stack gas pressure, in. Hg.	Ps	30.18	30.22	30.22
11	Barometric pressure, in. Hg.	Pbar	30.18	30.22	30.22
12	Average absolute stack temperature, °R	Ts	791	778	778
13	Average $\sqrt{\text{velocity head}}$, (Cp= .81)	$\sqrt{\Delta P}$	1.20	1.20	1.20
14	Average stack gas velocity ft. / sec.	Vs	81	80	81
	STACK MOISTURE CONTENT				
15	Total water collected by train, ml.	Vic	236.0	224.0	246.0
16	Moisture in stack gas, %	Bws	21.6	21.1	22.5
	EMISSIONS DATA:				
17	Stack gas flow rate, dscf/hr. (000's)	Qsd	2,363	2,396	2,361
18	Total particulate concentration, gr/dscf	Cs			
19	Total particulate emissions lbs/hr	E			
20	Total SO concentration, lbs/dscf	C'	.000022	.000024	.000025
21	Total SO_2 emissions lbs/hr	E'	52.78	58.35	58.15
	ORSAT DATA				
22	Percent CO2 by volume	CO2	.0	.0	.0
23	Percent O2 by volume	O2	.0	.0	.0
24	Percent CO by volume	CO	.0	.0	.0
25	Percent N2 by volume	N2	0	.0	0

Dry Gas Volume :

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

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 $^\circ R$

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

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

Y = Dry gas meter calibration factor

13.6 = Inches water per inches Hg.

Run # 1 $V_{m(std)} = 17.64 \quad (1.00)(39.91) \left[\frac{(30.18) + \frac{1.60}{13.6}}{530} \right] = 40.37$ ds

Run # 2 $V_{m(std)} = 17.64 \quad (1.00)(40.29) \left[\frac{(30.22) + \frac{1.60}{13.6}}{546} \right] = 39.61$

Run # 3 $V_{m(std)} = 17.64 \quad (1.00)(41.83) \left[\frac{(30.22) + \frac{1.60}{13.6}}{561} \right] = 40.02$

Water vapor condensed :

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

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

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)

V_f = Final volume of impinger contents, ml.

V_i = Initial volume of impinger contents

P = Density of water, (0.002201 lb/ml).

R = Ideal gas constant, 21.85 (in.Hg.)(cu.ft./lb.-mole)(°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) (227.0) =	10.7	cu.ft
	$V_{wsg(std)}$	= (0.04715) (9.0) =	.4	cu.ft
Run # 2:	$V_{wc(std)}$	= (0.04707) (214.0) =	10.1	cu.ft
	$V_{wsg(std)}$	= (0.04715) (10.0) =	.5	cu.ft
Run # 3:	$V_{wc(std)}$	= (0.04707) (238.0) =	11.2	cu.ft
	$V_{wsg(std)}$	= (0.04715) (8.0) =	.4	cu.ft

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: $$B_{ws} = \frac{10.7 + .4}{10.7 + .4 + 40.37} \times 100 = 21.6\ \%$$

Run # 2: $$B_{ws} = \frac{10.1 + .5}{10.1 + .5 + 39.61} \times 100 = 21.1\ \%$$

Run # 3: $$B_{ws} = \frac{11.2 + .4}{11.2 + .4 + 40.02} \times 100 = 22.5\ \%$$

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: $M_s = 30.0\ (1- .216\ ) + 18\ (\ .216\ ) = 27.4$ (lb./lb.-mole).

Run # 2: $M_s = 30.0\ (1- .211\ ) + 18\ (\ .211\ ) = 27.5$ (lb./lb.-mole).

Run # 3: $M_s = 30.0\ (1- .225\ ) + 18\ (\ .225\ ) = 27.3$ (lb./lb.-mole).

Stack gas velocity:

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

Where:

V_s = Average velocity of gas stream in stack, ft./sec.

K_p = 85.49 ft/sec $\left[(g/g\text{-}mole)\text{-}(mm\ Hg) \ / \ (^{\circ}K)(\ mm\ H_2O) \right]^{1/2}$

C_p = Pitot tube coefficient,(dimensionless).

ΔP = 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, ($^{\circ}$f).

T_s = Absolute stack temperature, ($^{\circ}$R). = 460 + t_s.

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

Run # 1: $V = (85.49)\ (\ .81)\ (\ 1.20) \sqrt{\dfrac{791}{(30.18)(27.41)}} = 81.26$ ft/s

Run # 2: $V = (85.49)\ (\ .81)\ (\ 1.20) \sqrt{\dfrac{778}{(30.22)(27.47)}} = 80.44$ ft/s

Run # 3: $V = (85.49)\ (\ .81)\ (\ 1.20) \sqrt{\dfrac{778}{(30.22)(27.30)}} = 80.69$ ft/s

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 (°f).
T_s	=	Absolute stack temperature, (°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:

$$Q_{sd} = 3600\ (1-.216)\ (81.26)\ (15.3) \left[\frac{528}{791} \right] \left[\frac{30.18}{29.92} \right] = 2362664 \text{ dscf.}$$

Run # 2:

$$Q_{sd} = 3600\ (1-.211)\ (80.44)\ (15.3) \left[\frac{528}{778} \right] \left[\frac{30.22}{29.92} \right] = 2396239 \text{ dscf.}$$

Run # 3:

$$Q_{sd} = 3600\ (1-.225)\ (80.69)\ (15.3) \left[\frac{528}{778} \right] \left[\frac{30.22}{29.92} \right] = 2361036 \text{ dscf.}$$

Sulfur Dioxide Concentration

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

Where; CSO_2 = Sulfur dioxide concentration, (lbs/dscf)

K_3 = 7.061×10^{-5} Lb/meq

N = Normality of barium perchlorate titrant, g equivalents/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 sulfuric acid or sulfur dioxide sample is contained, 250 ml or 1,000 ml respectively

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

V_a = Volume of sample aliquot titrated (10 ml for SO_2)

Run # 1: $CSO_2 = 7.061 \times 10^{-5} \left[\frac{.0099000 \, (12.90 - .00) \, (1000/10)}{(40.370)} \right] = .0000223400$ lbs./dscf

Run # 2: $CSO_2 = 7.061 \times 10^{-5} \left[\frac{.0099000 \, (13.80 - .00) \, (1000/10)}{(39.610)} \right] = .0000243500$ lbs./dscf

Run # 3: $CSO_2 = 7.061 \times 10^{-5} \left[\frac{.0099000 \, (14.10 - .00) \, (1000/10)}{(40.020)} \right] = .0000246300$ lbs./dscf

Sulfur Dioxide Emissions

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

Where; E = Emissions of sulfur dioxide in pounds per hour

Q_{sd}= Stack gas flow rate (dscf/hr)

CSO_2= Sulfur dioxide concentration (lbs/dscf)

Run # 1: E = (.000022340 lbs/dscf) (2362664 dscf/hr) = 52.78 lbs/hr

Run # 2: E = (.000024350 lbs/dscf) (2396239 dscf/hr) = 58.35 lbs/hr

Run # 3: E = (.000024630 lbs/dscf) (2361036 dscf/hr) = 58.15 lbs/hr

Emissions of SO_2 PPM (Parts Per Million)

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

Where;

CSO_2	=	Concentration of SO_2 in lbs/dscf
453.593	=	Conversion to grams
MOL SO_2	=	Molar conversion for SO_2
22.4 l/MOL	=	Volumetric molar conversion @ 273°K
293°K/273°K	=	Temperature correction to std conditions
28.317 l	=	Conversion of liters to cubic feet
1,000,000	=	Conversion to parts per million

Run # 1:

$$E = \frac{.0000223400\ lbs}{dscf} \left| \frac{453.593g}{1\ lb} \right| \frac{MOL\ SO_2}{64g\ SO_2} \left| \frac{22.4\ l}{MOL} \right| \frac{293^\circ K}{273^\circ K} \left| \frac{ft^3}{28.317\ l} \right| 1{,}000{,}000 \Bigg| =$$

134.424 ppm

Run # 2:

$$E = \frac{.0000243500\ lbs}{dscf} \left| \frac{453.593g}{1\ lb} \right| \frac{MOL\ SO_2}{64g\ SO_2} \left| \frac{22.4\ l}{MOL} \right| \frac{293^\circ K}{273^\circ K} \left| \frac{ft^3}{28.317\ l} \right| 1{,}000{,}000 \Bigg| =$$

146.518 ppm

Run # 3:

$$E = \frac{.0000246300\ lbs}{dscf} \left| \frac{453.593g}{1\ lb} \right| \frac{MOL\ SO_2}{64g\ SO_2} \left| \frac{22.4\ l}{MOL} \right| \frac{293^\circ K}{273^\circ K} \left| \frac{ft^3}{28.317\ l} \right| 1{,}000{,}000 \Bigg| =$$

148.203 ppm

Sulfur Dioxide Concentration - (28)

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

Where; CSO_2 = Sulfur dioxide concentration, (lbs/dscf)

$K_3 = 7.061 \times 10^{-5}$ Lb/meq

N = Normality of barium perchlorate titrant, g equivalents/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 sulfuric acid or sulfur dioxide sample is contained, 250 ml or 1,000 ml respectively

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

V_a = Volume of sample aliquot titrated (10 ml for SO_2)

Run # 1: $CSO_2 = 7.061 \times 10^{-5} \left[\frac{.0099000 \; (1.60 - .00) \; \left(\frac{250}{20}\right)}{(40.370)} \right] = .0000003500$ lbs./dscf

Run # 2: $CSO_2 = 7.061 \times 10^{-5} \left[\frac{.0099000 \; (1.20 - .00) \; \left(\frac{250}{20}\right)}{(39.610)} \right] = .0000002600$ lbs./dscf

Run # 3: $CSO_2 = 7.061 \times 10^{-5} \left[\frac{.0099000 \; (1.30 - .00) \; \left(\frac{250}{20}\right)}{(40.020)} \right] = .0000002800$ lbs./dscf

Emissions of SO_2 PPM (Parts Per Million) - CH_2SO_4

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

Where;

CSO_2	=	Concentration of SO_2 in lbs/dscf
453.593	=	Conversion to grams
MOL SO_2	=	Molar conversion for SO_2
22.4 l/MOL	=	Volumetric molar conversion @ 273°K
293°K/273°K	=	Temperature correction to std conditions
28.317 l	=	Conversion of liters to cubic feet
1,000,000	=	Conversion to parts per million

Run # 1:

$$E = \frac{.0000003500\ lbs}{dscf} \left| \frac{453.593g}{1\ lb} \right| \frac{MOL\ SO_2}{64g\ SO_2} \left| \frac{22.4\ l}{MOL} \right| \frac{293^\circ K}{273^\circ K} \left| \frac{ft^3}{28.317\ l} \right| 1{,}000{,}000 \Bigg| =$$

2.106 ppm

Run # 2:

$$E = \frac{.0000002600\ lbs}{dscf} \left| \frac{453.593g}{1\ lb} \right| \frac{MOL\ SO_2}{64g\ SO_2} \left| \frac{22.4\ l}{MOL} \right| \frac{293^\circ K}{273^\circ K} \left| \frac{ft^3}{28.317\ l} \right| 1{,}000{,}000 \Bigg| =$$

1.564 ppm

Run # 3:

$$E = \frac{.0000002800\ lbs}{dscf} \left| \frac{453.593g}{1\ lb} \right| \frac{MOL\ SO_2}{64g\ SO_2} \left| \frac{22.4\ l}{MOL} \right| \frac{293^\circ K}{273^\circ K} \left| \frac{ft^3}{28.317\ l} \right| 1{,}000{,}000 \Bigg| =$$

1.685 ppm

Sulfur Dioxide Emissions - CH_2SO_4

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

Where; E = Emissions of sulfur dioxide in pounds per hour

Q_{sd}= Stack gas flow rate (dscf/hr)

CSO_2= Sulfur dioxide concentration (lbs/dscf)

Run # 1: E = (.000000350 lbs/dscf) (2362664 dscf/hr) = .83 lbs/hr

Run # 2: E = (.000000260 lbs/dscf) (2396239 dscf/hr) = .62 lbs/hr

Run # 3: E = (.000000280 lbs/dscf) (2361036 dscf/hr) = .66 lbs/hr

VIII. FIELD DATA

RAMCON ENVIRONMENTAL CORPORATION

Plant Thompson McCully
Location Hwy 94 And Brunswick
Operator Sam Turner
Date 7-17-87
Run No. 2
Sample Box No. 1
Meter Box No. 620775
Meter H @ 1.98
C Factor 1.003
Pitot Tube Coefficient Cp .81

Schematic of Stack Cross Section

	IMPINGER VOLUME, ml	SILICA GEL WEIGHT, g
FINAL	514	213
INITIAL	300	203
DIFFERENCE	214	10

Ambient Temperature 70
Barometric Pressure 30.22
Assumed Moisture, %
Probe Length, m(ft) 3'
Nozzle Identification No. NA
Avg. Calibrated Nozzle Dia., (in.) NA
Probe Heater Setting
Leak Rate, m³/min. (cfm) .007 at 6" Hg
Probe Liner Material Pyrex
Static Pressure, mm Hg (in. Hg) .01
Filter No. N/A

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 ft³	GAS SAMPLE TEMP. AT DRY GAS METER °F Inlet	Outlet	FILTER HOLDER TEMP °F	GAS TEMP LVG CONDENSER OR LAST IMPINGER °F
1	9:23 / 9:28	3	292	1.45	1.6	190.45 / 193.70	84	86	225	60
2	9:33	4	299	1.45	1.6	196.80	86	84	260	~~60~~ 48
3	9:38	4	311	1.45	1.6	200.51	86	84	265	48
4	9:43	4	318	1.45	1.6	203.84	86	84	240	60
5	9:48	4	322	1.45	1.6	207.27	86	84	250	60
6	9:53	4	325	1.45	1.6	210.59	86	84	250	60
7	9:58	4	325	1.45	1.6	213.95	88	84	230	55
8	10:03	4	325	1.45	1.6	217.23	88	84	230	52
9	10:08	4	325	1.45	1.6	220.68	90	84	230	52
10	10:13	4	325	1.45	1.6	224.86	90	86	230	50
11	10:18	4	325	1.45	1.6	227.30	90	86	230	50
12	10:23	4	325	1.45	1.6	230.75	92	86	230	50

230.84 10:28

RAMCON ENVIRONMENTAL CORPORATION

Plant Thompson McCully
Location Highway 94 to Lawsonville
Operator Bill Turner
Date 7-17-87
Run No. 3
Sample Box No. 1
Meter Box No. 670775
Meter H @ 1.98
C Factor 1.003
Pitot Tube Coefficient Cp .81

Ambient Temperature 77
Barometric Pressure 30.22
Assumed Moisture, %
Probe Length, m(ft) 3'
Nozzle Identification No. NA
Avg. Calibrated Nozzle Dia., (in.) NA
Probe Heater Setting 3
Leak Rate, m^3/min. (cfm) .001 @ 6" vac
Probe Liner Material Pyrex
Static Pressure, mm Hg (in. Hg) .01
Filter No. N/A

	IMPINGER VOLUME, ml	SILICA GEL WEIGHT, g
FINAL	538	214
INITIAL	300	206
DIFFERENCE	238	8

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 H2O	PRESSURE DIFF. ORF. MTR in H2O	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
A 1	11:15 / 11:20	2	288	1.45	1.6	239.06 / 242.54	92	94	225	60
2	11:25	2	304	1.45	1.6	246.18	102	94	225	60
3	11:30	2	315	1.45	1.6	249.66	109	94	230	60
4	11:35	2	319	1.45	1.6	253.08	110	94	225	55
5	11:40	2	319	1.45	1.6	256.58	112	94	225	55
6	11:45	2	321	1.45	1.6	260.07	112	94	225	55
7	11:50	2	324	1.45	1.6	263.93	112	94	225	55
8	11:55	2	325	1.45	1.6	266.91	110	94	225	50
9	12:00	2	325	1.45	1.6	270.47	110	94	225	50
10	12:05	2	325	1.45	1.6	273.96	110	94	225	50
11	12:10	2	325	1.45	1.6	277.31	108	94	230	55
12	12:15	2	325	1.45	1.6	280.89	108	94	230	55

280:91 12:19:40
289:[illegible] 12:34:30

(32)

RAMCON ENVIRONMENTAL CORPORATION

Plant Thomson McKilly

Location Hwy 94 & Rawsonville

Operator Bill Turner

Date 7-17-87

Run No. 1

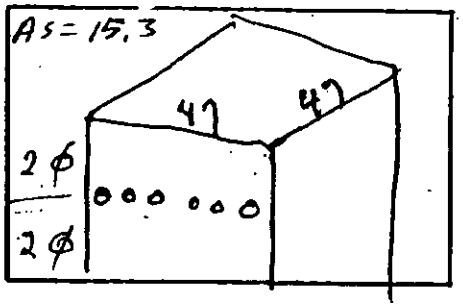
Sample Box No. & 2

Meter Box No. 670775

Meter H @ 1.98

C Factor 1.003

Pitot Tube Coefficient Cp .81



Schematic of Stack Cross Section

Ambient Temperature 63

Barometric Pressure 30.18

Assumed Moisture, %

Probe Length, m(ft) 3'

Nozzle Identification No. NA

Avg. Calibrated Nozzle Dia., (in.) NA

Probe Heater Setting 3

Leak Rate, m³/min. (cfm) .009 @ 6" vac

Probe Liner Material Pyrex

Static Pressure, mm Hg (in. Hg) .01

Filter No. N/A

	METER VOLUME m³	SILICA GEL WEIGHT g
FINAL	627	206
INITIAL	300	199
DIFFERENCE	327	7

TRAV. PT NO.	SAMPLING TIME (θ) min.	VACUUM in. Hg	STACK TEMP (Ts) °F	VELOCITY HEAD (Ps) 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	7:20 / 7:25	3	330	~~1.45~~	1.60	142.17 / 146.00	64	64	230	60
2	7:30	3	331	1.45	1.60	148.77	66	64	230	50
3	7:35	3	331	1.45	1.60	151.94	68	64	230	60
4	7:40	3	331	1.45	1.60	155.36	70	64	240	60
5	7:45	3	331	1.45	1.60	158.66	72	64	250	60
6	7:50	3	332	1.45	1.60	161.90	72	66	250	60
7	7:55	3	334	1.45	1.60	165.23	74	68	255	55
8	8:00	3	331	1.45	1.60	168.57	76	70	255	55
9	8:05	3	331	1.45	1.60	171.93	78	70	250	55
10	8:10	3	331	1.45	1.60	175.38	78	70	250	55
11	8:15	3	331	1.45	1.60	178.69	78	70	245	60
12	8:20	3	331	1.45	1.6	182.08	80	72	245	60

(23)

IX. CALIBRATIONS

METER BOX CALIBRATION DATA AND CALCULATION FORM

(English units)

Date 18-11-87 Meter box number 670775

Barometric pressure, P_b = 30.28 in. Hg Calibrated by Sam Turner

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								
1.5	5	140.90 / 145.945	72	96 / 108	74 / 74	88	7.53	.978	1.84
2.0	10	146.40 / 156.185	72	96 / 111	74 / 76	89.25	12.95	.98	1.81
3.0	10	124.20 / 134.55	72	99 / 111	74 / 74	89.5	10.53	.99	1.79
4.0	10								
							Avg	.983	1.81

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		
1.5	0.110	30.39	
2.0	0.147		
3.0	0.221		
4.0	0.294		

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

METER BOX CALIBRATION DATA AND CALCULATION FORM

(English units)

Date 7-10-87 Meter box number 670775

Barometric pressure, P_b = 29.38 in. Hg Calibrated by Sam Turney

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	634.00 / 639.062	76	88 / 86	81 / 80	83.75	9.25	.999	1.95
1.5	10								
2.0	10	623.40 / 623.49	76	89 / 90	81 / 81	85.25	13.25	1.003	1.996
3.0	10	612.80 / 622.84	76	92 / 92	80 / 81	86.25	10.82	1.007	1.993
4.0	10								
							Avg	1.003	1.98

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		
1.5	0.110		
2.0	0.147		
3.0	0.221		
4.0	0.294		

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

Form #REC-02

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 6-17-86 Thermocouple number inlet / outlet

Ambient temperature 24 °C Barometric pressure 29.95 in. Hg

Calibrator S Turney Reference: mercury-in-glass ✓

other _____

Reference point number	Source[a] (specify)	Reference thermometer temperature, °C	Thermocouple potentiometer temperature, °C	Temperature difference,[b] %
A	inlet ambient	24 °C	24 °C	0
B	outlet ambient	24 °C	24 °C	0
C.	Ambient 7-17-80	70°F	70°F	0%

[a]Type of calibration system used.

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

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 6-17-86 Thermocouple number Hotbox

Ambient temperature 24 °C Barometric pressure 29.95 in. Hg

Calibrator Sam Turney Reference: mercury-in-glass ✓

other _____

Reference point number	Source[a] (specify)	Reference thermometer temperature, °C	Thermocouple potentiometer temperature, °C	Temperature difference,[b] %
A	boiling water	100 °C	100 °C	0
B	Ambient	24 °C	23.9	2.1 %
C	ambient			
	7-17-82	70°F	70°F	0 %

[a]Type of calibration system used.

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

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 1/08/87 Thermocouple number 32

Ambient temperature 60°F °C Barometric pressure 30.34 in. Hg

Calibrator Shawn 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	212°F	0%
C	Oil	410°F	413°F	.007%
D	Ambient	60°F	60°F	0%
	7-17-87	70°F	70°F	0%

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

[b]Type of calibration system used.

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

RAMCON

Lear Siegler Stack Sampler

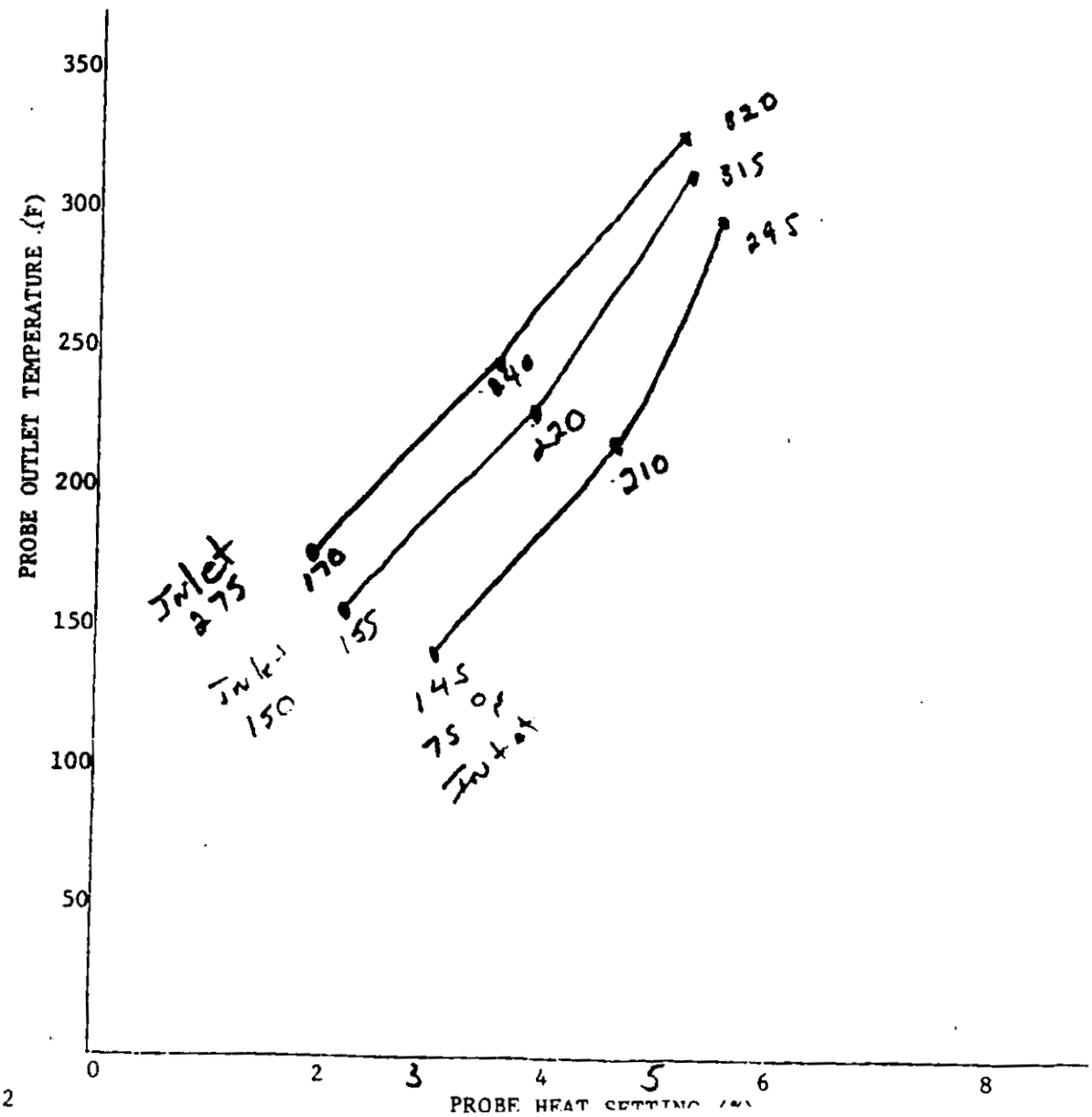
Heating Probe Calibration

Probe No. _____ Probe Length 3'

Date of Calibration 6-23-87 Signature Sam Turner

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

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. 3 Date 5-12-87

Calibrated by: R. Allmendinger

Ranchero

"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	1.00	1.50	0.816	0.002
2	0.31	1.20	0.821	0.007
3	0.63	0.97	0.806	-0.008
		$\bar{C}_p$ (SIDE A)	0.814	

"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	1.00	1.50	0.816	0
2	0.81	1.20	[illegible]	[illegible]
3	0.63	0.96	0.810	-0.006
		$\bar{C}_p$ (SIDE B)	0.816	

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

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

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

Form No. EED-17-1

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 400 stacks including over 300 asphalt plants. He is 42 years old and a graduate of the University of Mississippi with graduate studies at Memphis State University and State Technical Institute of Memphis.

Sam Turner - Field Supervisor

Sam Turner has five years experience in the Air Division and is our field supervisor. He has sampled over 30 large boiler stacks and approximately 200 asphalt plants. He is a graduate of State Technical Institute of Memphis, and holds an Associate Degree in Environmental Engineering. He also has current certification as a V.E. reader.