RAMCON ENVIRONMENTAL CORPORATION

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

RECEIVED

JUL 10 [illegible]

AIR MANAGEMENT
ADMINISTRATION

SOURCE SAMPLING
for
PARTICULATE EMISSIONS
R.F. KLINE, INC.
FREDERICK, MARYLAND
June 9 & 10, 1986

Ken Bruchey

Ken Bruchey
R.F. Kline, Inc.

Sumner Buck

G. Sumner Buck, III
President

Sam Turner

Sam Turner
Field Supervisor

RAMCON ENVIRONMENTAL CORPORATION

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

July 1, 1986

Mr. Ken Bruchey
R.F. Kline, Inc.
P.O. Box 665
Frederick, MD 21701

Subject: Particulate Emissions Test - Frederick, Maryland

Dear Mr. Bruchey:

Enclosed are four copies of our report on particulate emissions. Based on our test results, your plant does pass both New Source Performance Standards set by EPA and those set by the State of Maryland. The average grain loading of the three test runs was in compliance with State and Federal Standards. Your plant also meets State requirements for SO_2 emissions.

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

Mr. Craig Holdefer
Maryland Air Management
Div. of Environmental Affairs
P.O. Box 13387
Baltimore, MD 21203

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

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I. INTRODUCTION

On June 9 & 10, 1986, personnel from RAMCON Environmental Corporation (REC) conducted a source emissions test for particulates, SO_2, SO_3 and H_2SO_4 (combined) emissions compliance at R.F. Kline's H & B batch mix asphalt plant located in Frederick, Maryland. RAMCON personnel conducting the test were Sam Turner, Field Supervisor and Allen Turner. Kim Rea was responsible for the final laboratory analysis including taring the beakers and filters and recording final data in the laboratory record books. Custody of the samples were limited to Mr. Turner and Ms. Rea.

The purpose of the test was to determine if the rate of particulate and sulfur emissions from the plant's baghouse and the total contaminants by weight (grain loading) are below the limits set by US EPA N.S.P.S. and the State of Maryland.

II. TEST RESULTS

Table I summarizes the test results. The grain loading limitation for EPA is specified in 39 FR 9314, March 8, 1974, 60.92 Standards for Particulate Matter (1), as amended. The allowable particulate emissions for the State of Maryland are the same as those set by EPA. The SO_2 and SO_3 allowable emissions for the State of Maryland are 500 ppm for SO_2 and 35 mg/m3 for SO_3.

Mr. Craig Holdefer of Maryland's Office of Environmental Programs observed the testing conducted by RAMCON and conducted the visible emissions test (Method 9).

TABLE I

SUMMARY OF TEST RESULTS
June 9 & 10, 1986

Test Run	Time	Grain Loading	Actual Emissions	SO_2 Emissions
1	08:16 to 09:33	0.0436 gr/DSCF	12.2 lbs/hr	84.54 ppm
2	10:15 to 11:32	0.0469 gr/DSCF	14.0 lbs/hr	51.56 ppm
3	06:54 to 08:10	0.0073 gr/DSCF	2.0 lbs/hr	5.12 ppm
	Average:	0.0326 gr/DSCF	9.4 lbs/hr	47.07 ppm

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 Maryland. The SO_2 emissions is below the 500 ppm standard set by the State of Maryland. Therefore, the plant is operating in compliance with State and Federal Standards for particulates and SO_2.

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: The field sampling for SO_3/H_2SO_4 caused a high bias in the laboratory analysis. This problem did not materially affect the SO_2 lab analysis since the results are so low anyway, however, the SO_2 results are understated and the SO_3/H_2SO_4 results are overstated. The bias was caused when liquid from the second impinger backwashed into the first impinger. The second impinger contains the SO_2 absorbing solution, hydrogen peroxide. When mixed into the first impinger absorbing solution, both SO_3/H_2SO_4 <u>and</u> SO_2 are absorbed in the first impinger.

B. Problems Encountered (continued):

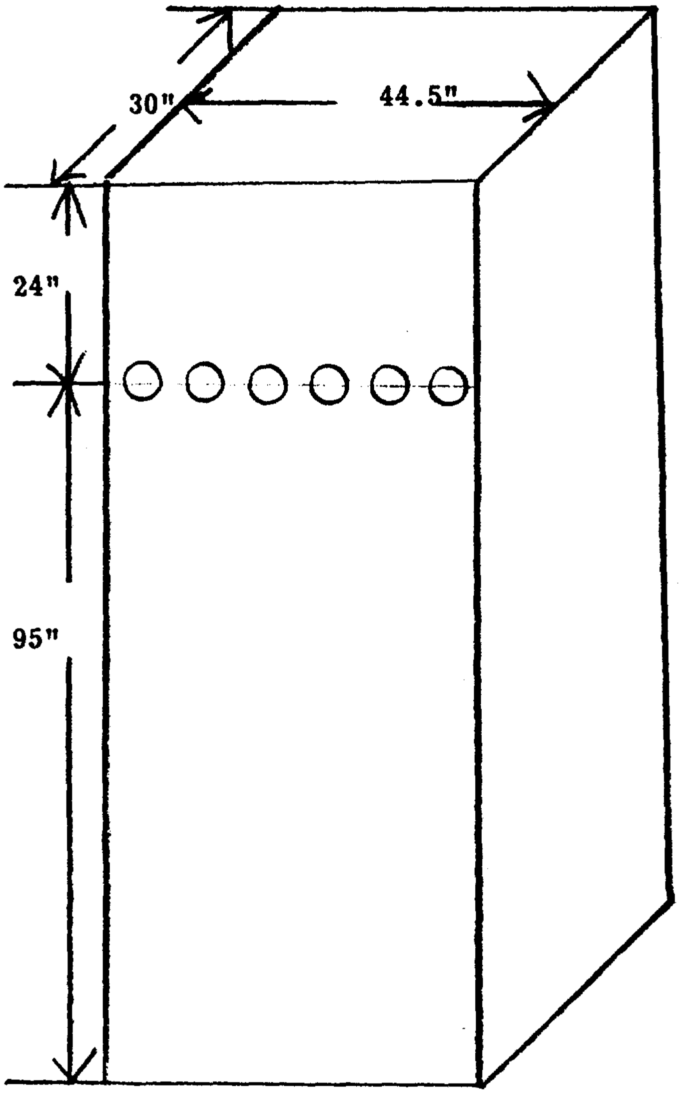
An asphalt plant is a drying operation and the very large amounts of moisture that are driven from the aggregate in the drum dryer pass through the control device and go out the stack. As this moisture is condensed in the back half of the Method 8 impinger train, the first impinger overflows into the second impinger. When an unheated filter is placed between impingers one and two (as called for in the method), it becomes wet causing a high vacuum drop at that point. When the sampling pump is shut off at the end of each sample port some liquid is inevitably pulled backwards against this vacuum.

Under normal operating conditions (with excess air and water) in an asphalt plant, there should be rather complete conversion of sulfur to SO_2. When the SO_3/H_2SO_4 is calculated as SO_2, the emissions are still well within the 500 ppm limit set by the State of Maryland. Therefore, RAMCON Environmental Corporation recommends the SO_3/H_2SO_4 results be considered biased high and disregarded. Further, it is recommended that these test results be accepted as demonstration of compliance with SO_2 and SO_3/H_2SO_4 emissions standards set by the State of Maryland. Further, it is recommended that for the future, SO_3/H_2SO_4 testing using the Method 8 train be modified for asphalt plants by deleting the unheated filter between impingers one and two, or by adding an empty impinger to the train after the first impinger and before the filter.

C. Sampling Site: The emissions test was conducted after a baghouse on a rectangular stack measuring 30" x 44.5" with an equivalent diameter of 35.8". Six sampling ports were placed 24" down (0.7 diameters upstream) from the top of the stack and 95" up (2.6 diameters downstream) from the last flow disturbance. Twenty four points were sampled, four through each port for three minutes each.

Points on a Diameter	Probe Mark
1	*9.8"
2	17.3"
3	24.8"
4	32.3"

* Measurements include a 6.0" standoff.



IV. THE SOURCE

IV. THE SOURCE

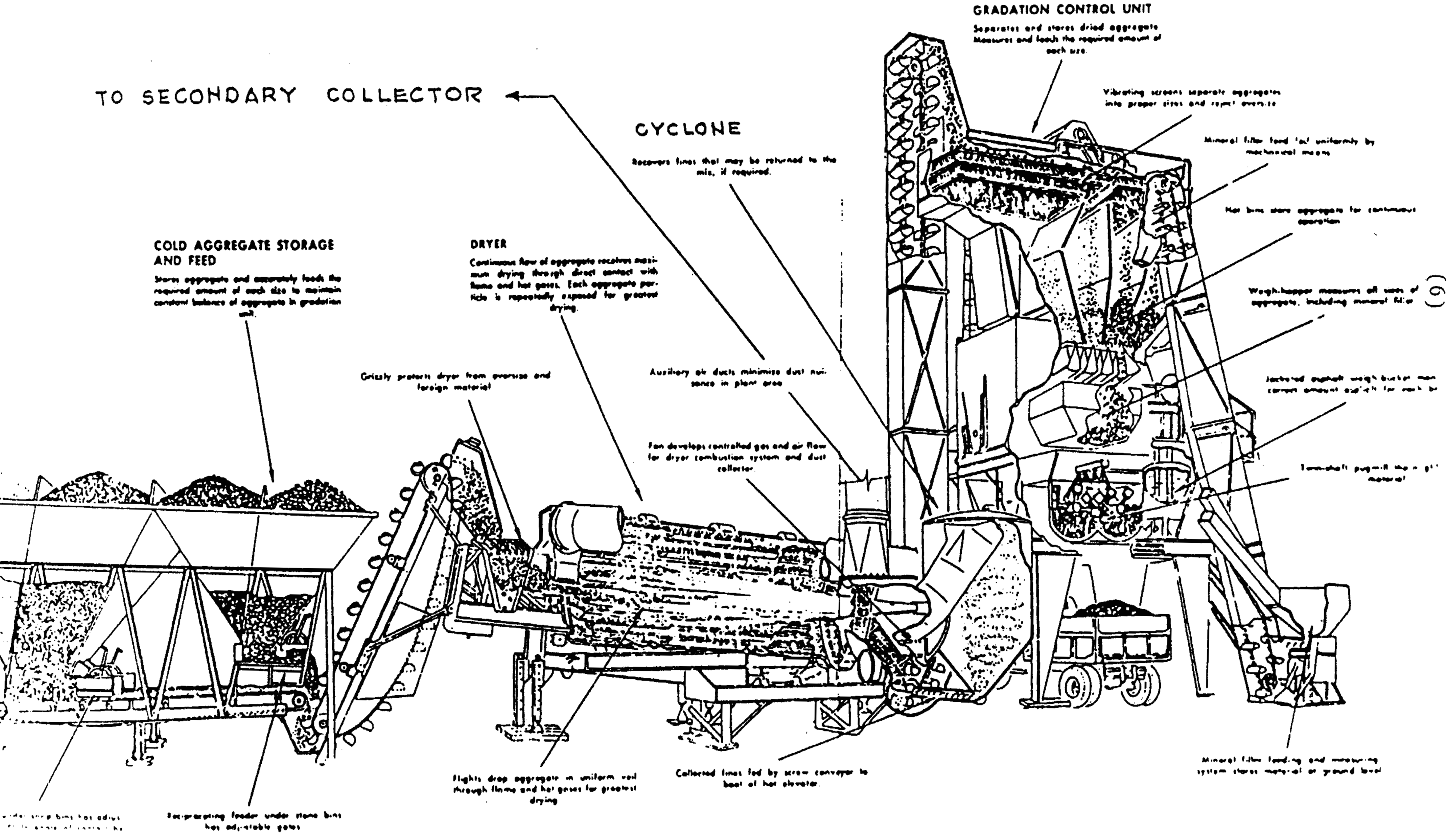
R.F. Kline, Inc. employs an H & B batch mix asphalt concrete plant which is used to manufacture hot mix asphalt for road pavement. The process consists of blending prescribed portions of cold feed materials (sand, gravel, screenings, chips, etc.) uniformly and adding sufficient hot asphalt oil to bind 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 and recycled asphalt pavement 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 mixer uses a burner fired with a mixture of coal and propane to heat air to dry the aggregate. The air is drawn into the system via an exhaust fan. After passing through the burner, the air passes through a high efficiency scrubber. The scrubber is manufactured by H & B. The exhaust gasses are blown through the scrubber and discharged to the atmosphere through the stack. The design pressure drop across the venturi is in excess of 15 inches of water. The particulate matter, which is removed by the scrubber is fed into a scrubber pond where it drops out of suspension.

Figure 4-1

ASPHALT BATCH MIX PLANT - AN EXPLODED VIEW



DATA SUMMARY

Plant

1. Manufacturer of plant [illegible] ____.

2. Designed maximum operating capacity [illegible] TPH @ ____ % moisture.

3. Actual operation rate 270-300 TPH @ ____ % moisture.

4. Startup date ____.

5. Type of fuel used in dryer Propane [illegible].

6. Quanity of fuel consumption [illegible].

Aggregate

7. Name/type of mix [illegible].

8. Percent asphalt in mix [illegible] %.

9. Temperature of asphalt [illegible].

10. Sieve/Screening analysis: % Passing;

1"		3/8"		#	
3/4"		#		#	
1/2"		#		#200	

Baghouse

11. Manufacturer H&B.

12. No. of bags 756. Type of bags [illegible].

13. Air to cloth ratio 5:1. Designed ACFM ____.

14. Square feet of bags ____.

15. Type of cleaning; pulse jet ✓, reverse air ____,
plenum pulse ____, other ____.

16. Cleaning cycle time .4.

17. Interval between cleaning cycle 30 [illegible].

18. Pressure drop across baghouse 1 psi.

19. Pulse pressure on cleaning cycle [illegible] psi.

COMPANY NAME [illegible] DATE [illegible]

COMPANY REPRESENTATIVE [illegible]

PLANT DATA (8)

COMPANY NAME R.F. Kline Inc.
COMPANY REP. [illegible] DATE 6/9/86 PHONE #
DATA SOURCE
PLANT LOCATION Frederick, MD
PLANT MFG. H&B PLANT MODEL # PLANT TYPE [illegible]
MIX SPECIFICATION # OIL SPECIFICATION #

TEST 1
[illegible] 8:16

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
[illegible]	[illegible]	7.5	[illegible]		2.93	[illegible]	[illegible]
8:05	" "	6	288		3	300	3.2
8:20	" "	5	300		4.3	330	[illegible]
8:35	" "	6	302		3.2	350	3.4
8:50	" "	5	270		3.5	330	3.4
9:05	" "	5	320		3.7	330	3.6
9:20	" "	5	220		2.5	320	4
9:35	" "	5	300		2.7	330	4

PLANT DATA

(9)

COMPANY NAME R. F. Kline Inc

COMPANY REP. ____________ DATE 6/[illegible]/86 PHONE #(301)[illegible]-1761

DATA SOURCE ____________

PLANT LOCATION Frederick, MD

PLANT MFG. H&B PLANT MODEL # ____________ PLANT TYPE [illegible]

MIX SPECIFICATION # ____________ OIL SPECIFICATION # ____________

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
10:17	25% 75%	4	270	/	3	330	4
10:32	" "	5	270		3	330	4
10:47	" "	5	280		3.6	330	4
11:02	" "	5	320		3	320	4
11:17	" "	5	300		3	315	4
11:32	" "	3	323		3.5	340	4.
11:47							
7:04	25 75	5	300		[illegible]	300	4.
7:24	" "	5	300		3	330	4
7:37	" "	5	290		[illegible]	330	[illegible]
7:54	" "	4	310		[illegible]	340	[illegible]
8:04	" "	4	220		2.5	340	4

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.

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 glass filter holder which was used in field sampling. In the lab these holders are opened. The filter is placed in its petri dish with the lid off and returned to the dessicator for at least 24 hours. The top half of the filter holder is washed into the corresponding probe wash bottle and the bottom half of the filter holder is washed into the corresponding impinger catch bottle. (See II, C and D). After dessication, the filters are reweighed. The final weight is recorded in the lab record book. The filter pick up weight is calculated and recorded also. This procedure is repeated for all filters used in the field.

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 sealed silica gel jars should be reweighed on the triple-beam balance and their weights recorded as shown on previous page.

C. PROBE RINSINGS: In all tests, a probe wash-out analysis will be necessary. These samples are returned in sealed Mason jars and consist of A.R. Acetone with an unknown solid content. Clean 250 ml beakers are used to make this analysis. These should be immaculately washed and rinsed with deionized water, then oven dried at 105°C for about one hour. The beakers should be moved to the dessicator to cool for ninety (90) minutes, then labeled with a pencil and weighed on the Sartorius analytical balance. Any variance from this procedure should be duplicated exactly when reweighing, as this procedure has been found to be quite sensitive. After preparing the necessary number of beakers (one for each probe wash and one blank) the Mason jars should be opened, poured into the beaker, and any material remaining on the jar walls rinsed with an acetone wash bottle into the beaker. The amount of liquid in the beaker should be noted on the analysis form. The acetone rinsings are evaporated on a warming plate. The liquid is kept swirled with an air sweep to prevent "bumping". When the acetone is evaporated the beakers are weighed as in Section II A.

D. IMPINGER CATCH: In some testing cases, the liquid collected in the impingers must be analyzed for solids 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 in the 1 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.

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.

(13B)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Research Triangle Park, North Carolina 27711

SUBJECT: Spurious Acid Mist Results Caused by Peroxides in Isopropyl Alcohol Solutions Used in EPA Test Method (M-8)

DATE: January 22, 1976

Joseph E. Knoll

FROM: Dr. Joseph E. Knoll, QAB/EMSL (MD#77)

TO: Mr. Roger T. Shigerhara, EMB/ESED (MD#19)

An evaluation study of EPA Test Method (M-8) for the Determination of Sulfuric Acid Mist and Sulfur Dioxide Emissions from Stationary Sources has been carried out in the Quality Assurance Branch. One result of this study has been the finding that peroxide impurities in the isopropyl alcohol used for acid mist collection can convert sulfur dioxide to sulfuric acid and result in erroneously high acid mist values. The quantities of sulfur dioxide collected as sulfuric acid were of the order of from ten to twenty five percent of the EPA compliance standard. It was independent of the quantity or concentration of sulfur dioxide that had passed through the system and only dependent on the quantity of peroxide, traces of which may occasionally be found in reagent grade isopropyl alcohol.

The following test is tentatively proposed for detecting peroxides in isopropyl alcohol:

> Shake 10 ml of isopropyl alcohol with 10 ml of freshly prepared 10% potassium iodide solution. Prepare a blank by similarly treating 10 ml of distilled water. After one minute, read the absorbance at 352 nm. If absorbance exceeds 0.1, reject alcohol for use.

Peroxides may be removed from isopropyl alcohol by redistilling or by passage through a column of activated alumina. However, it is possible to obtain reagent grade isopropyl alcohol with suitably low peroxide levels from commercial sources, so that rejection of contaminated lots may be a more efficient procedure.

cc: M. R. Midgett

Form REC#8

SAMPLE ANALYTICAL DATA FORM

Plant Location R.F. Kline

Relative humidity in lab 49 %

Sample Location Asphalt plant stack

Density of Acetone (pa) .7853 mg/ml

Blank volume (V_a) 200 ml

Date/Time wt. blank 6/12/86

Date/Time wt. blank 6/13/86

Gross wt. 95.0446 mg

Gross wt. 95.0445 mg

Ave. Gross wt. 95.0446 mg

Tare wt. 95.0440 mg

Weight of blank (m_{ab}) .0006 mg

Acetone blank residue concentration (C_a) $(C_a) = (M_{ab}) / (V_a) (p_a)$ = (.000004 mg/g)

Weight of residue in acetone wash: $W_a = C_a V_{aw} P_a$ = (.000004)(200)(.7853) = (.0006)

		Run # 1	Run # 2	Run # 3
Acetone rinse volume (V_{aw})	ml	200	200	200
Date/Time of wt 6/12/86 Gross wt	g	90.9437	95.7888	94.2578
Date/Time of wt 6/13/86 Gross wt	g	90.9435	95.7885	94.2577
Average Gross wt	g	90.9436	95.7887	94.2578
Tare wt	g	90.8230	95.6546	94.2427
Less acetone blank wt (W_a)	g	.0006	.0006	.0006
Wt of particulate in acetone rinse (m_a)	g	.1200	.1335	.0145

Filter Numbers	#	ST-1455	ST-1456	ST-1444
Date/Time of wt 6/12/86 Gross wt	g	.5309	.5333	.5234
Date/Time of wt 6/13/86 Gross wt	g	.5305	.5330	.5233
Average Gross wt	g	.5307	.5332	.5234
Tare wt	g	.5192	.5187	.5150

Weight of particulate on filters(s) (m_f)	g	.0115	.0145	.0084
Weight of particulate in acetone rinse	g	.1200	.1335	.0145
Total weight of particulate (m_n)	g	.1315	.1480	.0229

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 Kim Rea Signature of reviewer

H_2SO_4 ANALYSIS

(Method 8)

Plant Kline

Date 6/13/86

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~~ 1 Combined.

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)	25	25	25	25	25	25		
N	(N)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100		
V_t	(ml)	16.2	16.1	9.6	9.6	23.5	23.6		
$V_{m(std)}$	(dscf)								
C_{SO_2}	(lb/dscf)								

K_3 = 7.061×10^{-5} lb/meq

Analysis performed by: LD

Approved by:

SO_2 ANALYSIS
(Method 8)

Plant Kline **Date** 6/13/86

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)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100		
V_t (ml)	09.2	09.3	5.9	5.9	.6	.55		
$V_{m(std)}$ (dscf)								
C_{SO_2} (lb/dscf)								

K_3 = 7.061×10^{-5} lb/meq

Analysis performed by: John R Riggs

Approved by:

VII. CALCULATIONS

NAME: R.F. KLINE, INC.

LOCATION: FEDERICK, MARYLAND

		date	6/09/86	6/09/86	6/10/8
	SUMMARY OF TEST DATA		RUN # 1	RUN # 2	RUN #
	SAMPLING TRAIN DATA	start	08:16	10:15	06:54
		finish	09:33	11:32	08:10
1	Sampling time, minutes	θ	72	72	72
2	Sampling nozzle diameter, in.	Dn	.190	.190	.190
3	Sampling nozzle cross-sectional area, ft^2.	An	.000197	.000197	.000197
4	Isokinetic variation	I	92	90	98
5	Sample gas volume - meter conditions, cf.	Vm	47.98	50.81	48.77
6	Average meter temperature, °R	Tm	558	566	544
7	Average oriface pressure drop, in.H_2O	ΔH	1.45	1.80	1.59
8	Total particulate collected mg.	Mn	131.5	148.0	22.9
	VELOCITY TRAVERSE DATA				
9	Stack area, ft^2.	A	9.3	9.3	9.3
10	Absolute stack gas pressure, in. Hg.	Ps	30.01	30.01	29.78
11	Barometric pressure, in. Hg.	Pbar	30.01	30.01	29.78
12	Average absolute stack temperature, °R	Ts	704	699	691
13	Average $\sqrt{\text{velocity head}}$, (Cp= .80)	$\sqrt{\Delta P}$	1.44	1.53	1.41
14	Average stack gas velocity ft. / sec.	Vs	91	97	89
	STACK MOISTURE CONTENT				
15	Total water collected by train, ml.	Vic	162.0	176.0	190.0
16	Moisture in stack gas, %	Bws	14.0	14.6	15.8
	EMISSIONS DATA:				
17	Stack gas flow rate, dscf/hr. (000's)	Qsd	1,964	2,086	1,904
18	Total particulate concentration, gr/dscf	Cs	.0436	.0469	.0073
19	Total particulate concentration, lbs/hr	E	12.2	14.0	2.0
20	Total particulate concentration, lbs/mbtu	E'	.0000	.0000	.0000
	ORSAT DATA				
21	Percent CO2 by volume	CO2	3.2	2.5	2.5
22	Percent O2 by volume	O2	15.5	15.0	15.0
23	Percent CO by volume	CO	.0	.0	.0
24	Percent N2 by volume	N2	81.3	82.5	82.5

Buzzycalc

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 ($528^{\circ}R$)

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 $$V_{m(std)} = 17.64 \; (1.02)(47.98) \left[\frac{(30.01) + \frac{1.45}{13.6}}{558} \right] = 46.50 \text{ ds}$$

Run # 2 $$V_{m(std)} = 17.64 \; (1.02)(50.81) \left[\frac{(30.01) + \frac{1.80}{13.6}}{566} \right] = 48.59 \text{ ds}$$

Run # 3 $$V_{m(std)} = 17.64 \; (1.02)(48.77) \left[\frac{(29.78) + \frac{1.59}{13.6}}{544} \right] = 48.13 \text{ ds}$$

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: $$C_s' = \left[0.0154 \frac{gr}{mg} \right] \left[\frac{131.5}{46.50} \right] = .0436 \text{ gr./dscf.}$$

Run # 2: $$C_s' = \left[0.0154 \frac{gr}{mg} \right] \left[\frac{148.0}{48.59} \right] = .0469 \text{ gr./dscf.}$$

Run # 3: $$C_s' = \left[0.0154 \frac{gr}{mg} \right] \left[\frac{22.9}{48.13} \right] = .0073 \text{ gr./dscf.}$$

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: $M_d = 0.44(\ 3.2\%\ ) + 0.32(15.5\%\ ) + 0.28(\ \ .0\% + 81.3\%\ ) =$ 29.1 lb./lb.-mol

Run # 2: $M_d = 0.44(\ 2.5\%\ ) + 0.32(15.0\%\ ) + 0.28(\ \ .0\% + 82.5\%\ ) =$ 29.0 lb./lb.-mol

Run # 3: $M_d = 0.44(\ 2.5\%\ ) + 0.32(15.0\%\ ) + 0.28(\ \ .0\% + 82.5\%\ ) =$ 29.0 lb./lb.-mol

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) (157.0) = 7.4 cu.ft
$V_{wsg(std)}$ = (0.04715) (5.0) = .2 cu.ft

Run # 2: $V_{wc(std)}$ = (0.04707) (170.0) = 8.0 cu.ft
$V_{wsg(std)}$ = (0.04715) (6.0) = .3 cu.ft

Run # 3: $V_{wc(std)}$ = (0.04707) (186.0) = 8.8 cu.ft
$V_{wsg(std)}$ = (0.04715) (4.0) = .2 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: $$B_{ws} = \frac{7.4 + .2}{7.4 + .2 + 46.50} \text{ X } 100 = 14.0\ \%$$

Run # 2: $$B_{ws} = \frac{8.0 + .3}{8.0 + .3 + 48.59} \text{ X } 100 = 14.6\ \%$$

Run # 3: $$B_{ws} = \frac{8.8 + .2}{8.8 + .2 + 48.13} \text{ X } 100 = 15.8\ \%$$

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: $M_s = 29.1\ (1- .140\ ) + 18\ (\ .140\ ) = 27.5$ (lb./lb.-mole).

Run # 2: $M_s = 29.0\ (1- .146\ ) + 18\ (\ .146\ ) = 27.4$ (lb./lb.-mole).

Run # 3: $M_s = 29.0\ (1- .158\ ) + 18\ (\ .158\ ) = 27.3$ (lb./lb.-mole).

Stack gas velocity:

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

Where:

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

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

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, (°f).

T_s = Absolute stack temperature, (°R). = 460 + t_s.

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

Run # 1: $V = (85.49)\ (\ .80)\ (\ 1.44) \sqrt{\frac{704}{(30.01)(27.55)}}$ = 90.99 ft/se

Run # 2: $V = (85.49)\ (\ .80)\ (\ 1.53) \sqrt{\frac{699}{(30.01)(27.39)}}$ = 96.62 ft/se

Run # 3: $V = (85.49)\ (\ .80)\ (\ 1.41) \sqrt{\frac{691}{(29.78)(27.26)}}$ = 89.08 ft/se

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:

$$Q_{sd} = 3600\ (1-.140)\ (\ 90.99)\ (\quad 9.3) \left[\frac{528}{704}\right] \left[\frac{30.01}{29.92}\right] = \quad 1964446 \text{ dscf/}$$

Run # 2:

$$Q_{sd} = 3600\ (1-.146)\ (\ 96.62)\ (\quad 9.3) \left[\frac{528}{699}\right] \left[\frac{30.01}{29.92}\right] = \quad 2086259 \text{ dscf/}$$

Run # 3:

$$Q_{sd} = 3600\ (1-.158)\ (\ 89.08)\ (\quad 9.3) \left[\frac{528}{691}\right] \left[\frac{29.78}{29.92}\right] = \quad 1903678 \text{ dscf.}$$

Emissions rate from stack:

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

Where:

E = Emissions rate, lb./hr.

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

Q = Dry volumetric stack gas flow rate corrected to standard conditions, (dscf/hr).

Run # 1: $$E = \frac{(.0436)(1964446)}{7000} = 12.2 \text{ lb. / hr.}$$

Run # 2: $$E = \frac{(.0469)(2086259)}{7000} = 14.0 \text{ lb. / hr.}$$

Run # 3: $$E = \frac{(.0073)(1903678)}{7000} = 2.0 \text{ lb. / hr.}$$

Isokinetic variation : $$I = 100\ T_s \left[\frac{0.002669\ V_{ic} + (V_m/T_m)(P_{bar} + \Delta H/13.6)}{60\quad 0\quad V_s\quad P_s\quad A_n} \right]$$

Where:

I = Percent isokinetic sampling.

100 = Conversion to percent.

T_s = Absolute average stack gas temperature, °R.

0.002669 = Conversion factor, Hg - ft^3/ml - °R.

V_{ic} = Total volume of liquid collected in impingers and silica gel,

T_m = Absolute average dry gas meter temperature, °R.

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

ΔH = Average pressure differential across the oriface meter, (in.H_2

13.6 = Specific gravity of mercury.

60 = Conversion seconds to minutes

0 = 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:

$$I = 100 \times 704 \left[\frac{(0.002669)(162.0) + \frac{48.0}{558} \left[30.01 + \frac{1.45}{13.6} \right]}{60\ (\ 72\ )\ (\ 90.99\ )\ (30.01\ )\ (\ .000197\ )} \right] = 92\ \%$$

Run # 2:

$$I = 100 \times 699 \left[\frac{(0.002669)(176.0) + \frac{50.8}{566} \left[30.01 + \frac{1.80}{13.6} \right]}{60\ (\ 72\ )\ (\ 96.62\ )\ (30.01\ )\ (\ .000197\ )} \right] = 90\ \%$$

Run # 3:

$$I = 100 \times 691 \left[\frac{(0.002669)(190.0) + \frac{48.8}{544} \left[29.78 + \frac{1.59}{13.6} \right]}{60\ (\ 72\ )\ (\ 89.08\ )\ (29.78\ )\ (\ .000197\ )} \right] = 98\ \%$$

Sulfuric Acid Concentration (Including SO_3) Impinger 1

$$C_{H_2SO_4} = \frac{K_2 N \; (V_t - V_{tb}) \left(\frac{V_{soln}}{V_a}\right)}{V_{m(std)}}$$

Where; H_2SO_4 = Sulfuric acid concentration (including SO_3), (g/dscm)

$K_2 = 1.081 \times 10^{-4}$ lbs/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 sample is contained, 250 ml.

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

V_a = Volume of sample aliquot titrated (25 ml for H_2SO_4).

Run #1: $$C_{H_2SO_4} = .04904 \quad \frac{.0100 \; (16.2 - .00) \; \frac{(250)}{25}}{(1.3167 \text{ m}^3)} = .0603 \text{ g/dscm}$$ or 60.3 mg/m^3

Run #2: $$C_{H_2SO_4} = .04904 \quad \frac{.0100 \; (9.6 - .00) \; \frac{(250)}{25}}{(1.3759 \text{ m}^3)} = .0342 \text{ g/dscm}$$ or 34.2 mg/m^3

Run #3: $$C_{H_2SO_4} = .04904 \quad \frac{.0100 \; (23.5 - .00) \; \frac{(250)}{25}}{(1.3628 \text{ m}^3)} = .0846 \text{ g/dscm}$$ or 84.6 mg/m^3

Sulfuric Acid Concentration as SO_2:

$$C_{SO_2} = C_{H_2SO_4} \left| \frac{64 \text{ mg } SO_2}{98 \text{ mg } H_2SO_4} \right.$$

$$\text{Run 1} = \frac{60.3 \text{ mg } H_2SO_4}{\text{dscm}} \left| \frac{64 \text{ mg } SO_2}{98 \text{ mg } H_2SO_4} \right. = 39.4 \text{ mg } SO_2$$

$$\text{Run 2} = \frac{34.2 \text{ mg } H_2SO_4}{\text{dscm}} \left| \frac{64 \text{ mg } SO_2}{98 \text{ mg } H_2SO_4} \right. = 22.3 \text{ mg } SO_2$$

$$\text{Run 3} = \frac{84.6 \text{ mg } H_2SO_4}{\text{dscm}} \left| \frac{64 \text{ mg } SO_2}{98 \text{ mg } H_2SO_4} \right. = 55.2 \text{ mg } SO_2$$

$$\text{Run 1} = \frac{39.4 \text{ mg } SO_2}{\text{dscm}} \left| \frac{1 \text{ g}}{1{,}000 \text{ mg}} \right| \frac{\text{mol } SO_2}{64 \text{ g } SO_2} \left| \frac{22.4 \text{ l}}{\text{mol}} \right| \frac{293^{\circ}\text{K}}{273^{\circ}\text{K}} \left| \frac{1 \text{ dscm}}{1{,}000 \text{ l}} \right| \begin{array}{c} 1{,}000{,}000 = \\ 14.8 \text{ ppm} \end{array}$$

$$\text{Run 2} = \frac{22.3 \text{ mg } SO_2}{\text{dscm}} \left| \frac{1 \text{ g}}{1{,}000 \text{ mg}} \right| \frac{\text{mol } SO_2}{64 \text{ g } SO_2} \left| \frac{22.4 \text{ l}}{\text{mol}} \right| \frac{293^{\circ}\text{K}}{273^{\circ}\text{K}} \left| \frac{1 \text{ dscm}}{1{,}000 \text{ l}} \right| \begin{array}{c} 1{,}000{,}000 = \\ 8.4 \text{ ppm} \end{array}$$

$$\text{Run 3} = \frac{55.2 \text{ mg } SO_2}{\text{dscm}} \left| \frac{1 \text{ g}}{1{,}000 \text{ mg}} \right| \frac{\text{mol } SO_2}{64 \text{ g } SO_2} \left| \frac{22.4 \text{ l}}{\text{mol}} \right| \frac{293^{\circ}\text{K}}{273^{\circ}\text{K}} \left| \frac{1 \text{ dscm}}{1{,}000 \text{ l}} \right| \begin{array}{c} 1{,}000{,}000 = \\ 20.7 \text{ ppm} \end{array}$$

Sulfur Dioxide Concentration (Impinger 2 & 3)

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

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

K_3 = 7.061×10^{-5} 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 correcte to standard conditions, dscf.

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

Run # 1: $$CSO_2 = 7.061 \times 10^{-5} \frac{[\,.0100000\,(\;9.25-\;.00)\;\frac{(1000)}{10}\,]}{(\;46.500\;)} = .0000140500$$ lbs./dscf

Run # 2: $$CSO_2 = 7.061 \times 10^{-5} \frac{[\,.0100000\,(\;5.90-\;.00)\;\frac{(1000)}{10}\,]}{(\;48.590\;)} = .0000085700$$ lbs./dscf

Run # 3: $$CSO_2 = 7.061 \times 10^{-5} \frac{[\,.0100000\,(\;.58-\;.00)\;\frac{(1000)}{10}\,]}{(\;48.130\;)} = .0000008500$$ lbs./dscf

Sulfur Dioxide Emissions (Impinger 2 & 3)

$E = CSO_2 \times Q_{sd}$

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 = (.000014050 lbs/dscf) (1964446 dscf/hr) = 27.60 lbs/hr

Run # 2: E = (.000008570 lbs/dscf) (2114096 dscf/hr) = 18.12 lbs/hr

Run # 3: E = (.000000850 lbs/dscf) (1903678 dscf/hr) = 1.62 lbs/hr

Emissions of SO_2PPM (Parts Per Million) (Impinger 2 & 3)

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

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:

$$E = \frac{.0000140500\text{ lbs}}{\text{dscf}} \left| \frac{453.593\text{g}}{1\text{ lb}} \right| \frac{\text{MOL } SO_2}{64\text{g } SO_2} \left| \frac{22.4\text{ l}}{\text{MOL}} \right| \frac{293^\circ\text{K}}{273^\circ\text{K}} \left| \frac{\text{ft}^3}{28.317\text{ l}} \right| 1{,}000{,}000 \right| =$$

84.541 ppm

Run # 2:

$$E = \frac{.0000085700\text{ lbs}}{\text{dscf}} \left| \frac{453.593\text{g}}{1\text{ lb}} \right| \frac{\text{MOL } SO_2}{64\text{g } SO_2} \left| \frac{22.4\text{ l}}{\text{MOL}} \right| \frac{293^\circ\text{K}}{273^\circ\text{K}} \left| \frac{\text{ft}^3}{28.317\text{ l}} \right| 1{,}000{,}000 \right| =$$

51.567 ppm

Run # 3:

$$E = \frac{.0000008500\text{ lbs}}{\text{dscf}} \left| \frac{453.593\text{g}}{1\text{ lb}} \right| \frac{\text{MOL } SO_2}{64\text{g } SO_2} \left| \frac{22.4\text{ l}}{\text{MOL}} \right| \frac{293^\circ\text{K}}{273^\circ\text{K}} \left| \frac{\text{ft}^3}{28.317\text{ l}} \right| 1{,}000{,}000 \right| =$$

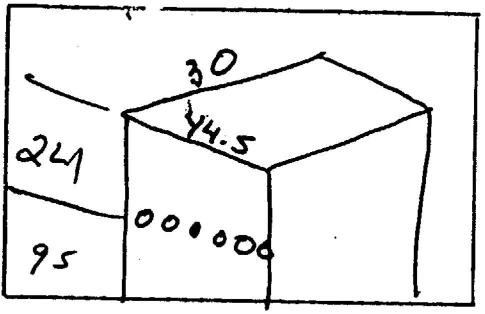
5.115 ppm

VIII. FIELD DATA

RAMCON ENVIRONMENTAL CORPORATION

Plant R.F. Kline

Location Fredrick Md.
Operator Sam Turner
Date 6-9-86
Run No. 1
Sample Box No. 1
Meter Box No. 670775
Meter H @ 1.76
C Factor 1.018
Pitot Tube Coefficient Cp .801



Schematic of Stack Cross Section

Ambient Temperature 67
Barometric Pressure 30.01
Assumed Moisture, % 20
Probe Length, m(ft) 3'
Nozzle Identification No. ,0001969
Avg. Calibrated Nozzle Dia., (in.) ,19/,19/.19
Probe Heater Setting 5
Leak Rate, m3/min.(cfm) ,02 at 9.5" Vac
Probe Liner Material Stainless Steel
Static Pressure, mm Hg(in.Hg) +.12/13.6
Filter No. ST-1455 (.5192) Part.
ST-1454 (.5160) method 8

	IMPINGER VOLUME, ml	SILICA GEL WEIGHT, g
FINAL	457	512
INITIAL	300	507
DIFFERENCE	157	5

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	GAS SAMPLE TEMP. AT DRY GAS METER °F Outlet	FILTER HOLDER TEMP °F	GAS TEMP LVG CONDENSER OR LAST IMPINGER °F
A	1	8:16 / 8:19	3	233	2.0	1.4	693.97 / 696.10	78	74	235	60
	2	8:22	3	245	2.3	1.6	698.20	92	74	255	60
	3	8:25	3	240	2.3	1.6	699.90	98	75	250	50
	4	8:28	2	226	1.6	1.1	702.00	102	76	250	50
B	1	8:29 / 8:32	4	252	2.4	1.7	704.00	102	78	245	50
	2	8.35	4	252	2.3	1.6	706.20	106	78	250	50
	3	8:38	4	256	1.9	1.3	708.20	110	80	250	50
	4	8:41	4	254	2.0	1.4	710.09	112	81	245	50
C	1	8:42 / 8:45	5	251	2.3	1.6	712.30	108	82	245	50
	2	8:48	5	247	2.3	1.6	714.30	114	83	245	50
	3	8:51	5	244	2.0	1.4	716.28	115	84	250	50
	4	8:54	5	239	2.0	1.4	718.20	116	86	250	50
0	1	8:54:30 / 8:57:30	5	225	1.7	1.2	720.20	116	86	250	60

co2 = 3.5 %
o2 = 15.5 %

co2 3.0
o2 = 15.5

co2 = 3.0
o2 = 15.5

Form #REC-05

Form #REC-08 275 270

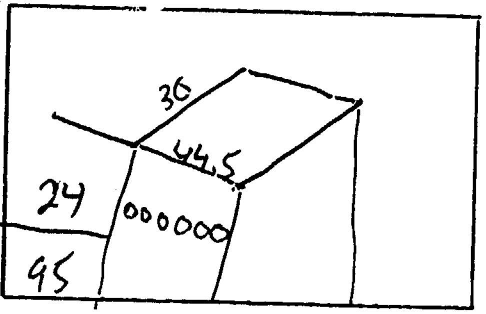
RAMCON emissions test log sheet, cont. DATE 6-9-86 LOCATION Fredrick md TEST NO. 1

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 V_m (ft.^{3})	GAS SAMPLE TEMP. (°F) in	GAS SAMPLE TEMP. (°F) out	SAMPLE BOX TEMP. (°F)	IMPINGER TEMP (°F)
2	9:00:30	6	243	2.0	1.4	722.30	117	86	255	60
3	9:01 9:04	6	253	2.3	1.6	724.30	117	86	255	60
4	9:07	6	255	2.0	1.4	725.95	120	88	250	60
E 1	9:08 9:11	5	230	1.8	1.2	728.00	113	88	245	60
2	9:14	5	245	2.0	1.4	729.90	119	89	245	60
3	9:17	5	247	1.8	1.2	731.40	120	90	245	60
4	9:20	6	246	2.2	1.5	733.64	121	90	250	60
F 1	9:21 9:24	8	243	3.0	2.0	736.00	116	90	250	60
2	9:27	8	244	2.8	1.9	738.50	122	91	250	60
3	9:30	6	241	2.0	1.4	740.50	122	91	250	60
4	9:33	4	240	1.2	.82	741.95	122	91	240	60

RAMCON ENVIRONMENTAL CORPORATION

Plant R. F. Kline

Location Frederick Md.
Operator Allen Turner
Date 6-9-86
Run No. 2
Sample Box No. 2
Meter Box No. 626225
Meter H @ 1.76
C Factor 1.018
Pitot Tube Coefficient Cp .801



Schematic of Stack Cross Section

Ambient Temperature 67
Barometric Pressure 30.01
Assumed Moisture, % 20
Probe Length, m(ft) 3
Nozzle Identification No. 0001969
Avg. Calibrated Nozzle Dia., (in.) .19/.19/.19
Probe Heater Setting 5
Leak Rate, m3/min. (cfm) .015 at 8" Vac
Probe Liner Material stainless steel
Static Pressure, mm Hg (in. Hg) +.12/13.6
Filter No. ST-1456

	IMPINGER VOLUME, ml	SILICA GEL WEIGHT, g
FINAL	470	527
INITIAL	300	521
DIFFERENCE	170	6

743.81

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		FILTER HOLDER TEMP °F	GAS TEMP LVG CONDENSER OR LAST IMPINGER °F
							Inlet	Outlet		
a. 1	10:15 10:18	4	242	3.4	2.4	743.8 744.4	110	90	230	60
2	10:21	4	242	2.8	2.2	746.7	112	90	240	60
3	10:24	4	242	2.6	1.9	749.2	112	90	240	60
4	10:27	4	250	2.0	1.5	751.2	120	90	260	60
B 1	10:28 10:31	3	240	2.4	1.9	753.5	114	90	255	60
2	10:34	3	241	2.0	1.5	755.5	120	90	255	60
3	10:37	3	241	2.2	1.7	757.4	120	90	255	60
4	10:40	2	237	2.0	1.5	759.6	120	90	255	60
C 1	10:41 10:44	2	239	2.0	1.5	761.4	120	90	255	60
2	10:47	3	241	2.2	1.7	763.6	120	90	255	60
3	10:50	4	237	2.8	2.2	766.7	124	92	260	60
4	10:53	4	236	2.4	1.9	768.4	124	92	260	60
D 1	10:54 10:57	4	236	2.4	1.9	770.6	120	92	260	60

CO2 2%
O2 15%

CO2 2.5%
O2 15%

CO2 3%
O2 15

Form #REC-05

Form #REC-06

RAMCON emissions test log sheet, cont. DATE________ LOCATION________ TEST NO.________

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)		SAMPLE BOX TEMP. (°F)	IMPINGER TEMP (°F)
							in	out		
2	11:00	4	239	2.4	1.9	272.8	124	92	260	60
3	11:03	3	240	2.2	1.7	275.0	124	92	260	60
4	11:06	3	228	2.2	1.7	277.2	124	92	260	60
E 1	11:07 11:10	4	240	2.4	1.9	279.6	118	92	260	60
2	11:13	4	240	2.2	1.7	281.5	124	92	260	60
3	11:16	3	237	2.0	1.5	283.5	124	92	260	60
4	11:19	3	235	2.2	1.7	285.8	124	92	260	60
F 1	11:20 11:23	4	239	2.6	1.9	288.0	120	92	260	60
2	11:26	4	235	2.5	1.8	290.2	124	92	260	60
3	11:29	3	238	2.5	1.8	292.4	124	92	260	60
4	11:32	4	241	2.2	1.7	294.616	124	92	260	60

RAMCON ENVIRONMENTAL CORPORATION

Plant RF Klinwe
Location Fredrick md
Operator Sam Turner
Date 6-10-86
Run No. 3
Sample Box No. 3
Meter Box No. 670775
Meter H @ 1.76
C Factor 1.018
Pitot Tube Coefficient Cp .801

Ambient Temperature 60
Barometric Pressure 29.78
Assumed Moisture, % 13
Probe Length, m(ft) 3
Nozzle Identification No. .0001969
Avg. Calibrated Nozzle Dia., (in.) .19/.19/.19
Probe Heater Setting 5
Leak Rate, m^3/min. (cfm) .02 at 10" Vac
Probe Liner Material Stainless Steel
Static Pressure, mm Hg (in. Hg) -.12/13.6
Filter No. ST-1444 .5150 Particulate
ST-1449 .5199 method 5

	IMPINGER VOLUME, ml	SILICA GEL WEIGHT, g
FINAL	486	504
INITIAL	300	500
DIFFERENCE	186	4

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 ft^3	GAS SAMPLE TEMP. AT DRY GAS METER °F Inlet	GAS SAMPLE TEMP. AT DRY GAS METER °F Outlet	FILTER HOLDER TEMP °F	GAS TEMP LVG CONDENSER OR LAST IMPINGER °F
A	1	6:54 6:57	4	210	2.0 3.00	1.6	794.90 797.20	68	58	255	60
	2	7:00	5	210	2.8	2.2	799.60	80	60	260	55
	3	7:03	4	200	2.0	1.6	801.60	86	60	260	55
	4	7:06	2	200	1.2	.95	80320	88	61	230	40
B	1	7:07 7:10	5	216	2.8	2.2	805.40	88	62	235	40
	2	7:13	3	218	1.6	1.3	807.40	94	64	240	40
	3	7:16	3	220	1.8	1.4	809.40	96	66	240	40
	4	7:19	4	231	2.0	1.6	811.25	98	66	235	40
C	1	7:20 7:23	4	235	2.0	1.6	813.50	92	66	245	45
	2	7:26	4	235	2.0	1.6	815.56	100	68	245	45
	3	7:29	4	235	2.0	1.6	817.40	100	68	240	45
	4	7:32	5	240	2.5	2.0	819.65	103	70	240	45
D	1	7:33 7:36	4	243	2.0	1.6	821.70	96	70	245	50

Form #REC-06

RAMCON emissions test log sheet, cont. DATE 6-10-86 LOCATION Frederick md 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)
2	739	4	243	2.2	1.7	823.70	104	72	245	50
3	7:42	4	246	2.0	1.6	825.90	106	72	240	50
4	7:45	6	246	2.0	1.6	827.84	106	74	245	50
E 1	7:45:30 7:48:30	6	249	2.0	1.6	829.90	104	74	245	50
2	7:51:30	6	251	1.8	1.4	831.80	106	76	245	50
3	7:54:30	6	246	1.8	1.4	833.70	108	76	245	50
4	7:57:30	7	241	2.2	1.7	835.80	108	76	240	50
F 1	7:58 8:01	8	226	1.8	1.4	837.80	108	78	245	50
2	8:04	7	232	1.8	1.4	839.80	108	78	240	50
3	8:07	8	232	2.2	1.7	841.80	110	78	240	50
4	8:10	8	227	1.8	1.4	843.67	110	78	245	50

IX. CALIBRATIONS

METER BOX CALIBRATION DATA AND CALCULATION FORM

(English units)

Date 6-12-86 Meter box number 670775

Barometric pressure, P_b = 30.01 in. Hg Calibrated by Sam T. Turner

Vac	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	928.0 933.06	77	98 108	79 81	91.5	13.03	1.014	1.88
5	1.0	5	922.80 927.865	77	78 104	78 80	85	8.88	.999	1.76
	1.5	10								
	2.0	10								
6	3.0	14	896.60 910.717	77	95 114	82 84	93.75	14.75	1.015	1.83
	4.0	10								
								Avg	1.009	1.82

ΔH, in. H_2O	$\frac{\Delta H}{13.6}$	$Y_i = \frac{V_w P_b (t_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6})(t_w + 460)}$	$\Delta H@_i = \frac{0.0317\ \Delta H}{P_b (t_d + 460)} \left[\frac{(t_w + 460)\ \Theta}{V_w}\right]^2$
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.

14:45
8:53

METER BOX CALIBRATION DATA AND CALCULATION FORM

(English units)

Date 6-2-86   Meter box number 670775

Barometric pressure, P_b = 29.77 in. Hg   Calibrated by Sam T. Turner

Orifice manometer setting (ΔH), in. H_2O	Gas volume		Temperature				Time (θ), min	Y_i	$\Delta H@_i$ in. H_2O
	Wet test meter (V_w), ft^3	Dry gas meter (V_d), ft^3	Wet test meter (t_w), °F	Dry gas meter[a]					
				Inlet (t_{d_i}), °F	Outlet (t_{d_o}), °F	Avg[a] (t_d), °F			
0.5	5	462,90 467.914	78	87 110	82 82	9025	12.43	1.019	1.73
1.0	5	457,30 462,31	78	96 110	78 80	91	8.90	1,019	1.77
1.5	10								
2.0	10								
3.0	10.5	446,69 457,110	78	90 108	76 79	88.25	10.82	1,016	1.79
4.0	10								
							Avg	1,018	1.76

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.

8:54

RAMCON ENVIRONMENTAL CORPORATION

Date 5-16-86 Thermocouple number Hot Box

Ambient temperature 23 °C Barometric pressure 30.03 in. Hg

Calibrator Sam [illegible] Reference: mercury-in-glass ✓

other ______

Reference point number[a]	Source[b] (specify)	Reference Thermometer Temperature, °C	Thermocouple Potentiometer Temperature, °C	Temperature Difference,[c] %
A	boiling H_2O	100 °C	100 °C	0 %
B	Ambient	23 °C	22.8°C	<.1 %
	Ambient 6-9-86	67 °F	67 °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.

RAMCON ENVIRONMENTAL CORPORATION

Date 5-16-86 Thermocouple number inlet/outlet

Ambient temperature 23 °C Barometric pressure 30.03 in. Hg

Calibrator Sam T. [illegible] Reference: mercury-in-glass ✓

other ______

Reference point number[a]	Source[b] (specify)	Reference Thermometer Temperature, °C	Thermocouple Potentiometer Temperature, °C	Temperature Difference,[c] %
A	inlet Ambient	73 °F	73 °F	0.0 %
B	outlet Ambient	73 °F	73 °F	0.0 %
C	Ambient 6-9-86	67 °F	67 °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.

(41)

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. 31 Date 5-14-86

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	.78	1.2	.806	-.005
2	.60	.95	.795	.006
3	.90	1.4	.802	-.001
		$\bar{C}_p$ (SIDE A)	.801	

"B" SIDE CALIBRATION

Run No.	Δp std cm H_2O (in. H_2O)	$\Delta p(s)$ cm H_2O in. H_2O)	$C_p(s)$	DEVIATION $C_p(s)-\bar{C}_p(B)$
1	.78	1.2	.806	-.005
2	.60	.95	.795	.006
3	.90	1.4	.802	-.001
		$\bar{C}_p$ (SIDE B)	.801	

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

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

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

Form No. EED-17-1

RAMCON

Lear Siegler Stack Sampler

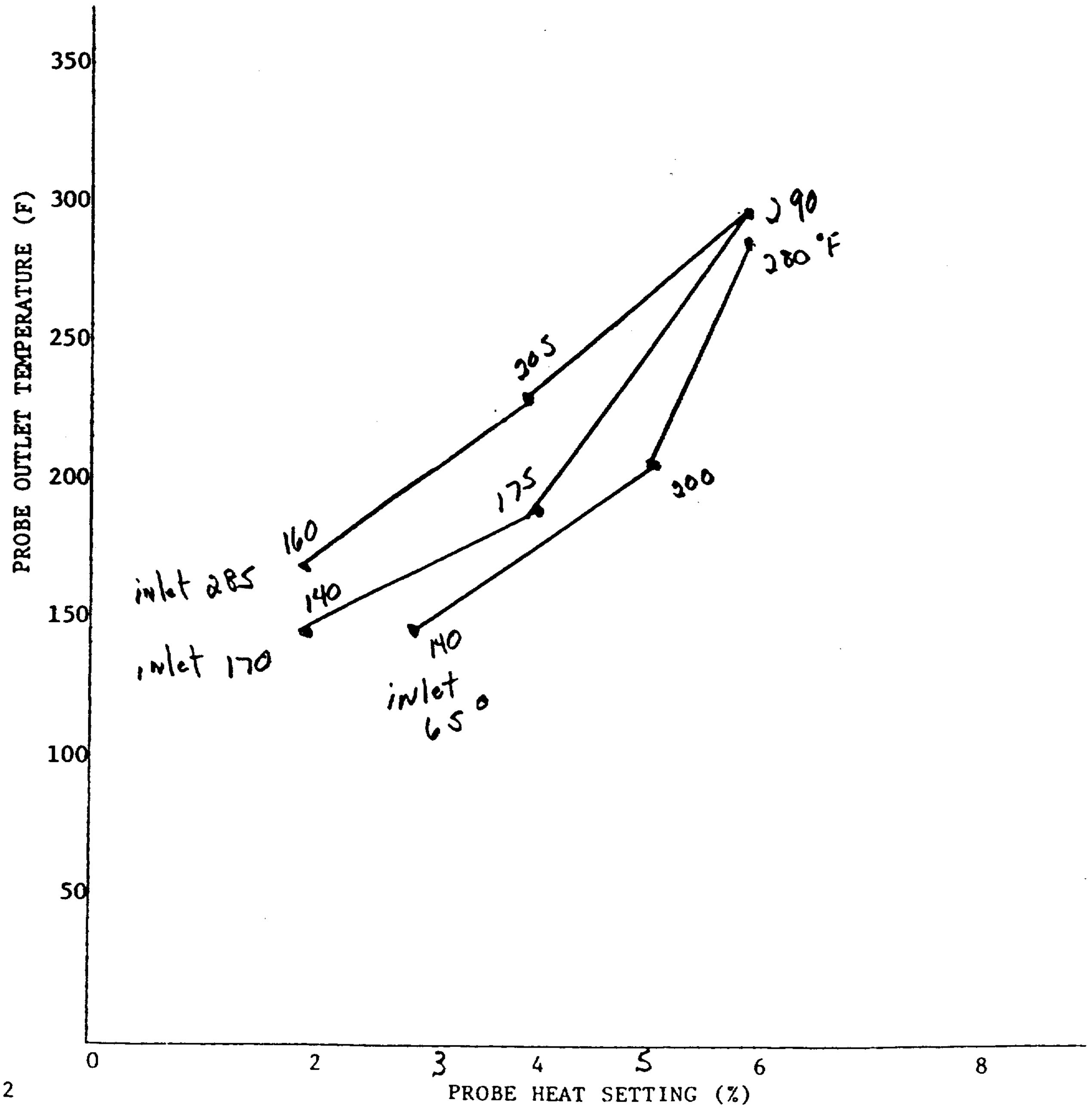
Heating Probe Calibration

Probe No. 31 Probe Length 3'

Date of Calibration 4-2-86 Signature Sam T. 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



RAMCON ENVIRONMENTAL CORPORATION

Date 5-16-86 Thermocouple number 31

Ambient temperature 23 °C Barometric pressure 30.03 in. Hg

Calibrator Sam Turner 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	0,0 %
B	Boiling H_2O	212°F	212°F	0.0 %
C	Boiling oil	410.5°F	412.8°F	< .5 %
D	Ambient 6-9-86-	67°F	67°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.