AP42 Section:	11.20
Reference:	12
Title:	Particulate Emission Source Test Conducted On No. 1 Kiln Wet Scrubber At Tombigbee Lightweight Aggregate Corporation, Livingston, Alabama, Resource Consultants, Brentwood, TN, November 12, 1981.

RECEIVED MA
AP-42 Section 11.20
Reference 12
Report Sect. 4
Reference 12

STATE OF ALABAMA
DEPARTMENT OF ENVIRONMENTAL MANAGE

A-82-39
II-D-128

Mailing Address:
State Capitol
Montgomery, AL 36130
Telephone: 205/277-3630

March 2, 1983

Ms. Amy J. Nelson
Midwest Research Institute
4505 Creedmoore Road
Raleigh, NC 27612

Dear Ms. Nelson:

Enclosed are complete particulate emissions test reports of the No. 1 and No. 2 kilns at Tombigbee Lightweight Aggregate Corporation in Livingston, Alabama.

This data consists of two 50 page test reports. A charge of $25.00 is assessed for duplication. The check should be made payable to Department of Environmental Management-Air Program. It should be sent to the following address: Alabama Department of Environmental Management, State Capitol, Montgomery, Alabama 36130.

If I may be of further assistance, please write or call.

Yours very truly,

Richard E. Grusnick, Director
Air Program

REG/FBT:sp
Enclosures

OK to pay
WHM

...ed are:

- [ ] Blueprints
- [X] Manufacturer's Literature
- [ ] Emission Test of Existing Installation
- [ ] Fan Curves
- [ ] Particle Size Distribution
  - [ ] Physical
  - [ ] Aerodynamic
- [ ] Size-Efficiency Cures
- [ ] Other ______________________

9. Provide a sketch of device, if it is of unusual design.

Attached

#1

10. List below the important operating parameters for the device. (For example: air/cloth ratio and fabric type, weight, and weave for a baghouse; throat velocity and water use rate for a venturi scrubber; etc.)

Water use rate = 8½ gals. per 1000 cfm

Static pressure drop through system = 14 inches w.g.

Compressed air pressure = 9 psi

Compressed air capacity = 1,275 scfm

11. By-pass (if any) is to be used when: Existing multiclones to be used during scrubber upset conditions. Kiln feed rate will be reduced to one-half the normal rate.

PARTICULATE EMISSION SOURCE TEST

CONDUCTED ON

NO. 1 KILN WET SCRUBBER

AT

TOMBIGBEE LIGHTWEIGHT AGGREGATE CORPORATION
Livingston, Alabama

November 12, 1981

RESOURCE
CONSULTANTS
environmental engineers and scientists

November 19, 1981

Mr. Clem Blackburn
Tombigbee Lightweight Aggregate Corp.
P. O. Drawer V
Livingston, AL 44101

Dear Clem:

The enclosed report presents the results of the particulate emission source test conducted November 12, 1981 on the Fuller wet scrubber controlling emissions from the No. 1 rotary kiln. The test results indicate that the average particulate mass rate of the three test runs was 17.3 pounds per hour. The allowable emission rate based on the Alabama Air Pollution Control Rules and Regulations is 40.7 pounds per hour.

We again appreciate this opportunity to be of service to Tombigbee Lightweight Aggregate Corporation. Thank you for the cooperation and assistance provided to us during the course of our work. Should you require additional information or if we may be of further assistance, please let us know.

Sincerely,

RESOURCE CONSULTANTS, INC.

J. R. Reehl
Pollution Control Specialist

Billy R. Nichols, P.E.
Director, Air Services Section

JRR:BRN/jd
enclosure

P.O. Box 498 • Two Maryland Farms • Suite 340 • Brentwood, Tennessee 37027 • 615-373-5040
a tennessee corporation

PARTICULATE EMISSION SOURCE TEST
CONDUCTED ON
NO. 1 KILN WET SCRUBBER

AT

TOMBIGBEE LIGHTWEIGHT AGGREGATE CORPORATION
Livingston, Alabama

On

November 12, 1981

By

ALABAMA
Registered
12818
PROFESSIONAL
Engineer
BILLY R. NICHOLS

RESOURCE CONSULTANTS, INC.
Two Maryland Farms, Suite 340
Brentwood, Tennessee 37027

RESOURCE
CONSULTANTS INC

TABLE OF CONTENTS

INTRODUCTION

This report presents the results of the particulate emission source test conducted November 12, 1981, on the wet scrubber system controlling emissions from the No. 1 rotary kiln at Tombigbee Lightweight Aggregate Corporation in Livingston, Alabama. Three isokinetic test runs were conducted to determine the amount of particulate matter being emitted into the atmosphere from the cyclonic separator stack. Test results are to be used to determine compliance with the Rules and Regulations of the Alabama Air Pollution Control Commission.

Exhaust gases from the processing of raw clay in the rotary kiln were drafted through a primary multiclone collector and a Fuller compressed air atomizing scrubber system. Testing was conducted in the cyclonic separator stack, which included a rectangular grid of flow straightening vanes. Two sampling ports were located at a right angle from each other in the 56-inch diameter stack. The ports were situated at a point 2.0 stack diameters downstream from the separator outlet and 0.5 stack diameters upstream from the stack outlet. During each test run, sampling was conducted over two traverses of the stack with each traverse having 24 sampling points. Sampling time at each point was two minutes for a total sampling time of 96 minutes per test run.

Mr. James Colburn of Tombigbee Lightweight Aggregate Corporation arranged testing facilities, programmed desired process operations and documented production records. For the Alabama Air Pollution Control Commission, Mr. Freddie Thomas observed the process operations and Mr. Timothy Owen observed source testing procedures. For Resource Consultants, Inc., Messrs. Larry Garner, John Marino and Roger Reehl conducted the source test; Mr. Billy Nichols supervised the testing program.

RESULTS

The results of the series of three test runs conducted November 12, 1981, on the No. 1 kiln wet scrubber are presented in the following table:

	Run 1	Run 2	Run 3	Average
Sampling Period (CST)	0845-1033	1128-1322	1430-1617	--
Gas Stream Temperature (°F)	138	138	138	138
Moisture Content (% by Volume)	17.3	17.7	17.6	17.5
Gas Stream Velocity (ft/sec)	56.6	56.0	56.9	56.5
Volumetric Flow Rate (acfm)	58,000	57,400	58,400	57,900
Volumetric Flow Rate (dscfm)	42,400	41,700	42,500	42,200
Particulate Concentration (gr/dscf)	0.0440	0.0508	0.0487	0.0478
Particulate Mass Rate (lb/hr)	16.00	18.16	17.75	17.3
Process Weight Rate (tons/hr)	--	--	--	32.8 (31.0 tph clay / 1.8 tph coal)
Allowable Emission Rate (lb/hr)	--	--	--	40.7
Isokinetic Rate (%)	96.7	97.5	98.6	--

The amount of particulate matter collected during each test run may be gravimetrically differentiated with respect to the point of collection within the sampling train as follows:

Run No.	Particulate Collected in Probe and Front Half of Filter Holder (mg / % of total)	Particulate Collected on Filter (mg / % of total)	Total Particulate Collected (mg)
1	35.6 / 16%	188.2 / 84%	223.8
2	61.2 / 24%	195.1 / 76%	256.3
3	62.1 / 25%	191.1 / 75%	253.2

Because of the potential for the existence of cyclonic flow in the cyclonic separator stack, the pitot tube rotational angles were determined at each point by the null technique of Method 1 to verify the extent of cyclonic flow. As a result of the installation of a rectangular grid of flow straightening vanes, the rotational angles at all points were measured to be less than 10 degrees from parallel flow relative to the stack wall, indicating suitable conditions for conducting a source test. However, the short downstream length of stack from the vane outlet to the sampling ports may not have allowed the flow profile to stabilize resulting in a less than ideal sampling site.

Because of the high moisture content of the gas stream, the pitot lines were routinely purged to eliminate plugging from condensed moisture.

During the testing program, the No. 1 kiln was operating at an average process weight rate of 32.8 tons per hour. As directed in Section 4.4.2 of the Alabama Air Pollution Control Commission Rules and Regulations, particulate matter shall not be emitted from this source in excess of 40.7 pounds per hour based on the indicated process weight rate as calculated by the equation:

$$E = (55.0)P^{0.11} - 40, \qquad P \geq 30 \text{ tons/hour}$$

where E = emissions in pounds per hour
P = process weight rate in tons per hour.

The test results indicate that the average particulate emission rate during the source test was 17.3 pounds per hour.

SAMPLING AND ANALYTICAL PROCEDURES

All testing was performed using procedures described in the Federal Register, Volume 42, Number 160, dated August 18, 1977, as ammended in Volume 43, Number 57, dated March 23, 1978, and as approved by the Alabama Air Pollution Control Commission.

Sampling sites were selected using Method 1; stack gas velocity and volumetric flow rates were determined by using Method 2. Determination of the gaseous components of the stack effluent was performed using the Fyrite sampling technique described in Method 3. The determinations of particulate emissions and associated moisture content of the stack effluent were accomplished using Method 5.

Gas flow rates were calculated using the gas temperature, density, pressure, velocity, and the cross-sectional area of the stack. The gas velocity was calculated from velocity head measurements made with a Type S pitot tube and an inclined manometer using standard traverse procedures.

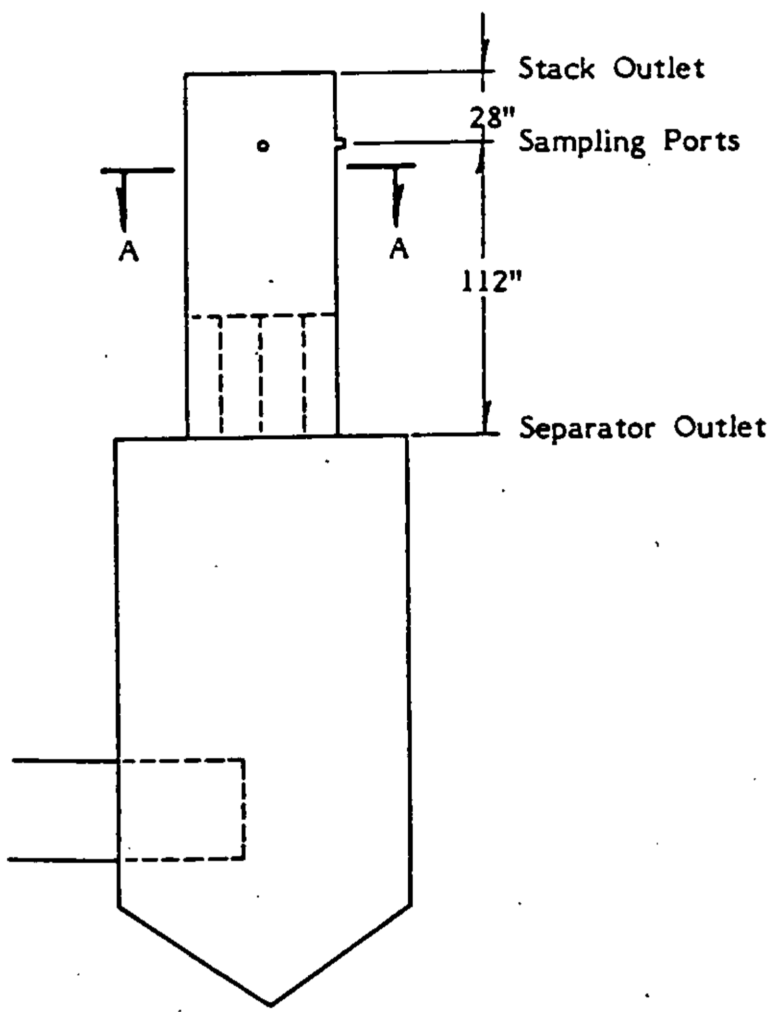
Continuous gas samples were taken under isokinetic conditions during each test. The samples were passed through a heated probe and filter, and four Greenburg-Smith impingers (all, except No. 2, modified by removal of the impinger shield) charged in the following manner:

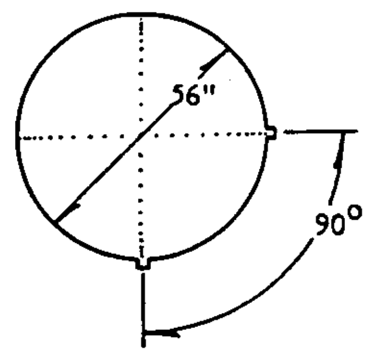
Impinger No. 1 - 100 ml deionized water
Impinger No. 2 - 100 ml deionized water
Impinger No. 3 - Dry
Impinger No. 4 - 250 grams silica gel

At the end of each test, the volume of the impinger solutions was measured to determine the amount of condensate collected. The amount of vapor in the gas sample was calculated using the condensate measurement and data on the gases that passed through the meter.

The amount of particulate matter collected by the probe and front half of the filter holder was determined by placing washings from these components into crucibles tared to a constant weight and evaporating to dryness. The filter and crucibles from each test run were then desiccated for a minimum of 24 hours, weighed to a constant weight, and the results reported to the nearest 0.1 milligram.

Number of Inches from Stack Wall			
Point	Inches	Point	Inches
1	1.0	13	33.7
2	1.8	14	37.9
3	3.1	15	40.8
4	4.4	16	43.1
5	5.9	17	45.1
6	7.4	18	47.0
7	9.0	19	48.6
8	10.9	20	50.1
9	12.9	21	51.6
10	15.2	22	52.9
11	18.1	23	54.2
12	22.3	24	55.0





Section A-A

Location of Sampling Ports and Traverse Points

No. 1 Kiln Wet Scrubber System

Tombigbee Lightweight Aggregate Corporation
Livingston, Alabama

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NOMENCLATURE

A_s = Cross-sectional area of stack or duct, ft^2
A_n = Cross-sectional area of the nozzle, ft^2
B_{ws} = Water vapor in the gas stream, proportion by volume
$B_{ws(sat)}$ = Water vapor in the gas stream at saturation, proportion by volume
C_p = Pitot tube assembly coefficient, dimensionless
c_s = Particulate concentration, dry basis, standard conditions, gr/dscf
c_{si} = Particulate concentration including non-filterable condensable fraction, gr/dscf
I = Percent of isokinetic sampling, %
K_p = Pitot tube constant, 85.49 ft/sec $\left[(lb/lb\text{-}mole)(in.\ Hg)/(^oR)(in.\ H_2O)\right]^{1/2}$
L_a = Maximum acceptable leakage rate for either a post-test leak check or for a leak check following a component change; equal to 0.02 cfm or 4 percent of the average sampling rate, whichever is less.
L_i = Individual leakage rate observed during the leak check conducted prior to the "i^{th}" component change (i=1, 2, 3...n), cfm
L_p = Leakage rate observed during the post-test leak check, cfm
M_{CO_2} = Molecular weight of CO_2, 44.01 lb/lb-mole
M_d = Molecular weight of gas stream, dry basis, lb/lb-mole
m_n = Total weight of particulate collected, mg
m_{ni} = Particulate collected including non-filterable condensable fraction, mg
$M_{N_2\ or\ CO}$ = Molecular weight of N_2 or CO, 28.01 lb/lb-mole
M_{O_2} = Molecular weight of O_2, 32.00 lb/lb-mole
M_s = Molecular weight of gas stream, wet basis, lb/lb-mole
M_w = Molecular weight of water, 18.02 lb/lb-mole
P_{bar} = Barometric pressure at the sampling site, in. Hg
P_g = Static pressure of gas stream, in. H_2O
P_s = Absolute pressure of gas stream, in. Hg
P_{std} = Standard absolute pressure, 29.92 in. Hg
PMR = Particulate mass rate, lb/hr
PMR_i = Particulate mass rate, including non-filterable condensable fraction, lb/hr
Q_s = Actual volumetric flow rate of gas stream, acfm
$Q_{s(std)}$ = Dry volumetric flow rate of gas stream, standard conditions, dscfm
R = Ideal gas constant, 21.85 in. Hg-ft^3/^{o}R-lb-mole
t_m = Average dry gas meter temperature, ^{o}F
T_m = Absolute average dry gas meter temperature, ^{o}R
t_s = Average gas stream temperature, ^{o}F

T_s	= Absolute average gas stream temperature, ^oR
T_{std}	= Standard absolute temperature, 527.7^oR
V_{lc}	= Total volume of liquid collected in impingers and silica gel, ml
V_m	= Volume of gas sample as measured by the dry gas meter, dcf
$V_{m(std)}$	= Volume of gas sample, corrected to standard conditions, dscf
v_s	= Average gas stream velocity, ft/sec
Y	= Dry gas meter calibration factor, dimensionless
ΔH	= Average pressure differential across the orifice meter, in. H_2O
Δp	= Velocity head of gas stream, in. H_2O
$\sqrt{\Delta p}$	= Average of square roots of gas stream velocity heads, $\sqrt{\text{in. } H_2O}$
%CO	= Percent CO in gas stream by volume, dry basis, %
%CO_2	= Percent CO_2 in gas stream by volume, dry basis, %
%N_2	= Percent N_2 in gas stream by volume, dry basis, %
%O_2	= Percent O_2 in gas stream by volume, dry basis, %
ρw	= Density of water, lb/ml
θ	= Total sampling time, min
θ_I	= Sampling time interval, from beginning of run until the first component change, min
θ_i	= Sampling time interval, between two successive component changes, beginning with the interval between the first and second changes, min
θ_p	= Sampling time interval, from the final (n^{th}) component change until the end of the sampling run, min

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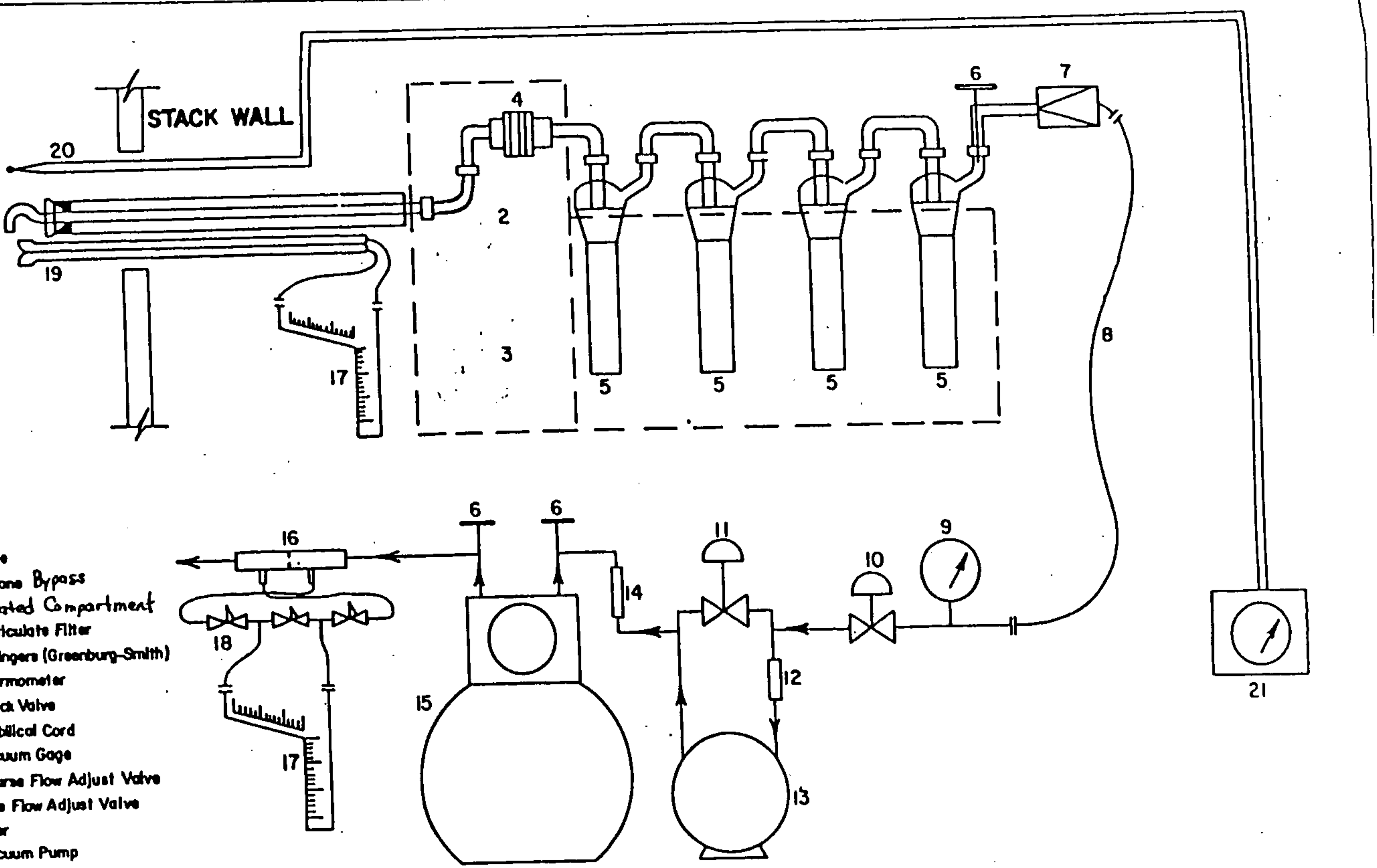

1) Probe
2) Cyclone Bypass
3) Heated Compartment
4) Particulate Filter
5) Impingers (Greenburg-Smith)
6) Thermometer
7) Check Valve
8) Umbilical Cord
9) Vacuum Gage
10) Course Flow Adjust Valve
11) Fine Flow Adjust Valve
12) Oiler
13) Vacuum Pump
14) Filter
15) Dry Gas Meter
16) Orifice Tube
17) Incline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

SAMPLING TRAIN
USED FOR ISOKINETIC SAMPLING

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APPENDIX A

CALCULATIONS, LABORATORY AND FIELD DATA

SUMMARY OF PARTICULATE EMISSIONS SOURCE TEST DATA

Company Tombigbee Lightweight Aggregate Test Date 11/12/81

Source No. 1 Kiln Wet Scrubber Run No. 1

Determination of Dry Standard Gas Sample Volume		
Average pressure differential across the orifice meter, in. H_2O	ΔH	2.49
Barometric pressure at the sampling site, in. Hg	P_{bar}	29.97
Absolute average dry gas meter temperature, ^oR	T_m	543.0
Dry gas meter calibration factor, dimensionless	Y	1.01
Volume of gas sample as measured by the dry gas meter, dcf	V_m	79.343
Volume of gas sample, corrected to standard conditions, dscf	$V_{m(std)}$	78.49
Determination of Moisture Content of Gas Stream		
Total volume of liquid collected in impingers and silica gel, ml	V_{lc}	349.5
Volume of water vapor in gas sample, standard conditions, scf	$V_{w(std)}$	16.45
Water vapor in the gas stream, proportion by volume	B_{ws}	0.173
Water vapor in the gas stream at saturation, proportion by volume	$B_{ws(sat)}$	0.184
Determination of Gas Stream Molecular Weights		
Percent CO_2 in gas stream by volume, dry basis	$\%CO_2$	4.5
Percent O_2 in gas stream by volume, dry basis	$\%O_2$	(15.5)
Molecular weight of gas stream, wet basis, lb/lb-mole	M_s	27.4
Determination of Gas Stream Velocity and Volumetric Flow Rates		
Average of square roots of gas stream velocity heads, $\sqrt{\text{in. } H_2O}$	$\sqrt{\Delta p}$	0.923
Static pressure of gas stream, in. H_2O	P_g	-0.55
Absolute average gas stream temperature, ^oR	T_s	597.2
Pitot tube assembly coefficient, dimensionless	C_p	0.84
Cross-sectional area of stack or duct, ft^2	A_s	17.10
Absolute pressure of gas stream, in. Hg	P_s	29.93
Average gas stream velocity, ft/sec.	v_s	56.6
Actual volumetric flow rate of gas stream, acfm	Q_s	58,000
Dry volumetric flow rate of gas stream, standard conditions, dscfm	$Q_{s(std)}$	42,400
Determination of Particulate Emission Data		
Total weight of particulate matter collected, mg	m_n	223.8
Total sampling time, min.	θ	96
Cross-sectional area of the nozzle, ft^2	A_n	0.000341
Particulate concentration, dry basis, standard conditions, gr/dscf	c_s	0.0440
Particulate mass rate, lb/hr	PMR	16.00
Percent of isokinetic sampling, %	I	96.7

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Run No. 1 Source No. 1 Kiln Wet Scrubber Test Date 11/12/81

DETERMINATION OF DRY STANDARD GAS SAMPLE VOLUME
(Method 5)

ΔH = 2.49 in. H_2O, average pressure differential across the orifice meter

P_{bar} = 29.97 in. Hg, barometric pressure at the sampling site

P_{std} = 29.92 in. Hg, standard absolute pressure

T_m = 543.0 ^oR, absolute average dry gas meter temperature

T_{std} = 527.7 ^oR, standard absolute temperature

Y = 1.01 dimensionless, dry gas meter calibration factor

V_m = 79.343 dcf, volume of gas sample as measured by the dry gas meter

$$V_{m(std)} = V_m \, Y \left(\frac{T_{std}}{T_m}\right)\left(\frac{P_{bar} + (\Delta H/13.6)}{P_{std}}\right)$$

$V_{m(std)}$ = 78.49 dscf, volume of gas sample, corrected to standard conditions

DETERMINATION OF MOISTURE CONTENT OF GAS STREAM
(Method 5)

R = 21.85 in. Hg-ft^3/^{o}R-lb-mole, ideal gas constant

ρ_w = 0.002201 lb/ml, density of water

M_w = 18.02 lb/lb-mole, molecular weight of water

V_{lc} = 349.5 ml, total volume of liquid collected in impingers and silica gel

$$V_{w(std)} = V_{lc}\left(\frac{\rho_w}{M_w}\right)\left(\frac{R \, T_{std}}{P_{std}}\right)$$

$V_{w(std)}$ = 16.45 scf, volume of water vapor in gas sample, standard conditions

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

B_{ws} = 0.173 proportion by volume, water vapor in the gas stream

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Run No. 1 Source No. 1 Kiln Wet Scrubber Test Date 11/12/81

DETERMINATION OF THEORETICAL MOISTURE CONTENT AT SATURATED CONDITIONS (Method 5)

In addition to the calculation of the moisture content of the gas stream from the impinger analysis, a second calculation from the assumption of saturated conditions is made whenever there is the probability that the gas stream is saturated or laden with water droplets.

A = 6.691, water vapor constant for Antoine's vapor pressure equation

B = 3144, water vapor constant for Antoine's vapor pressure equation

C = 68.84, water vapor constant for Antoine's vapor pressure equation

T_s = 597.2 ^oR, absolute average gas stream temperature

P_g = -0.55 in. H_2O, static pressure of gas stream

$$B_{ws(sat)} = \frac{\text{antilog}_{10}\left[A - (B/(T_s - C))\right]}{P_{bar} + (P_g/13.6)}$$

$B_{ws(sat)}$ = 0.184 proportion by volume, water vapor in gas stream at saturation

$B_{ws(sat)}$ shall be considered correct if this value is less than the value calculated from the impinger analysis; accordingly, $B_{ws(sat)}$ and the following values calculated for $V_{w(std)}$ and V_{lc}, based upon $B_{ws(sat)}$, shall be used in all subsequent calculations.

$$V_{w(std)} = \frac{B_{ws(sat)} V_{m(std)}}{1 - B_{ws(sat)}}$$

$V_{w(std)}$ = N/A scf, volume of water vapor in gas sample, standard conditions, not exceeding saturated gas stream conditions.

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

V_{lc} = N/A ml, Volume of liquid collected in impingers and silica gel, not exceeding saturated gas stream conditions.

Run No. 1 Source No. 1 Kiln Wet Scrubber Test Date 11/12/81

DETERMINATION OF GAS STREAM MOLECULAR WEIGHTS
(Method 3)

M_{CO_2} = 44.01 lb/lb-mole, molecular weight of CO_2

M_{O_2} = 32.00 lb/lb-mole, molecular weight of O_2

$M_{N_2 \text{ or } CO}$ = 28.01 lb/lb-mole, molecular weight of N_2 or CO

% CO_2 = 4.5 %, percent CO_2 in gas stream by volume, dry basis

$\%O_2$ = 15.5 %, percent O_2 in gas stream by volume, dry basis

$\%N_2 + \%CO_2$ = 80.0 %, percent N_2 and CO in gas stream by volume, dry basis

$$M_d = 44.01 \frac{\%CO_2}{100} + 32.00 \frac{\%O_2}{100} + 28.01 \frac{\%N_2 + \%CO}{100}$$

M_d = 29.3 lb/lb-mole, molecular weight of gas stream, dry basis

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

M_s = 27.4 lb/lb-mole, molecular weight of gas stream, wet basis

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Run No. 1 Source No. 1 Kiln Wet Scrubber Test Date 11/12/81

DETERMINATION OF GAS STREAM VELOCITY AND VOLUMETRIC FLOW RATES
(Method 2)

P_g = -0.55 in. H_2O, static pressure of gas stream

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

C_p = 0.84 dimensionless, pitot tube assembly coefficient

$\sqrt{\Delta p}$ = 0.923 $\sqrt{\text{in. } H_2O}$, average of square roots of gas stream velocity heads

T_s = 597.2 $^{\circ}$R, absolute average gas stream temperature

A_s = 17.10 ft^2, cross-sectional area of stack or duct

$$P_s = \frac{P_g}{13.6} + P_{bar}$$

P_s = 29.93 in. Hg, absolute gas stream pressure

$$v_s = K_p C_p \sqrt{\Delta p} \sqrt{\frac{T_s}{P_s M_s}}$$

v_s = 56.6 ft/sec, average gas stream velocity

$$Q_s = (60 \text{ sec/min})\ A_s v_s$$

Q_s = 58,000 acfm, actual volumetric flow rate of gas stream

$$Q_{s(std)} = (60 \text{ sec/min})\ (1-B_{ws})\ A_s v_s \left(\frac{T_{std}}{T_s}\right)\left(\frac{P_s}{P_{std}}\right)$$

$Q_{s(std)}$ = 42,400 dscfm, dry volumetric flow rate of gas stream, standard conditions

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Run No. 1 Source No. 1 Kiln Wet Scrubber Test Date 11/12/81

Determination of Particulate Emission Data (Method 5)

m_n = 223.8 mg, total weight of particulate matter collected

θ = 96 min, total sampling time

A_n = 0.000341 ft^2, cross-sectional area of the nozzle

K_1 = 0.002669 in. Hg-ft^3/ml-^oR

c_s = $(0.01543 \text{ gr/mg})\left(m_n/V_{m(std)}\right)$

c_s = 0.0440 gr/dscf, particulate concentration, dry basis, standard conditions

PMR = $(60 \text{ min/hr})(0.0001428 \text{ lb/gr})\ c_s\ Q_{s(std)}$

PMR = 16.00 lb/hr, particulate mass rate

$$I = 100\ \frac{T_s\left[K_1\ V_{lc} + (V_m\ Y/T_m)(P_{bar} + \Delta H/13.6)\right]}{(60 \text{ sec/min})\ \theta\ v_s\ P_s\ A_n}$$

I = 96.7 %, percent of isokinetic sampling

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LABORATORY ANALYSIS

Client Tombigbee Lightweight Aggregate Source #2 Kiln Wet Scrubber

Date 11/11/81 Run No. 1 Sample Box No. 1

MOISTURE CONDENSATE

Impinger No.	1. Deionized H_2O	2. Deionized H_2O	3. Dry	4. Silica Gel
Gross Volume, ml or g	300	141	5	267.8
Tare Volume, ml or g	100	100	0	250.0
Net Volume, ml or g	200	41	5	17.8

Total Moisture Condensate Collected:	263.8 ml

PARTICULATE COLLECTED

Component	Glass-Fiber Filter	Acetone Rinse	Acetone Blank	Impinger Condensate	Impinger Blank
I.D. No.	2221	308	189		
Volume, ml		375	250		
Gross Weight, g	0.9167	110.7019	91.1923		
Gross Weight, g	0.9166	110.7018	91.1923		
Average Gross, g	0.9166	110.7018	91.1923		
Tare Weight, g	0.6910	110.6245	91.1914		
Residue, g		0.0014			
Net Weight, g	0.2256	0.0759	0.0009		

Residue in Acetone Rinse: $\frac{(0.0009 \text{ g blank})(375 \text{ ml rinse})}{(250 \text{ ml blank})}$ = 0.0014 g

Allowable Rinse Residue:(0.00001 of acetone weight)(0.7857 g/ml)(375 ml rinse)= 0.0029 g

Residue in Impinger Condensate: $\frac{(\quad \text{ g blank})(\quad \text{ ml condensate})}{(\quad \text{ ml blank})}$ = ______ g

Particulate Collected (excluding impinger catch):	0.3015 g
Particulate Collected (including impinger catch):	g

The particulate collected in each component was weighed to a constant weight, meaning a difference of no more than 0.5 mg or 1 percent of total weight less tare weight, whichever is greater, between two consecutive weighings, with no less than 6 hours of dessication time between weighings.

Comments:

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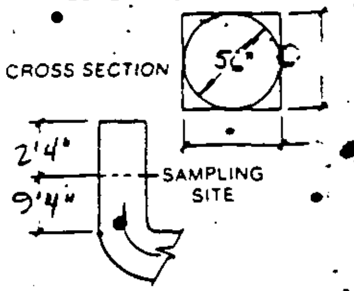
Laboratory Analyst J Roger Roell

FIELD DATA LOG

PLANT Tombigbee Lightweight Aggregate SOURCE #1 Kiln Wet Scrubber

SCHEMATIC OF STACK



PORT LOCATION

NOMOGRAPH VALUES	
ΔH@	C FACTOR
Tm	AVG ΔP
%H_2O	T_s
REFERENCE	

FINAL VOLUME	743.452
INITIAL VOLUME	664.109
NET VOLUME	79.343

RUN NO 1
DATE 11/12/81
OPERATORS REEHL & GARNER
METER BOX NO 1
SAMPLE BOX NO. 5
FILTER NO. 2225
IMPINGER GAUGE NO 2
STACK GAUGE NO. 5-1
PITOT COEFFICIENT 0.84 (5-1)
*PROBE HEATER SETTING 95%

BAROMETRIC PRESSURE 29.97
STATIC PRESSURE -0.55
AMBIENT TEMPERATURE 46°F
PROBE LENGTH 66"
PROBE LINER SS
PORT LENGTH 3"
PORT DIAMETER 3"
METER SYSTEM LEAK-CHECK 0.0
ORSAT LEAK-CHECK N/A
SAMPLE BAG LEAK-CHECK N/A

TRAVERSE POINT NUMBER	SAMPLING TIME CLOCK	SAMPLING TIME SAMPLE	STACK TEMP. (T_s) °F	VELOCITY HEAD (ΔPs)	VELOCITY HEAD ($\sqrt{\Delta Ps}$)	ORIFICE METER (ΔH) in., H_2O ACTUAL	ORIFICE METER DESIRED	GAS SAMPLE VOLUME (Vm), ft^3	GAS SAMPLE TEMP. AT DRY GAS METER INLET (Tm_{in}) °F	OUTLET (Tm_{out}) °F	SAMPLE BOX TEMP. °F	TEMP. OF GAS LEAVING LAST IMPINGER °F	PUMP VACUUM GAUGE in., Hg
	0845	0						664.109					
A-1		2	137	0.64		1.80		665.50	60	59	260	46	5
2		4	137	0.66		1.85		666.92	64	60	260	44	5
3		6	137	0.66		1.85		668.33	67	60	260	44	5
4		8	137	0.69		1.95		670.[illegible]	71	60	255	44	5
5		10	137	0.71		2.00		671.70	74	61	260	44	5
6		12	138	0.74		2.10		672.67	77	62	260	46	6
7		14	138	0.76		2.15		674.17	79	63	265	48	6
8		16	138	0.80		2.25		675.88	81	64	265	49	6
9		18	138	0.84		2.35		677.30	82	65	270	50	6
10		20	138	0.89		2.50		678.96	85	65	275	51	6
11		22	138	0.95		2.70		680.62	86	66	275	52	7
12		24	138	0.98		2.80		682.38	88	67	275	52	7
13		26	138	0.96		2.75		684.10	89	69	275	53	7
14		28	137	0.97		2.80		685.80	90	69	275	54	7
15		30	137	1.00		2.90		687.56	91	70	275	54	7
16		32	138	1.10		3.15		689.30	93	71	270	54	8
17		34	138	1.15		3.30		691.24	95	72	270	54	9
18		36	138	1.20		3.45		693.17	97	72	270	54	9
19		38	138	1.20		3.45		695.10	98	73	270	54	9
20		40	138	1.15		3.35		697.02	99	74	270	54	9
21		42	138	1.10		3.25		698.95	101	75	270	54	9
22		44	138	1.05		3.05		700.82	102	75	265	54	9
23		46	138	1.00		2.90		702.62	103	76	265	55	8
24	0933	48	137	0.98		2.85		704.440	103	77	260	55	8
TOTAL													
AVERAGE													

STATIC PITOT LEAK-CHECK @ 15 sec.	0.0
IMPACT PITOT LEAK-CHECK @ 15 sec.	0.0
TRAIN LEAK RATE @ 60 sec.	0.003 cf @ 8 in

STACK GAS ANALYSIS

ORSAT ☐ FYRITE ☒

TIME	CO_2	O_2	CO	N_2
	4.5	15.5		
	4.5	15.5		

NOZZLE CALIBRATION-I.D. NO. 05

PRETEST		POST-TEST	
DIA. 1	0.250	DIA. 1	
DIA. 2	0.251	DIA. 2	
DIA. 3	0.250	DIA. 3	
AVERAGE	0.250	AVERAGE	

SIGNATURE [signature]
TEST TEAM CHIEF

RESOURCE CONSULTANTS INC.

FIELD DATA LOG

PLANT Tombigbee Lightweight Aggregate SOURCE #1 Kiln Wet Scrubber RUN NO 1

TRAVERSE POINT NUMBER	SAMPLING TIME CLOCK	SAMPLING TIME SAMPLE	STACK TEMP (Ts) °F	VELOCITY HEAD (ΔPs)	VELOCITY HEAD (√ΔPs)	ORIFICE METER (ΔH) in. H_2O ACTUAL	ORIFICE METER DESIRED	GAS SAMPLE VOLUME (Vm) ft^3	GAS SAMPLE TEMP AT DRY GAS METER INLET (Tm_{in}) °F	OUTLET (Tm_{out}) °F	SAMPLE BOX TEMP °F	TEMP OF GAS LEAVING LAST IMPINGER °F	PUMP VACUUM GAUGE in. Hg
	0945	48											
B-1		50	137	0.90		2.60		706.13	82	75	270	49	7
2		52	138	0.90		2.55		707.82	85	75	275	46	7
3		54	138	0.90		2.60		709.53	90	75	275	46	7
4		56	138	0.93		2.70		711.22	93	75	270	46	7
5		58	138	0.99		2.85		713.00	96	76	270	47	8
6		60	137	0.99		2.90		714.80	98	77	270	48	8
7		62	137	1.10		3.20		716.62	99	77	270	49	9
8		64	137	1.10		3.20		718.52	102	78	265	49	9
9		66	137	1.05		3.10		720.50	104	79	265	50	8
10		68	137	0.90		2.65		722.22	105	79	265	51	8
11		70	138	0.88		2.60		723.93	105	80	265	52	8
12		72	138	0.88		2.60		725.65	106	81	265	52	8
13		74	138	0.78		2.30		727.30	105	81	265	52	7
14		76	137	0.74		2.20		729.00	104	82	260	52	7
15		78	137	0.69		2.05		730.53	103	83	265	53	7
16		80	137	0.70		2.05		732.05	102	83	270	54	7
17		82	137	0.68		2.00		733.55	101	83	270	55	7
18		84	137	0.66		1.95		735.05	100	83	270	56	7
19		86	137	0.66		1.95		736.54	100	83	270	56	7
20		88	137	0.66		1.95		738.05	101	83	265	56	7
21		90	138	0.57		1.65		739.46	100	83	265	56	6
22		92	138	0.55		1.60		740.83	99	83	260	56	6
23		94	137	0.51		1.50		742.12	99	83	260	56	6
24	1033	96	137	0.50		1.50		743.452	99	84	260	57	6
TOTAL		96	6601		44.306	119.75		79.343	4453	3546			MAX
AVERAGE		—	137		0.923	2.49		—	92.8	73.9			9

83.3

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SUMMARY OF PARTICULATE EMISSIONS SOURCE TEST DATA

Company Tombigbee Lightweight Aggregate   Test Date 11/12/81

Source No. 1 Kiln Wet Scrubber   Run No. 2

Determination of Dry Standard Gas Sample Volume

Average pressure differential across the orifice meter, in. H_2O	ΔH	2.48
Barometric pressure at the sampling site, in. Hg	P_{bar}	29.97
Absolute average dry gas meter temperature, ^oR	T_m	555.9
Dry gas meter calibration factor, dimensionless	Y	1.01
Volume of gas sample as measured by the dry gas meter, dcf	V_m	80.611
Volume of gas sample, corrected to standard conditions, dscf	$V_{m(std)}$	77.89

Determination of Moisture Content of Gas Stream

Total volume of liquid collected in impingers and silica gel, ml	V_{lc}	355.7
Volume of water vapor in gas sample, standard conditions, scf	$V_{w(std)}$	16.74
Water vapor in the gas stream, proportion by volume	B_{ws}	0.177
Water vapor in the gas stream at saturation, proportion by volume	$B_{ws(sat)}$	0.187

Determination of Gas Stream Molecular Weights

Percent CO_2 in gas stream by volume, dry basis	$\%CO_2$	4.5
Percent O_2 in gas stream by volume, dry basis	$\%O_2$	15.5
Molecular weight of gas stream, wet basis, lb/lb-mole	M_s	27.3

Determination of Gas Stream Velocity and Volumetric Flow Rates

Average of square roots of gas stream velocity heads, $\sqrt{\text{in. } H_2O}$	$\sqrt{\Delta p}$	0.912
Static pressure of gas stream, in. H_2O	P_g	-0.55
Absolute average gas stream temperature, ^oR	T_s	597.8
Pitot tube assembly coefficient, dimensionless	C_p	0.84
Cross-sectional area of stack or duct, ft^2	A_s	17.10
Absolute pressure of gas stream, in. Hg	P_s	29.93
Average gas stream velocity, ft/sec.	v_s	56.0
Actual volumetric flow rate of gas stream, acfm	Q_s	57,400
Dry volumetric flow rate of gas stream, standard conditions, dscfm	$Q_{s(std)}$	41,700

Determination of Particulate Emission Data

Total weight of particulate matter collected, mg	m_n	256.3
Total sampling time, min.	θ	96
Cross-sectional area of the nozzle, ft^2	A_n	0.000341
Particulate concentration, dry basis, standard conditions, gr/dscf	c_s	0.0508
Particulate mass rate, lb/hr	PMR	18.16
Percent of isokinetic sampling, %	I	97.5

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Run No. 2 Source No. 1 Kiln Wet Scrubber Test Date 11/12/81

DETERMINATION OF DRY STANDARD GAS SAMPLE VOLUME
(Method 5)

ΔH = 2.48 in. H_2O, average pressure differential across the orifice meter

P_{bar} = 29.97 in. Hg, barometric pressure at the sampling site

P_{std} = 29.92 in. Hg, standard absolute pressure

T_m = 555.9 ^oR, absolute average dry gas meter temperature

T_{std} = 527.7 ^oR, standard absolute temperature

Y = 1.01 dimensionless, dry gas meter calibration factor

V_m = 80.611 dcf, volume of gas sample as measured by the dry gas meter

$$V_{m(std)} = V_m \, Y \left(\frac{T_{std}}{T_m}\right)\left(\frac{P_{bar} + (\Delta H/13.6)}{P_{std}}\right)$$

$V_{m(std)}$ = 77.89 dscf, volume of gas sample, corrected to standard conditions

DETERMINATION OF MOISTURE CONTENT OF GAS STREAM
(Method 5)

R = 21.85 in. Hg-ft^3/^{o}R-lb-mole, ideal gas constant

ρ_w = 0.002201 lb/ml, density of water

M_w = 18.02 lb/lb-mole, molecular weight of water

V_{lc} = 355.7 ml, total volume of liquid collected in impingers and silica gel

$$V_{w(std)} = V_{lc}\left(\frac{\rho_w}{M_w}\right)\left(\frac{R \, T_{std}}{P_{std}}\right)$$

$V_{w(std)}$ = 16.74 scf, volume of water vapor in gas sample, standard conditions

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

B_{ws} = 0.177 proportion by volume, water vapor in the gas stream

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Run No. 2 Source No. 1 Kiln Wet Scrubber Test Date 11/12/81

DETERMINATION OF THEORETICAL MOISTURE CONTENT AT SATURATED CONDITIONS (Method 5)

In addition to the calculation of the moisture content of the gas stream from the impinger analysis, a second calculation from the assumption of saturated conditions is made whenever there is the probability that the gas stream is saturated or laden with water droplets.

A = 6.691, water vapor constant for Antoine's vapor pressure equation
B = 3144, water vapor constant for Antoine's vapor pressure equation
C = 68.84, water vapor constant for Antoine's vapor pressure equation
T_s = 597.8 ^oR, absolute average gas stream temperature
P_g = -0.55 in. H_2O, static pressure of gas stream

$$B_{ws(sat)} = \frac{\text{antilog}_{10}\left[A - (B/(T_s - C))\right]}{P_{bar} + (P_g/13.6)}$$

$B_{ws(sat)}$ = 0.187 proportion by volume, water vapor in gas stream at saturation

$B_{ws(sat)}$ shall be considered correct if this value is less than the value calculated from the impinger analysis; accordingly, $B_{ws(sat)}$ and the following values calculated for $V_{w(std)}$ and V_{lc}, based upon $B_{ws(sat)}$, shall be used in all subsequent calculations.

$$V_{w(std)} = \frac{B_{ws(sat)}\, V_{m(std)}}{1 - B_{ws(sat)}}$$

$V_{w(std)}$ = N/A scf, volume of water vapor in gas sample, standard conditions, not exceeding saturated gas stream conditions.

$$V_{lc} = V_{w(std)} \left(\frac{M_w}{\rho_w}\right)\left(\frac{P_{std}}{R\, T_{std}}\right)$$

V_{lc} = N/A ml, Volume of liquid collected in impingers and silica gel, not exceeding saturated gas stream conditions.

Run No. 2 Source No. 1 Kiln Wet Scrubber Test Date 11/12/81

DETERMINATION OF GAS STREAM MOLECULAR WEIGHTS
(Method 3)

M_{CO_2} = 44.01 lb/lb-mole, molecular weight of CO_2

M_{O_2} = 32.00 lb/lb-mole, molecular weight of O_2

$M_{N_2 \text{ or } CO}$ = 28.01 lb/lb-mole, molecular weight of N_2 or CO

% CO_2 = 4.5 %, percent CO_2 in gas stream by volume, dry basis

$\%O_2$ = 15.5 %, percent O_2 in gas stream by volume, dry basis

$\%N_2 + \%CO_2$ = 80.0 %, percent N_2 and CO in gas stream by volume, dry basis

$$M_d = 44.01 \frac{\%CO_2}{100} + 32.00 \frac{\%O_2}{100} + 28.01 \frac{\%N_2 + \%CO}{100}$$

M_d = 29.3 lb/lb-mole, molecular weight of gas stream, dry basis

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

M_s = 27.3 lb/lb-mole, molecular weight of gas stream, wet basis

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Run No. 2 Source No. 1 Kiln Wet Scrubber Test Date 11/12/81

DETERMINATION OF GAS STREAM VELOCITY AND VOLUMETRIC FLOW RATES
(Method 2)

P_g = -0.55 in. H_2O, static pressure of gas stream

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

C_p = 0.84 dimensionless, pitot tube assembly coefficient

$\sqrt{\Delta p}$ = 0.912 $\sqrt{in.\ H_2O}$, average of square roots of gas stream velocity heads

T_s = 597.8 ^oR, absolute average gas stream temperature

A_s = 17.10 ft^2, cross-sectional area of stack or duct

$$P_s = \frac{P_g}{13.6} + P_{bar}$$

P_s = 29.93 in. Hg, absolute gas stream pressure

$$v_s = K_p C_p \sqrt{\Delta p} \sqrt{\frac{T_s}{P_s M_s}}$$

v_s = 56.0 ft/sec, average gas stream velocity

$$Q_s = (60\ sec/min)\ A_s v_s$$

Q_s = 57,400 acfm, actual volumetric flow rate of gas stream

$$Q_{s(std)} = (60\ sec/min)\ (1\text{-}B_{ws})\ A_s v_s \left(\frac{T_{std}}{T_s}\right)\left(\frac{P_s}{P_{std}}\right)$$

$Q_{s(std)}$ = 41,700 dscfm, dry volumetric flow rate of gas stream, standard conditions

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Run No. 2 Source No. 1 Kiln Wet Scrubber Test Date 11/12/81

Determination of Particulate Emission Data (Method 5)

m_n = 256.3 mg, total weight of particulate matter collected

θ = 96 min, total sampling time

A_n = 0.000341 ft^2, cross-sectional area of the nozzle

K_1 = 0.002669 in. Hg-ft^3/ml-°R

$$c_s = (0.01543 \text{ gr/mg})\left(m_n / V_{m(std)}\right)$$

c_s = 0.0508 gr/dscf, particulate concentration, dry basis, standard conditions

$$PMR = (60 \text{ min/hr})(0.0001428 \text{ lb/gr})\ c_s\ Q_{s(std)}$$

PMR = 18.16 lb/hr, particulate mass rate

$$I = 100\ \frac{T_s\left[K_1\ V_{lc} + (V_m\ Y/T_m)(P_{bar} + \Delta H/13.6)\right]}{(60 \text{ sec/min})\ \theta\ v_s\ P_s\ A_n}$$

I = 97.5 %, percent of isokinetic sampling

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LABORATORY ANALYSIS

Client Tombigbee Lightweight Aggregate Source # 2 Kiln Wet Scrubber

Date 11/11/81 Run No. 2 Sample Box No. 4

MOISTURE CONDENSATE

Impinger No.	1. Deionized H_2O	2. Deionized H_2O	3. Dry	4. Silica Gel
Gross Volume, ml or g	307	142	4	269.5
Tare Volume, ml or g	100	100	0	250.0
Net Volume, ml or g	207	42	4	19.5

Total Moisture Condensate Collected: 272.5 ml

PARTICULATE COLLECTED

Component	Glass-Fiber Filter	Acetone Rinse	Acetone Blank	Impinger Condensate	Impinger Blank
I.D. No.	2223	197	189		
Volume, ml		425	250		
Gross Weight, g	0.8815	88.5331	91.1923		
Gross Weight, g	0.8815	88.5330	91.1923		
Average Gross, g	0.8815	88.5330	91.1923		
Tare Weight, g	0.6924	88.4555	91.1914		
Residue, g		0.0015			
Net Weight, g	0.1891	0.0760	0.0009		

Residue in Acetone Rinse: $\frac{(0.0009 \text{ g blank})(425 \text{ ml rinse})}{(250 \text{ ml blank})}$ = 0.0015 g

Allowable Rinse Residue:(0.00001 of acetone weight)(0.7857 g/ml)(425 ml rinse)= 0.0033 g

Residue in Impinger Condensate: $\frac{(\quad \text{ g blank})(\quad \text{ ml condensate})}{(\quad \text{ ml blank})}$ = ______ g

Particulate Collected (excluding impinger catch): 0.2651 g

Particulate Collected (including impinger catch): g

The particulate collected in each component was weighed to a constant weight, meaning a difference of no more than 0.5 mg or 1 percent of total weight less tare weight, whichever is greater, between two consecutive weighings, with no less than 6 hours of dessication time between weighings.

Comments:

RESOURCE CONSULTANTS

Laboratory Analyst J Roger Reell

FIELD DATA LOG

PLANT Tombigbee Lightweight Aggregate SOURCE #1 Kiln Wet Scrubber

NOMOGRAPH VALUES	
ΔH@ ____	C FACTOR ____
Tm ____	AVG ΔP ____
%H₂O ____	Tₛ ____
REFERENCE ____	

FINAL VOLUME	824.412
INITIAL VOLUME	743.801
NET VOLUME	80.611

RUN NO 2
DATE 11/12/81
OPERATORS REEHL & GARNER
METER BOX NO 1
SAMPLE BOX NO 1
FILTER NO 2226
IMPINGER GAUGE NO. 4
STACK GAUGE NO. 5-1
PITOT COEFFICIENT 0.84 (5-1)
PROBE HEATER SETTING 98%

BAROMETRIC PRESSURE 29.97
STATIC PRESSURE −0.55
AMBIENT TEMPERATURE ____
PROBE LENGTH 66"
PROBE LINER SS
PORT LENGTH 3"
PORT DIAMETER 3"
METER SYSTEM LEAK-CHECK 0.0
ORSAT LEAK-CHECK N/A
SAMPLE BAG LEAK-CHECK N/A

SCHEMATIC OF STACK

CROSS SECTION 56"

2'4"

9'4"

SAMPLING SITE

PORT LOCATION

TRAVERSE POINT NUMBER	SAMPLING TIME CLOCK	SAMPLING TIME SAMPLE	STACK TEMP. (T_s) °F	VELOCITY HEAD (Δ Ps)	VELOCITY HEAD ($\sqrt{\Delta Ps}$)	ORIFICE METER (ΔH) in. H_2O ACTUAL	ORIFICE METER DESIRED	GAS SAMPLE VOLUME (V_m), ft³	GAS SAMPLE TEMP AT DRY GAS METER INLET ($T_{m_{in}}$) °F	OUTLET ($T_{m_{out}}$) °F	SAMPLE BOX TEMP. °F	TEMP OF GAS LEAVING LAST IMPINGER °F	PUMP VACUUM GAUGE in. Hg
	1728	0						743.801					
A-1		2	138	0.64		1.80		745.12	75	75	260	51	4
2		4	139	0.66		1.85		746.91	80	75	265	50	4
3		6	138	0.66		1.90		748.09	83	76	265	50	4
4		8	138	0.69		1.95		749.55	86	76	260	50	5
5		10	138	0.73		2.10		751.10	89	77	260	49	5
6		12	138	0.76		2.20		752.67	92	77	260	48	5
7		14	138	0.78		2.25		754.26	95	78	260	49	5
8		16	138	0.79		2.30		755.90	97	79	265	50	5
9		18	138	0.82		2.40		757.55	100	80	265	50	5
10		20	139	0.88		2.55		759.27	102	86	265	56	6
11		22	139	0.93		2.70		761.30	105	87	260	51	6
12		24	138	0.98		2.85		762.78	106	83	260	52	6
13		26	138	0.98		2.85		764.57	107	84	260	53	6
14		28	138	0.94		2.75		766.36	108	85	260	54	6
15		30	138	0.98		2.90		768.16	110	86	260	55	7
16		32	139	1.05		3.10		770.06	111	87	265	56	7
17		34	138	1.15		3.40		772.00	113	88	265	57	7
18		36	138	1.20		3.55		774.02	114	89	265	58	8
19		38	138	1.20		3.55		776.04	115	90	260	58	8
20		40	138	1.15		3.40		778.05	117	90	260	59	8
21		42	138	1.10		3.30		780.03	117	91	260	58	8
22		44	138	1.05		3.15		781.97	118	92	260	58	7
23		46	139	0.95		2.85		783.79	118	92	260	58	7
24	1216	48	137	0.93		2.80		785.598	116	93	255	58	7
TOTAL													
AVERAGE													

STATIC PITOT LEAK-CHECK @ 15 sec:	0.0
IMPACT PITOT LEAK-CHECK @ 15 sec:	0.0
TRAIN LEAK RATE @ 60 sec	0.000 cf @ 9 in.

STACK GAS ANALYSIS

ORSAT FYRITE

TIME	CO_2	O_2	CO	N_2
	4	16		
	4	16		

NOZZLE CALIBRATION I.D. NO. 05

PRETEST		POST-TEST	
DIA. 1		DIA. 1	
DIA. 2		DIA. 2	
DIA. 3		DIA. 3	
AVERAGE	0.250	AVERAGE	

RESOURCE CONSULTANTS INC.

SIGNATURE

TEST TEAM CHIEF

FIELD DATA LOG

PLANT Tombigbee Lightweight Aggregate SOURCE #1 Kiln Wet Scrubber RUN NO 2

TRAVERSE POINT NUMBER	SAMPLING TIME CLOCK	SAMPLING TIME SAMPLE	STACK TEMP (T_s) °F	VELOCITY HEAD (ΔP_s)	VELOCITY HEAD ($\sqrt{\Delta P_s}$)	ORIFICE METER (ΔH) in. H_2O ACTUAL	ORIFICE METER (ΔH) in. H_2O DESIRED	GAS SAMPLE VOLUME (V_m) ft³	GAS SAMPLE TEMP AT DRY GAS METER INLET ($T_{m_{in}}$) °F	GAS SAMPLE TEMP AT DRY GAS METER OUTLET ($T_{m_{out}}$) °F	SAMPLE BOX TEMP °F	TEMP OF GAS LEAVING LAST IMPINGER °F	PUMP VACUUM GAUGE in. Hg
	1228	48											
8-1		50	137	0.88		2.60		787.35	99	90	265	56	6
2		52	138	0.86		2.55		789.07	101	90	265	52	6
3		54	139	0.87		2.50		790.80	103	90	265	50	6
4		56	139	0.90		2.65		792.54	105	90	265	52	7
5		58	138	0.91		2.70		794.30	106	90	265	52	7
6		60	138	0.98		2.90		796.07	107	90	265	52	7
7		62	138	1.05		3.10		797.92	109	90	265	53	7
8		64	138	1.05		3.10		799.80	111	90	265	54	7
9		66	138	0.96		2.85		801.65	112	99	265	54	7
10		68	138	0.88		2.60		803.40	112	91	265	54	7
11		70	138	0.88		2.60		805.14	113	91	265	54	7
12		72	138	0.85		2.55		806.87	112	92	270	54	7
13		74	138	0.77		2.30		808.52	111	91	270	55	6
14		76	138	0.70		2.10		810.11	110	92	265	56	6
15		78	139	0.68		2.00		811.60	110	92	265	57	6
16		80	139	0.68		2.00		813.13	111	93	265	57	6
17		82	139	0.63		1.85		814.66	110	92	265	57	6
18		84	138	0.64		1.90		816.17	110	93	265	57	6
19		86	138	0.60		1.80		817.63	109	93	265	57	6
20		88	138	0.59		1.75		819.04	109	93	265	57	6
21	1314	90	138	0.55		1.60		820.43	98	91	270	57	5
22		92	138	0.53		1.60		821.82	100	91	270	58	5
23		94	138	0.49		1.45		823.14	101	91	265	58	5
24	1322	96	137	0.47		1.40		824.412	102	91	260	58	5
		98											
TOTAL		96	6628		43.861	118.90		80.611	5043	4196			MAX
AVERAGE		--	138.1		0.912	2.48		--	105.1	87.4			8

96.2

RESOURCE CONSULTANTS

SUMMARY OF PARTICULATE EMISSIONS SOURCE TEST DATA

Company Tombigbee Lightweight Aggregate Test Date 11/12/81

Source No. 1 Kiln Wet Scrubber Run No. 3

Determination of Dry Standard Gas Sample Volume		
Average pressure differential across the orifice meter, in. H_2O	ΔH	2.58
Barometric pressure at the sampling site, in. Hg	P_{bar}	29.97
Absolute average dry gas meter temperature, ^oR	T_m	553.0
Dry gas meter calibration factor, dimensionless	Y	1.01
Volume of gas sample as measured by the dry gas meter, dcf	V_m	82.590
Volume of gas sample, corrected to standard conditions, dscf	$V_{m(std)}$	80.24
Determination of Moisture Content of Gas Stream		
Total volume of liquid collected in impingers and silica gel, ml	V_{lc}	363.4
Volume of water vapor in gas sample, standard conditions, scf	$V_{w(std)}$	17.11
Water vapor in the gas stream, proportion by volume	B_{ws}	0.176
Water vapor in the gas stream at saturation, proportion by volume	$B_{ws(sat)}$	0.186
Determination of Gas Stream Molecular Weights		
Percent CO_2 in gas stream by volume, dry basis	$\%CO_2$	4.5
Percent O_2 in gas stream by volume, dry basis	$\%O_2$	15.5
Molecular weight of gas stream, wet basis, lb/lb-mole	M_s	27.4
Determination of Gas Stream Velocity and Volumetric Flow Rates		
Average of square roots of gas stream velocity heads, $\sqrt{\text{in. } H_2O}$	$\sqrt{\Delta p}$	0.928
Static pressure of gas stream, in. H_2O	P_g	-0.55
Absolute average gas stream temperature, ^oR	T_s	597.7
Pitot tube assembly coefficient, dimensionless	C_p	0.84
Cross-sectional area of stack or duct, ft^2	A_s	17.10
Absolute pressure of gas stream, in. Hg	P_s	29.93
Average gas stream velocity, ft/sec.	v_s	56.9
Actual volumetric flow rate of gas stream, acfm	Q_s	58,400
Dry volumetric flow rate of gas stream, standard conditions, dscfm	$Q_{s(std)}$	42,500
Determination of Particulate Emission Data		
Total weight of particulate matter collected, mg	m_n	253.2
Total sampling time, min.	θ	96
Cross-sectional area of the nozzle, ft^2	A_n	0.000341
Particulate concentration, dry basis, standard conditions, gr/dscf	c_s	0.0487
Particulate mass rate, lb/hr	PMR	17.75
Percent of isokinetic sampling, %	I	98.6

RESOURCE CONSULTANTS

Run No. 3 Source No. 1 Kiln Wet Scrubber Test Date 11/12/81

DETERMINATION OF DRY STANDARD GAS SAMPLE VOLUME
(Method 5)

ΔH = 2.58 in. H_2O, average pressure differential across the orifice meter

P_{bar} = 29.97 in. Hg, barometric pressure at the sampling site

P_{std} = 29.92 in. Hg, standard absolute pressure

T_m = 553.0 ^oR, absolute average dry gas meter temperature

T_{std} = 527.7 ^oR, standard absolute temperature

Y = 1.01 dimensionless, dry gas meter calibration factor

V_m = 82.590 dcf, volume of gas sample as measured by the dry gas meter

$$V_{m(std)} = V_m\, Y\left(\frac{T_{std}}{T_m}\right)\left(\frac{P_{bar} + (\Delta H/13.6)}{P_{std}}\right)$$

$V_{m(std)}$ = 80.24 dscf, volume of gas sample, corrected to standard conditions

DETERMINATION OF MOISTURE CONTENT OF GAS STREAM
(Method 5)

R = 21.85 in. Hg-ft^3/^{o}R-lb-mole, ideal gas constant

ρ_w = 0.002201 lb/ml, density of water

M_w = 18.02 lb/lb-mole, molecular weight of water

V_{lc} = 363.4 ml, total volume of liquid collected in impingers and silica gel

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

$V_{w(std)}$ = 17.11 scf, volume of water vapor in gas sample, standard conditions

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

B_{ws} = 0.176 proportion by volume, water vapor in the gas stream

RESOURCE CONSULTANTS

Run No. 3 Source No. 1 Kiln Wet Scrubber Test Date 11/12/81

DETERMINATION OF THEORETICAL MOISTURE CONTENT AT SATURATED CONDITIONS
(Method 5)

In addition to the calculation of the moisture content of the gas stream from the impinger analysis, a second calculation from the assumption of saturated conditions is made whenever there is the probability that the gas stream is saturated or laden with water droplets.

A = 6.691, water vapor constant for Antoine's vapor pressure equation

B = 3144, water vapor constant for Antoine's vapor pressure equation

C = 68.84, water vapor constant for Antoine's vapor pressure equation

T_s = 597.7 ^oR, absolute average gas stream temperature

P_g = -0.55 in. H_2O, static pressure of gas stream

$$B_{ws(sat)} = \frac{\text{antilog}_{10}\left[A - (B/(T_s - C))\right]}{P_{bar} + (P_g/13.6)}$$

$B_{ws(sat)}$ = 0.186 proportion by volume, water vapor in gas stream at saturation

$B_{ws(sat)}$ shall be considered correct if this value is less than the value calculated from the impinger analysis; accordingly, $B_{ws(sat)}$ and the following values calculated for $V_{w(std)}$ and V_{lc}, based upon $B_{ws(sat)}$, shall be used in all subsequent calculations.

$$V_{w(std)} = \frac{B_{ws(sat)}\, V_{m(std)}}{1 - B_{ws(sat)}}$$

$V_{w(std)}$ = N/A scf, volume of water vapor in gas sample, standard conditions, not exceeding saturated gas stream conditions.

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

V_{lc} = N/A ml, Volume of liquid collected in impingers and silica gel, not exceeding saturated gas stream conditions.

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Run No. 3 Source No. 1 Kiln Wet Scrubber Test Date 11/12/81

DETERMINATION OF GAS STREAM MOLECULAR WEIGHTS
(Method 3)

M_{CO_2} = 44.01 lb/lb-mole, molecular weight of CO_2

M_{O_2} = 32.00 lb/lb-mole, molecular weight of O_2

$M_{N_2 \text{ or } CO}$ = 28.01 lb/lb-mole, molecular weight of N_2 or CO

% CO_2 = 4.5 %, percent CO_2 in gas stream by volume, dry basis

$\%O_2$ = 15.5 %, percent O_2 in gas stream by volume, dry basis

$\%N_2+\%CO_2$ = 80.0 %, percent N_2 and CO in gas stream by volume, dry basis

$$M_d = 44.01 \frac{\%CO_2}{100} + 32.00 \frac{\%O_2}{100} + 28.01 \frac{\%N_2 + \%CO}{100}$$

M_d = 29.3 lb/lb-mole, molecular weight of gas stream, dry basis

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

M_s = 27.4 lb/lb-mole, molecular weight of gas stream, wet basis

Run No. 3 Source No. 1 Kiln Wet Scrubber Test Date 11/12/81

DETERMINATION OF GAS STREAM VELOCITY AND VOLUMETRIC FLOW RATES (Method 2)

P_g = -0.55 in. H_2O, static pressure of gas stream

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

C_p = 0.84 dimensionless, pitot tube assembly coefficient

$\sqrt{\Delta p}$ = 0.928 $\sqrt{\text{in. } H_2O}$, average of square roots of gas stream velocity heads

T_s = 597.7 ^{o}R, absolute average gas stream temperature

A_s = 17.10 ft^2, cross-sectional area of stack or duct

$$P_s = \frac{P_g}{13.6} + P_{bar}$$

P_s = 29.93 in. Hg, absolute gas stream pressure

$$v_s = K_p C_p \sqrt{\Delta p} \sqrt{\frac{T_s}{P_s M_s}}$$

v_s = 56.9 ft/sec, average gas stream velocity

$$Q_s = (60 \text{ sec/min})\ A_s v_s$$

Q_s = 58,400 acfm, actual volumetric flow rate of gas stream

$$Q_{s(std)} = (60 \text{ sec/min})\ (1-B_{ws})\ A_s v_s \left(\frac{T_{std}}{T_s}\right)\left(\frac{P_s}{P_{std}}\right)$$

$Q_{s(std)}$ = 42,500 dscfm, dry volumetric flow rate of gas stream, standard conditions

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Run No. 3 Source No. 1 Kiln Wet Scrubber Test Date 11/12/81

Determination of Particulate Emission Data (Method 5)

m_n = 253.2 mg, total weight of particulate matter collected

θ = 96 min, total sampling time

A_n = 0.000341 ft^2, cross-sectional area of the nozzle

K_1 = 0.002669 in. Hg-ft^3/ml-^oR

$$c_s = (0.01543\ \text{gr/mg})\left(m_n/V_{m(std)}\right)$$

c_s = 0.0487 gr/dscf, particulate concentration, dry basis, standard conditions

$$PMR = (60\ \text{min/hr})(0.0001428\ \text{lb/gr})\ c_s\ Q_{s(std)}$$

PMR = 17.75 lb/hr, particulate mass rate

$$I = 100\ \frac{T_s\left[K_1\ V_{lc} + (V_m\ Y/T_m)(P_{bar} + \Delta H/13.6)\right]}{(60\ \text{sec/min})\ \theta\ v_s\ P_s\ A_n}$$

I = 98.6 %, percent of isokinetic sampling

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LABORATORY ANALYSIS

Client Tombigbee Lightweight Aggregate Source #2 Kiln Wet Scrubber

Date 11/11/81 Run No. 3 Sample Box No. 3

MOISTURE CONDENSATE

Impinger No.	1. Deionized H_2O	2. Deionized H_2O	3. Dry	4. Silica Gel
Gross Volume, ml or g	322	147	4	271.5
Tare Volume, ml or g	100	100	0	250.0
Net Volume, ml or g	222	47	4	21.5

Total Moisture Condensate Collected: 294.5 ml

PARTICULATE COLLECTED

Component	Glass-Fiber Filter	Acetone Rinse	Acetone Blank	Impinger Condensate	Impinger Blank
I.D. No.	2224	302	189		
Volume, ml		460	250		
Gross Weight, g	0.9481	102.8422	91.1923		
Gross Weight, g	0.9481	102.8421	91.1923		
Average Gross, g	0.9481	102.8421	91.1923		
Tare Weight, g	0.7364	102.7395	91.1914		
Residue, g		0.0017			
Net Weight, g	0.2117	0.1009	0.0009		

Residue in Acetone Rinse: $\frac{(0.0009 \text{ g blank})(460 \text{ ml rinse})}{(250 \text{ ml blank})}$ = 0.0017 g

Allowable Rinse Residue: (0.00001 of acetone weight)(0.7857 g/ml)(460 ml rinse) = 0.0036 g

Residue in Impinger Condensate: $\frac{(\quad \text{ g blank})(\quad \text{ ml condensate})}{(\quad \text{ ml blank})}$ = ______ g

Particulate Collected (excluding impinger catch): 0.3126 g

Particulate Collected (including impinger catch): g

The particulate collected in each component was weighed to a constant weight, meaning a difference of no more than 0.5 mg or 1 percent of total weight less tare weight, whichever is greater, between two consecutive weighings, with no less than 6 hours of dessication time between weighings.

Comments:

RESOURCE CONSULTANTS

Laboratory Analyst J. Roger Reell

FIELD DATA LOG

PLANT Tombigbee Lightweight Aggregate SOURCE #1 Kiln Wet Scrubber

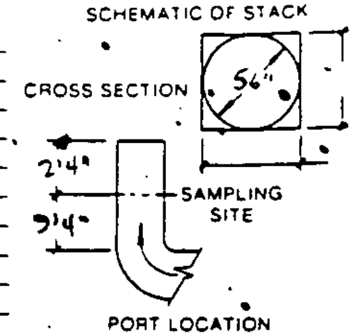
NOMOGRAPH VALUES	
ΔH@	C.FACTOR
Tm	AVG ΔP
H2O	Ts
REFERENCE	

FINAL VOLUME	907.494
INITIAL VOLUME	824.904
NET VOLUME	82.590

RUN NO 3
DATE 11/12/81
OPERATORS MARINO & GARDNER
METER BOX NO 1
SAMPLE BOX NO 4
FILTER NO. 2227
IMPINGER GAUGE NO. 4
STACK GAUGE NO. 5-1
PITOT COEFFICIENT 0.84 (5-1)
PROBE HEATER SETTING 98%

BAROMETRIC PRESSURE 29.97
STATIC PRESSURE -0.55
AMBIENT TEMPERATURE
PROBE LENGTH 66"
PROBE LINER SS
PORT LENGTH 0"
PORT DIAMETER 3"
METER SYSTEM LEAK-CHECK 0.0
ORSAT LEAK-CHECK N/A
SAMPLE BAG LEAK-CHECK N/A

SCHEMATIC OF STACK



TRAVERSE POINT NUMBER	SAMPLING TIME CLOCK	SAMPLING TIME SAMPLE	STACK TEMP. (T_s) °F	VELOCITY HEAD (ΔPs)	VELOCITY HEAD (√ΔPs)	ORIFICE METER (ΔH) in. H_2O ACTUAL	ORIFICE METER (ΔH) in. H_2O DESIRED	GAS SAMPLE VOLUME (V_m), ft³	GAS SAMPLE TEMP AT DRY GAS METER INLET (Tm_{in}) °F	GAS SAMPLE TEMP AT DRY GAS METER OUTLET (Tm_{out}) °F	SAMPLE BOX TEMP. °F	TEMP OF GAS LEAVING LAST IMPINGER °F	PUMP VACUUM GAUGE in. Hg
	14:30	0						824.904					
A-1		2	138	0.65		1.90		826.5	80	80	300	62	3.5
2		4	138	0.67		1.95		828.1	80	80	295	60	3.5
3		6	138	0.70		2.00		829.5	86	80	265	57	3.5
4		8	138	0.75		2.15		831.2	90	80	260	57	3.5
5		10	138	0.74		2.15		832.7	92	80	265	59	4.0
6		12	138	0.78		2.30		834.5	94	80	255	59	4.0
7		14	138	0.74		2.15		836.0	95	80	265	61	4.0
8		16	138	0.81		2.35		837.7	96	80	265	61	4.0
9		18	138	0.84		2.45		839.3	96	81	265	61	4.0
10		20	138	0.86		2.50		841.0	97	81	270	60	4.0
11		22	138	0.96		2.80		842.9	98	81	275	60	4.5
12		24	138	1.05		3.05		844.9	99	82	270	60	4.5
13		26	138	1.00		2.90		846.6	101	83	270	61	4.5
14		28	138	1.00		2.90		848.4	102	84	265	61	4.5
15		30	138	1.05		3.05		850.4	104	85	260	60	4.5
16		32	138	1.10		3.25		852.3	104	86	260	60	4.5
17		34	138	1.10		3.25		854.3	104	86	260	59	5.0
18		36	138	1.20		3.55		856.3	105	86	260	59	5.0
19		38	138	1.10		3.25		858.1	105	86	265	58	5.0
20		40	138	1.10		3.25		860.1	105	86	265	58	5.0
21		42	138	[illegible]		3.25		862.1	106	88	260	60	5.0
22		44	138	0.96		2.85		864.0	106	88	260	60	5.0
23		46	138	0.94		2.80		865.7	106	88	260	60	5.0
24	1518	48	188	0.93		2.75		867.80	106	89	260	60	5.0
								869.403					
TOTAL													
AVERAGE													

STATIC PITOT LEAK-CHECK @ 15 sec.	0.0
IMPACT PITOT LEAK-CHECK @ 15 sec.	0.0
TRAIN LEAK RATE @ 60 sec.	0.0013 cf @ 8 in.

STACK GAS ANALYSIS

ORSAT ☐ FYRITE ☒

TIME	CO_2	O_2	CO	N_2
	4.5	16		
	4.5	15.5		

NOZZLE CALIBRATION-I.D. NO. 05

PRETEST		POST-TEST	
DIA. 1		DIA. 1	0.250
DIA. 2		DIA. 2	0.250
DIA. 3		DIA. 3	0.250
AVERAGE	0.250	AVERAGE	0.250

RESOURCE CONSULTANTS

SIGNATURE John F. Marino
TEST TEAM CHIEF

FIELD DATA LOG

PLANT Tombigbee Lightweight Aggregate SOURCE #1 Kiln Wet Scrubber RUN NO 3

TRAVERSE POINT NUMBER	SAMPLING TIME CLOCK	SAMPLING TIME SAMPLE	STACK TEMP (Ts) °F	VELOCITY HEAD (ΔPs)	VELOCITY HEAD ($\sqrt{\Delta Ps}$)	ORIFICE METER (ΔH) in H_2O ACTUAL	ORIFICE METER (ΔH) in H_2O DESIRED	GAS SAMPLE VOLUME (Vm) ft³	GAS SAMPLE TEMP AT DRY GAS METER INLET (Tm_{in}) °F	GAS SAMPLE TEMP AT DRY GAS METER OUTLET (Tm_{out}) °F	SAMPLE BOX TEMP °F	TEMP OF GAS LEAVING LAST IMPINGER °F	PUMP VACUUM GAUGE in Hg
	15:29	48											
B-1		50	138	0.93		2.75		869.3	90	86	270	60	5.0
2		52	138	0.91		2.65		871.0	92	88	260	59	5.0
3		54	138	0.94		2.75		872.9	96	88	255	58	5.0
4		56	138	0.92		2.70		879.7	98	88	255	58	5.0
5		58	138	0.96		2.80		876.5	100	88	265	60	5.0
6		60	138	1.00		2.95		878.3	100	88	265	60	5.5
7		62	138	0.97		2.85		880.0	102	88	265	60	5.5
8		64	138	0.96		2.80		881.7	204	88	265	60	5.0
9		66	138	0.77		2.25		883.3	104	88	270	62	5.0
10		68	138	0.73		2.15		884.7	102	88	275	63	4.5
11		70	138	0.98		2.90		886.6	102	88	275	63	5.0
12		72	138	1.40		4.10		888.7	104	88	275	63	6.5
13		74	138	1.45		4.25		891.0	106	88	260	62	6.5
14		76	138	1.25		3.70		893.1	108	88	255	61	6.5
15		78	138	1.10		3.21		895.0	108	88	260	61	6.0
16		80	138	0.82		2.40		897.0	108	90	265	61	5.0
17		82	138	0.57		1.80		898.3	108	90	270	61	4.5
18		84	138	0.52		1.55		899.6	106	90	275	61	4.5
19		86	138	0.50		1.50		901.0	106	90	275	61	4.0
20		88	138	0.48		1.40		902.3	105	90	275	61	4.0
21		90	138	0.47		1.40		903.6	105	90	270	61	4.0
22		92	038	0.47		1.40		904.8	105	90	265	61	4.0
23		94	138	0.45		1.35		906.1	105	90	260	61	4.0
24	1617	96	138	0.51		1.50		907.49	105	90	260	61	4.5
TOTAL		96	6624		44.563	123.81		82.590	4826	4129			MAX
AVERAGE			138.0		0.928	2.58			100.5	86.0			6.5

93.3

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APPENDIX B

EQUIPMENT CALIBRATIONS

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, ^oF	TEMPERATURE DRY GAS METER INLET T_{di}, ^oF	TEMPERATURE DRY GAS METER OUTLET T_{do}, ^oF	TEMPERATURE DRY GAS METER AVERAGE T_d, ^oF	TIME θ MIN.	γ	$\Delta H@$
0.5	5	5.174	76.25	104.5	98.0	101.25	12.70	1.010	1.781
1.0	5	5.188	76.25	106.5	98.0	102.25	9.25	1.008	1.885
1.5	10	10.391	76.25	110.0	98.5	104.25	15.08	1.009	1.873
2.0	10	10.419	76.00	115.5	99.5	107.50	13.43	1.011	1.968
3.0	10	10.468	76.00	117.0	100.5	108.75	10.96	1.006	1.962
4.0	10	10.477	76.00	117.5	101.0	109.25	9.58	1.004	1.995
							AVERAGE	1.01	1.91

CALCULATIONS		γ	$\Delta H@$
ΔH	$\frac{\Delta H}{13.6}$	$\frac{V_w \; P_b \; (T_d + 460)}{V_d \; (P_b + \frac{\Delta H}{13.6})(T_w + 460)}$	$\frac{0.0317 \Delta H}{P_b \; (T_d + 460)} \left[\frac{(T_w + 460) \theta}{V_w} \right]^2$
0.5	0.0368	1.010	1.781
1.0	0.0737	1.008	1.885
1.5	0.110	1.009	1.873
2.0	0.147	1.011	1.968
3.0	0.221	1.006	1.962
4.0	0.294	1.004	1.995

ORIFICE AND DRY GAS METER CALIBRATION - FULL RANGE

CALIBRATED BY J. Roger Reall DATE 10/30/81

BAROMETRIC PRESSURE, P_b = 29.42 in. Hg, BOX NO. 1

VACUUM = 0 in. Hg

γ = Ratio of accuracy of wet test meter. Tolerance = $\pm$ 0.01

$\Delta H@$ = Orifice pressure differential that gives 0.75 cfm of air at 68 ^oF and 29.92 inches of mercury, in. H_2O. Tolerance = $\pm$ 0.15

RESOURCE CONSULTANTS

Orifice Manometer Setting ΔH, in. H_2O	Gas Volume Wet Test Meter V_w, ft^3	Gas Volume Dry Gas Meter V_d, ft^3	Temperature Wet Test Meter T_w, °F	Temperature Dry Gas Meter Inlet T_{di}, °F	Temperature Dry Gas Meter Outlet T_{do}, °F	Temperature Dry Gas Meter Average T_d, °F	Time θ Min.	γ	$\Delta H@$
2.50	10	10.190	76.00	99.5	89.0	94.25	11.72	1.008	1.934
2.50	10	10.274	76.00	111.0	93.0	102.00	11.75	1.014	1.918
2.50	10	10.353	76.00	117.5	97.5	107.50	11.77	1.016	1.905
							AVERAGE	1.01	1.92

CALCULATIONS		γ	$\Delta H@$
ΔH	$\frac{\Delta H}{13.6}$	$\frac{V_w \; P_b \; (T_d + 460)}{V_d \; (P_b + \frac{\Delta H}{13.6})(T_w + 460)}$	$\frac{0.0317 \Delta H}{P_b \; (T_d + 460)} \left[\frac{(T_w + 460)\,\theta}{V_w}\right]^2$
2.50	0.184	1.008	1.008
2.50	0.184	1.014	1.014
2.50	0.184	1.016	1.016

ORIFICE AND DRY GAS METER CALIBRATION - POST TEST

CALIBRATED BY John Marino DATE 11/17/81

BAROMETRIC PRESSURE, P_b = 29.16 in. Hg BOX NO. 1

VACUUM = 9 in. Hg

γ = Ratio of accuracy of wet test meter.
Tolerance = $\pm$ 0.01

$\Delta H@$ = Orifice pressure differential that gives 0.75 cfm of air at 68 °F and 29.92 inches of mercury, in. H_2O.
Tolerance = $\pm$ 0.15

RESOURCE CONSULTANTS

TYPE S PITOT TUBE ASSEMBLY CALIBRATION

IDENTIFICATION 5-1 CALIBRATED BY [illegible]

LENGTH 5 ft. DATE 4/23/80

P_A = 0.544 in. D_t = 0.375 in.

P_B = 0.544 in. γ = 2.5 °

P_{A+B} = 1.088 in. θ = 0.5 °

α_1 = 2.0 °(<10°) β_1 = 1.0 °(<5°)

α_2 = 4.0 °(<10°) β_2 = 0.5 °(<5°)

$Z = P_{A+B} \sin\gamma$ = 0.047 in. (< 0.125 in.)

$W = P_{A+B} \sin\theta$ = 0.009 in. (< 0.031 in.)

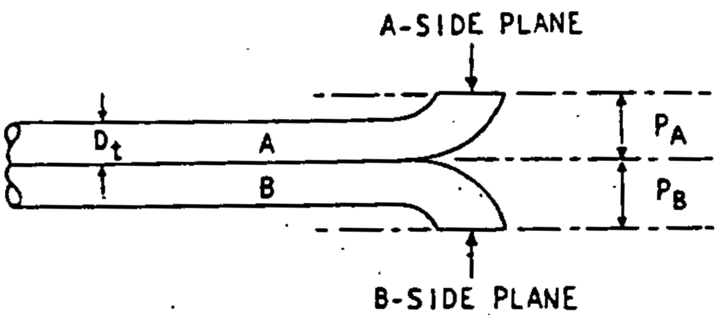
$1.05\, D_t$ = 0.394 $\leq P \leq 1.5\, D_t$ = 0.562

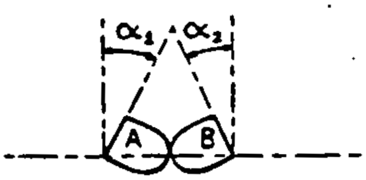
0.188 in. $\leq D_t \leq$ 0.375 in.

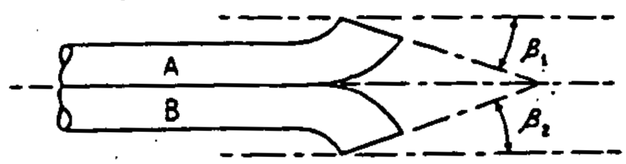
Distance between pitot tube and sampling nozzle ≥ 0.75 in.

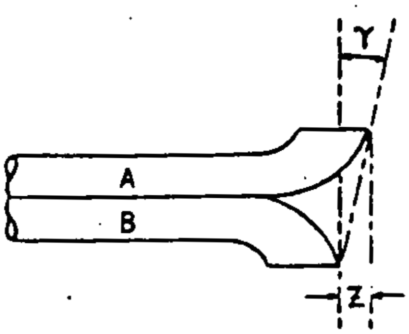
Distance between pitot tube and thermocouple ≥ 0.75 in.

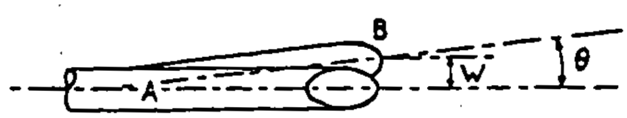
In accordance with 40 CFR Part 60, Appendix A, Method 2, Calibration Paragraph 4.1, the pitot tube assembly is assigned a coefficient of 0.84.











RESOURCE CONSULTANTS

TEMPERATURE GAUGE CALIBRATIONS

Temperature Gauge	No.	Test Run(s) Used	Average Temperature During Test	Gauge Reading (Calibration)	Reference Reading (Calibration)	Difference
Impinger Outlet (Pretest)	1			75	75	0
	2	1	52	75	75	0
	3			75	75	0
	4	2,3	57	74	75	-1
	5			74	75	-1
Meter Inlet (Pretest)	1	1,2,3	99	75	75	0
	2			75	75	0
	3					
Meter Outlet (Pretest)	1	1,2,3	82	75	75	0
	2			75	75	0
	3					
Filter Heating System (Pretest)	1	2	265	250	250	0
	2			250	250	0
	3			250	250	0
	4	3	265	250	250	0
	5	1	265	250	250	0
	6			250	250	0
In-Stack (Post Test)	5-1	1,2,3	138	140	140	0

Pretest Calibrations by J Roger Reell Title Poll Ctrl Spec Date 10/30/81

Post Test Calibrations by J Roger Reell Title " Date 11/17/81

Barometer Calibration by J Roger Reell Title " Date 11/6/81

Company Tombigbee Lightweight Aggregate Source No. 1 Kiln Wet Scrubber

Test Team Chief J Roger Reell Test Date 11/12/81

RESOURCE CONSULTANTS INC.

APPENDIX C

STATEMENT OF PROCESS WEIGHT RATE DATA

Statement of Process Weight Rate Data

On November 12, 1981, during the course of the source testing program conducted on the No. 1 wet scrubber, the process weight rate data was recorded for the purpose of calculating the allowable particulate emission rate. The weights of coal fired and raw clay fed to the kiln were totalized over known periods encompassing the source test. Coal was fired at an average rate of 1.8 tons per hour; raw clay was fed at an average rate of 31.0 tons per hour. The average total process weight rate during the testing period was 32.8 tons per hour.

TOMBIGBEE LIGHTWEIGHT AGGREGATE CORP.

James Colburn

James Colburn, Vice President

APPENDIX D

SAMPLE CHAIN OF CUSTODY

SAMPLE CHAIN OF CUSTODY

Plant Tombigbee Lightweight Aggregate Corporation / No. 1 Kiln Wet Scrubber
Date Sampled 11/12/81 Test Number
Run Number(s) 1, 2, 3

Sample Recovery

Container Code	Description
Log# 20231, Run 1	Filter, Acetone Rinse, Impinger Condensate
Log# 20232, Run 2	" " "
Log# 20233, Run 3	" " "

Person Engaged in Sample Recovery

Signature J. Roger Roell

Title Poll. Ctrl. Spec.

Location at which Recovery was done on-site

Date and time of Recovery 11/12/81

Sample(s) Recipient, Upon Recovery if not Recovery Person

Signature

Title

Date and Time of Receipt

Laboratory Person Receiving Sample

Signature J. Roger Roell

Title Poll. Ctrl. Spec.

Date and Time of Receipt 11/12/81 2300 CST

Sample Storage in lab

Analysis

Container Code	Method of Analysis	Date and Time of Analysis	Signature of Analyst
Log# 20231	Method 5	11/13-17/81	J R Roell
Log# 20232	Method 5	11/13-17/81	J R Roell
Log# 20233	Method 5	11/13-17/81	J R Roell

DRAFT/WP
d3006-4/971130
03/30/92 1

DATA RATING: B
REF. 12 (AP-42)
REF. 4-12

Emission Test Report
Review Checklist

Reviewer: R. MARINSHAW
Review Date: 11/17/92

A. Background Information

1. Facility name: TOMBIGBEE LIGHTWEIGHT AGGREGATE CORP.

   Location: LIVINGSTON, AL

2. Source category: LIGHTWEIGHT AGGREGATE

3. Test date: 11/12/81

4. Test sponsor: PLANT

5. Testing contractor: RESOURCE CONSULTANTS, INC.

6. Purpose of test: COMPLIANCE

7. Pollutants measured

   PM PM-10 CO SO_2 NO_x VOC Pb CO_2

   Others (list):

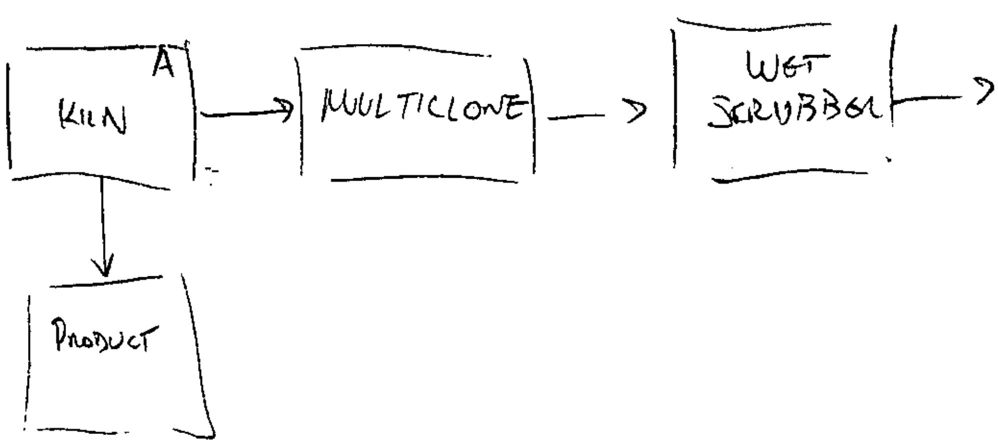
8. Process overview: On an attached page provide a block diagram of the unit operations and associated air pollution control systems at the facility. Identify process tested with letters from the beginning of the alphabet (A, B, C, etc.) and APC systems with letters from end of alphabet (V, W, X, etc.). Also identify test locations with Arabic numerals (1,2,3, ...). Using the ID symbols from that sketch complete the table below that identifies processes or unit operations tested.

Test ID	Process	Process ID	Emissions tested: Uncontrolled	Emissions tested: Controlled	APCD (controlled emissions only)
1	KILN NO 1	A		✓	WET SCRUBBER

B. Process Information

1. Provide a brief narrative description of the process. With as much detail as possible, (e.g., if a furnace or conveyor system is used, identify the type of unit) describe the equipment used for those operations tested. (Note: If process description provided in test report is adequate, attach copy or reproduce here.)

Exhaust gases from the processing of raw clay in the rotary kiln were drafted through a primary multiclone collector and a Fuller compressed air atomizing scrubber system. Testing was conducted in the cyclonic separator stack, which included a rectangular grid of flow straightening vanes.



2. For each process tested list feedstock materials and products. Indicate if activity factors are for feed (F) rate or product (P) rate.

Process ID	Feedstock materials	Products	Basis for activity factor	F/P
	COAL, CLAY -	LWA	CLAY	F

~~UNCLEAR IF FEED OR PRODUCTION RATE~~

Basis for data: ______________________
(Indicate page/table Nos. in test report)

3. For each process or operation tested and each test run note process capacity and operating rate during test.

Process ID	Capacity	Units	Test run	Process rate	Units	
			1	31.0 (CLAY)	TONS/HR (..	+1.8 TONS/HR (COAL)
			2	//		//
			3	//		//
			4			
			1			
			2			
			3			
			4			
			1			
			2			
			3			
			4			
			1			
			2			
			3			
			4			

Basis for data: APPENDIX C

C. Air Pollution Control Systems Tested

1. For each air pollution control system pollution control system identified in A.8, note the following

ID	Type of APCD	Manufacturer	Model No.

Note: Be as specific as possible in identifying APCD. For example, indicate "pulse jet fabric filter" rather than simply "fabric filter."

2. For each system identified above, provide a narrative description. For fugitive systems describe capture techniques as well as the removal techniques (use a separate page if necessary)

3. Using the attached parameter list for guidance complete the table below. (Use additional pages as needed.)

APCD ID	Parameter	Units	Readings Run 1	Run 2	Run 3	Run 4
	PRESSURE DROP	INCHES H_2O	14	14	14	
Type of APCD:	L/G	GAL/CFM	0.0085	0.0085	0.0085	
Type of APCD:						
Type of APCD:						

D. Sampling and Analysis Methods

1. Complete the following table

Test location	Pollutant	S & A method	Reference/ conditional method	Deviations noted
/	PM	5	Y/N	Y/N
	O_2	Orsat	Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N
			Y/N	Y/N

2. If a method used was not a reference or conditional method, provide a narrative discussion including any data manipulation needed to make results correspond to reference or conditional method results.

3. Describe any deviations identified above.

Because of the potential for the existence of cyclonic flow in the cyclonic separator stack, the pitot tube rotational angles were determined at each point by the null technique of Method 1 to verify the extent of cyclonic flow. As a result of the installation of a rectangular grid of flow straightening vanes, the rotational angles at all points were measured to be less than 10 degrees from parallel flow relative to the stack wall, indicating suitable conditions for conducting a source test. However, the short downstream length of stack from the vane outlet to the sampling ports may not have allowed the flow profile to stabilize resulting in a less than ideal sampling site.

Because of the high moisture content of the gas stream, the pitot lines were routinely purged to eliminate plugging from condensed moisture.

E. Emission Data Documentation

1. Tabulate the following stack gas data from the test report. (Use additional pages as needed.)

Test ID	Parameter	Units	Values reported			
			Run 1	Run 2	Run 3	Run 4
	Stack temperature	°F	138	138	138	
	Moisture	%	17.3	17.7	17.6	
	Oxygen					
	Volumetric flow, actual	dscfm	58000	57400	58400	
	Volumetric flow, standard		42400	41700	42500	
	Percent isokinetic		96.7	97.5	98.6	
	Pollutant concentration:					
	PM	gr/dscf	0.044	0.0508	0.0487	
	CO_2		4.5	4.5	4.5	
	Stack temperature					
	Moisture					
	Oxygen					
	Volumetric flow, actual					
	Volumetric flow, standard					
	Percent isokinetic					
	Pollutant concentration:					
	Stack temperature					
	Moisture					
	Oxygen					
	Volumetric flow, actual					
	Volumetric flow, standard					
	Percent isokinetic					
	Pollutant concentration:					

2. Tabulate pollutant mass flux rates

Test ID	Pollutant	Units	Mass flux rates			
			Run 1	Run 2	Run 3	Run 4
	PM	lb/hr	16	18.16	17.75	
	CO_2	lb/hr	13153	12937	13185	

3. Present example emission factor calculations below.

PM

16.00/31 = 0.52 lbs/ton

18.16/31 = 0.59 lbs/ton

17.75/31 = 0.57 lbs/ton

AVERAGE = 0.56

CO_2

13153/31 = 424 lbs/ton

12937/31 = 417

13185/31 = 425

AVE 422

4. Tabulate emission factors

Process	Pollutant	Units	Average emission factor	
			Uncontrolled	Controlled
	PM (FILT	lbs/ton		0.53

ATTACHMENT A
APCD PARAMETERS

Type of APCD	Parameters
Fabric filter	Cleaning mechanism Bag type Cleaning frequency Air to cloth ratio (A/C) Pressure drop Inlet temperature
ESP	Type (wet or dry) Number of fields Rapping cycle (if dry) Specific Collection Area (SCA) Particulate resistivity (if known) Spark rate Current and power levels
Venturi (or other high energy) scrubber	Pressure drop Liquid/gas (L/G) ratio Mist eliminator type
Packed-bed scrubber	Packing depth L/G ratio Caustic use (Y/N) pH Mist eliminator type
Carbon absorber	Bed depth Superficial gas velocity Bed temperature Desorption mechanism (media) Flue-gas moisture Cycle length Time-on-line after breakthrough