Note: This is a reference cited in *AP 42, Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources.* AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

The file name refers to the reference number, the AP42 chapter and section. The file name "ref02_c01s02.pdf" would mean the reference is from AP42 chapter 1 section 2. The reference may be from a previous version of the section and no longer cited. The primary source should always be checked.

NEDS data

Engineers Testing Laboratories, Inc.

AP-42 Section 11.17
Reference 15
Report Sect. 4
Reference 12

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2525 E. Indian School Rd. 264-4781 Phoen.

Gravel Bed

Rotary

Feed Capacity: 30 ton/hr

PAUL LIME PLANT, INC.
P. O. DRAWER T
DOUGLAS, ARIZONA 85607

26 JUNE 1973

ATTENTION: HOWARD AMES, JR , GENERAL MANAGER

RE: STACK EMISSIONS ON NO. 5 KILN

JOB NO. 343-279
INVOICE NO. 40-1130

ENCLOSED ARE THE RESULTS OF THE STACK EMISSIONS ANALYSIS PERFORMED JUNE 6 AND 7, 1973 ON THE DUST COLLECTION SYSTEM FOR THE NUMBER 5 KILN OF YOUR LIME PLANT.

SUMMARY OF RESULTS

3 runs on a gas-fired kiln controlled by cyclone + gravel bed. PM-filt; PM-cond

TEST NO. 1.	. . . 13.8 LBS.	TOTAL PARTICULATE/HOUR
TEST NO. 2.	. . . 9.9 LBS.	PARTICULATE/HOUR
TEST NO. 3.	. . . 10.9 LBS.	PARTICULATE/HOUR

KILN PRODUCES 340 TPD LIME GAS FIRED product

THE KILN OPERATED AT A RATE OF 25.2 TONS PER HOUR DURING THE TEST PERIOD. THE STATE OF ARIZONA PARTICULATE EMISSIONS STANDARD IS APPROXIMATELY 36 LBS. PER HOUR FOR THE 25.2 TONS PER HOUR PROCESS RATE.

12.6 ton product

RESPECTFULLY SUBMITTED,
ENGINEERS TESTING LABORATORIES, INC.

BY: R. L. Maurice, Jr AND P. Allard
R. L. MAURICE, JR. by Ra PETER F. ALLARD, P. E.

/JM

COPIES TO: ADDRESSEE (3)
DIVISION OF AIR POLLUTION CONTROL (2)

PAUL LIME PLANT, INC.
STACK EMISSIONS ON NO. 5 KILN
JOB NO. 343-279
INVOICE NO. 40-1130

DESCRIPTION OF THE PLANT AND DUST CONTROL SYSTEM

THE NO. 5 KILN AND DUST CONTROL SYSTEM ARE SIMILAR BUT LARGER THAN THE NO. 4 KILN AND DUST CONTROL SYSTEM, DESCRIBED IN THE ETL REPORT ON JOB NO. 240-386 DATED 29 JULY 1972.

THE CONTROL SYSTEM ON NO. 5 KILN IS COMPOSED OF FOURTEEN REX FILTER BED DUST COLLECTORS, AS IN THE FUNCTIONAL DIAGRAM SHOWN IN FIG. 1. THE DRUM-SHAPED UPPER PORTION OF THE COLLECTORS CONTAINS A FILTER BED OF QUARTZ PEBBLES. DUST LADEN GAS FIRST PASSES THROUGH A CYCLONE COLLECTOR, WHERE LARGER DUST PARTICLES ARE REMOVED. FINER PARTICLES NOT REMOVED IN THE CYCLONE ARE REMOVED IN THE FILTER BED, AND CLEANED GAS IS DISCHARGED TO ATMOSPHERE. AT INTERVALS EACH FILTER BED IS BACKWASHED TO CLEAN OUT COLLECTED DUST. BACKWASH AIR IS FORCED UP THROUGH THE FILTER BED WHILE THE QUARTZ PEBBLE FILTER MEDIUM IS MECHANICALLY AGITATED BY RABBLE ARMS. DISLODGED DUST, WHICH HAS BEEN AGGLOMERATED IN THE FILTER BED, IS RECYCLED TO THE CYCLONES, WHERE AGGLOMERATED PARTICLES ARE REMOVED, AND FINES PASSING THE CYCLONE ARE FILTERED AGAIN.

GRAVEL

STACK DIMENSIONS, PORTS, AND SAMPLING POINTS

THE STACK LAYOUT AND SAMPLING POINT LOCATIONS ARE SHOWN IN FIGURE 2. THE STACK IS 48 INCHES SQUARE BY APPROXIMATELY 45 FEET IN OVERALL HEIGHT. SAMPLE PORTS WERE LOCATED 18 FEET FROM THE FLARED INLET DUCT AND 6 FEET UPSTREAM FROM THE STACK EXIT.

SAMPLE POINTS WERE LOCATED ON CENTERS OF 1 FOOT SQUARES AS SHOWN.

SAMPLING EQUIPMENT

THE SAMPLING EQUIPMENT USED WAS A MODEL 2343 "STAKSAMPLER", MANUFACTURED BY RESEARCH APPLIANCE COMPANY, ALLISON PARK, PENNSYLVANIA. A SCHEMATIC OF THE SAMPLING TRAIN, WHICH CONFORMS TO THE EPA PARTICULATE SAMPLING TRAIN IS SHOWN IN FIGURE 3.

PAUL LIME PLANT, INC.
STACK EMISSIONS ON NO. 5 KILN
JOB NO. 343-279
INVOICE NO. 40-1130

SAMPLING TESTS AND CONDITIONS

DUST SAMPLES WERE COLLECTED IN TESTS NO. 1, 2, AND 3 FOR 7 MINUTES, 30 SECONDS AT EACH OF 16 SAMPLE POINTS, FOR A TOTAL TEST TIME OF 120 MINUTES.

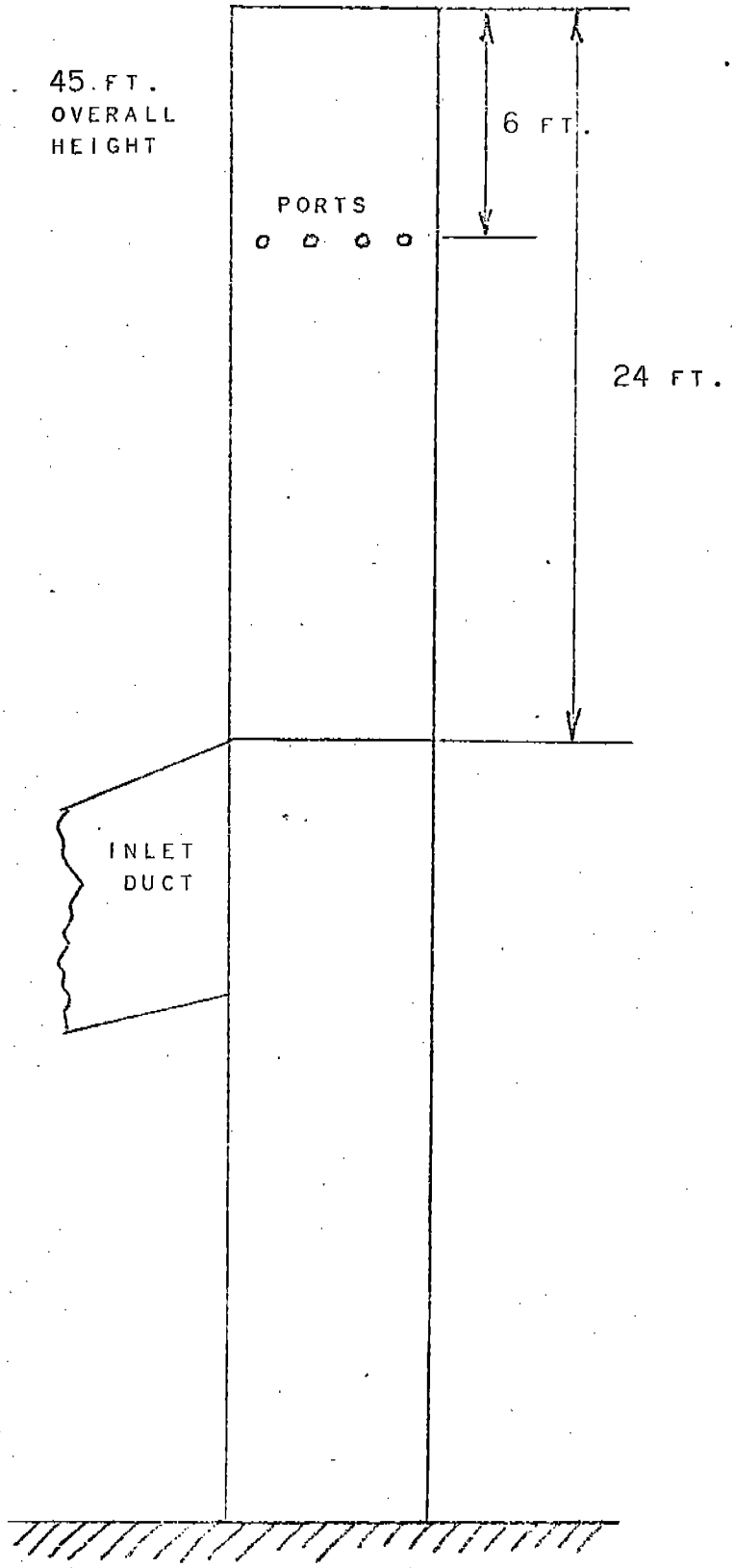
THE STACK FLOWRATE WAS DETERMINED BY PITOT TUBE MEASUREMENTS TAKEN DURING DUST SAMPLING. THE BACKWASH CYCLING APPARENTLY HAD NO MEASURABLE EFFECT ON THE STACK FLOWRATE.

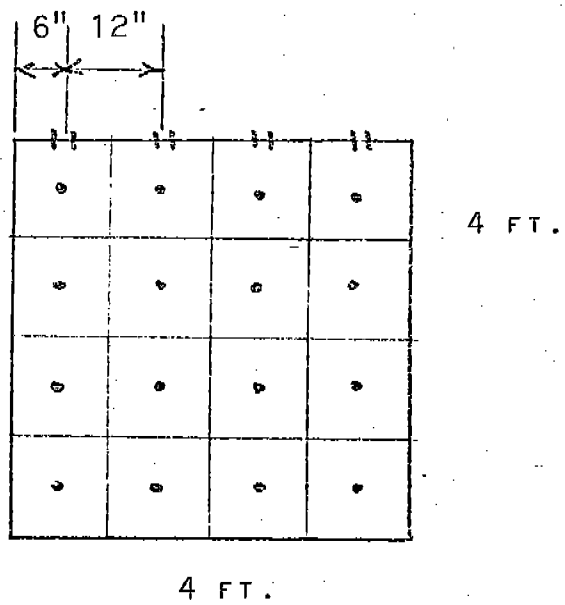
STACK MOISTURE WAS MEASURED DURING EACH TEST BY THE SUM OF CONDENSATION IN THE IMPINGERS AND COLLECTION IN SILICA GEL. CALCULATIONS ARE SHOWN IN APPENDIX 1.

IN THE INITIAL REPORT ON KILN NO. 4, AFTER DETAILED CALCULATIONS, THE AVERAGE STACK GAS DENSITY WAS FOUND TO BE ESSENTIALLY THAT OF AIR. THE NO. 5 KILN CALCULATIONS ASSUME THIS, AND A $G_D = 1.0$ IS USED FOR FLOWRATE CALCULATIONS.

FIGURE 2

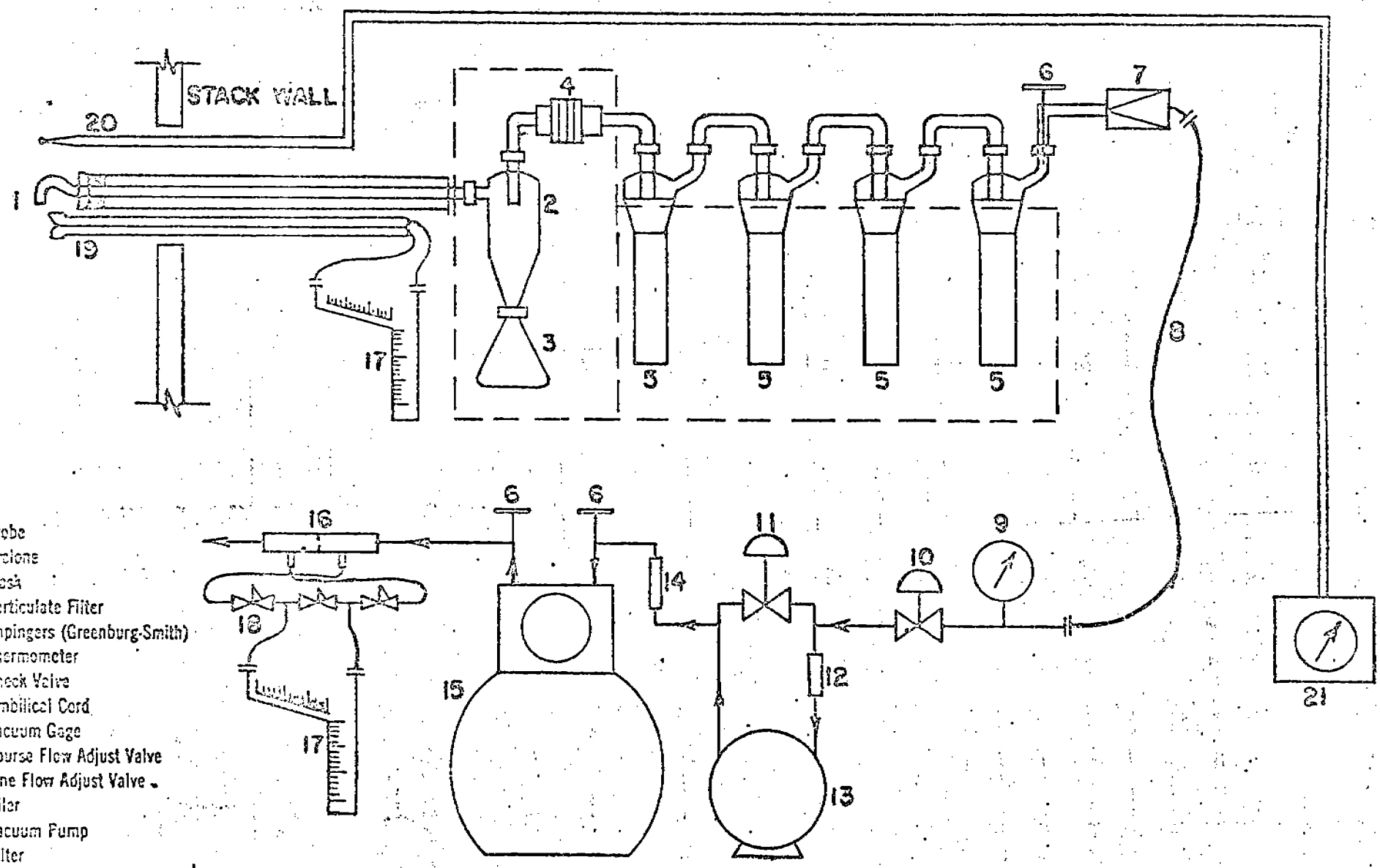
STACK LAYOUT AND SAMPLING POINT LOCATIONS





SAMPLE POINTS ARE ON CENTERS OF 1 FT. SQUARES

ETL



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

FIGURE 10

PROPERTY OF
RESEARCH APPLIANCE Co. ALLISON PARK, PA.

TOLERANCES DEC. ± FRACT. ±	TITLE STAKSAMPLER FLOW SYSTEM		
	DWG. NO. 1748	MATL	SCALE
NO. REQ'D	DRAWN BY R.G.	APPR.	DATE 6-27-69
FINISH		JIG NO.	PART NO.

JOB NO. 343-279

JOB: PAUL LIME PLANT, INC. DATE 6-6-73 TEST NO. 1

SAMPLING LOCATION: #5 KILN

PLANT CONDITIONS:

REFER TO BULLETIN WP-50 FOR TEST PROCEDURE, SAMPLING RATE AND FORMULAE USED:

TIME	SAMPLING POINT	GAS METER CU. FT.	GAS METER VAC. IN. Hg	GAS METER T. °F	METER RATE
PORT #1 0.0 MIN	1	0.06	3	92	
7.5	2	3.10	4	96	
15	3	6.56	5	99	
22.5	4	10.38	5	102	
PORT #2 30	1	14.37	2	107	
37.5	2	17.28	3	110	
45	3	20.27	4	111	
52.5	4	23.64	6	112	
PORT #3 60	1	27.53	2	113	
67.5	2	30.29	3	114	
75	3	33.19	5	115	
82.5	4	36.61	7	117	
PORT #4 90	1	40.46	4	118	
97.5	2	43.18	4	117	
105	3	46.07	6	120	
112.5	4	49.33	7	121	
120		52.92		120	
		52.86		111	

FLUE OR STACK PRESSURE: INCHES OF Hg. ABL. 26.10

METER TEMP. °F 111

METER VOLUME (C.F.) 52.86

FLUE OR STACK TEMPERATURE (°F) 400

SAMPLE NOZZLE DIA. (INCHES) 1/8

COLLECTION, ELAPSED TIME OF TEST (MINUTES) 120

WET BULB TEMPERATURE = N/A

DRY BULB TEMPERATURE = N/A

WATER VAPOR BY CONDENSATION 7.0 % BY VOLUME

WEIGHING DATA

	PROBE	FILTER NO.	IMPINGER NO.
GROSS	27.2919	8.0634	27.1903
TARE	27.2700	8.0162	27.1832
NET	0.0219	0.0472	0.0071

PROBE 0.0219

FILTER NO. 0.0472

IMPINGER NO. 0.0071

TOTAL WEIGHT OF PARTICULATES 0.0762

DUST CONCENTRATION CALCULATIONS

TOTAL METER VOL. = 52.86 + 3.98 = 56.84 CU. FT. (METER COND.)

METER CORR. = 56.84 × 860/571 × ____ = 85.61 CU. FT. (STACK COND.)

CONCENTRATION 0.0762 GM X 15.43 / 85.61 CU. FT. = 0.014 GR./CU. FT. (STACK COND.)

CALCULATED DUST LOAD: LBS./HR. = 0.014 GR/C.F. X 115,000 CFM X 60 / 7000 = 13.8

12.5 → 0.99 0.89

1.28 → 0.10 0.06

ETL Engineers Testing Laboratories, Inc.

JOB:

STACK FLOWRATE

PITOT TUBE TRAVERSE

TEST NUMBER: 1				TEST NUMBER:			
DATE: 6-6-73	TIME:			DATE:	TIME:		
FLUE OR STACK TEMPERATURE (°F) 400				FLUE OR STACK TEMPERATURE (°F)			
POINT	H.	$\sqrt{H.}$	VELOCITY FT./SEC.	POINT	H.	$\sqrt{H.}$	VELOCITY FT./SEC.
PORT #1							
1	2.10	1.449					
2	2.90	1.703					
3	3.40	1.844					
4	3.70	1.924					
PORT #2							
1	1.90	1.378					
2	2.00	1.414					
3	2.70	1.643					
4	3.60	1.897					
PORT #3							
1	1.70	1.304					
2	1.80	1.342					
3	2.70	1.643					
4	3.40	1.844					
PORT #4							
1	1.60	1.265					
2	1.80	1.342					
3	2.40	1.549					
4	3.20	1.789					
AVERAGE VELOCITY (FT./SEC.)			120	AVERAGE VELOCITY (FT./SEC.)			
FLUE OR STACK AREA (SQ. FT.)			16.0	FLUE OR STACK AREA (SQ. FT.)			
GAS VOLUME (CFM)			115,000	GAS VOLUME (CFM)			
AVERAGE GAS VOLUME (CFM)							

GAS VELOCITY DATA

TEST NUMBER	1	
PITOT TUBE CORRECTION FACTOR - F_s	.83	
DENSITY OF GAS REF. TO AIR - Gd	1.0	
FLUE OR STACK PRESSURE ("Hg) - Pa	26.10	
H_2O BY VOL., % CALCULATIONS	7.0	

TEST NUMBER: 1

$V_s = 2.9 (\quad F_s \quad) \sqrt{\frac{29.92}{Pa} \times \frac{1.00}{Gd} (\quad T_s \quad)} \sqrt{H}$

$P_a \times G_d = 26.10 \times 1.0 = 26.10$

$V_s = 2.9 (.83) \sqrt{\frac{29.92 \times 1.00}{(26.10)} (860)} \sqrt{H}$

$V_s = (75.6) \sqrt{H}$

PLANT CONDITIONS

MATERIAL PRODUCTION RATE

STACK CROSS SECTION IS 4 X 4 FT.

AVERAGE $\sqrt{H} = 1.583$

SEE PAGE _____ FOR FLUE OR STACK TRAVERSE LAYOUT.

JOB: PAUL LIME PLANT, INC. DATE 6-6-73 TEST NO. 2

SAMPLING LOCATION: #5 KILN

PLANT CONDITIONS:

REFER TO BULLETIN WP-50 FOR TEST PROCEDURE, SAMPLING RATE AND FORMULAE USED:

TIME	SAMPLING POINT	GAS METER CU. FT.	GAS METER VAC. IN. Hg	GAS METER T. °F	METER RATE
PORT #1 0.0 MIN.	1	52.92	2	104	
7.5	2	56.05	2	107	
15	3	59.46	3	109	
22.5	4	63.26	4	109	
PORT #2 30	1	67.29	2	111	
37.5	2	70.28	3	115	
45	3	73.29	3	118	
52.5	4	76.70	4	119	
PORT #3 60	1	80.59	2	116	
67.5	2	83.43	3	117	
75	3	86.34	4	116	
82.5	4	89.79	6	115	
PORT #4 90	1	93.69	2	114	
97.5	2	96.44	3	116	
105	3	99.25	4	115	
112.5	4	102.55	4	117	
120		106.10		118	
		53.18		114	

FLUE OR STACK PRESSURE: INCHES OF Hg. ABL. 26.00

METER TEMP. °F 114

METER VOLUME (C.F.) 53.18

FLUE OR STACK TEMPERATURE (°F) 405

SAMPLE NOZZLE DIA. (INCHES) 1/8

COLLECTION, ELAPSED TIME OF TEST (MINUTES) 120

WET BULB TEMPERATURE = N/A

DRY BULB TEMPERATURE = N/A

WATER VAPOR BY CONDENSATION 6.8 % BY VOLUME

WEIGHING DATA

	PROBE	FILTER NO.	IMPINGER NO.
GROSS	27.2502	8.6087	26.7669
TARE	27.2418	8.5625	26.7651
NET	0.0084	0.0462	0.0018

PROBE	0.0084
FILTER NO.	0.0462
IMPINGER NO.	0.0018
TOTAL WEIGHT OF PARTICULATES	0.0564

DUST CONCENTRATION CALCULATIONS

TOTAL METER VOL. = 53.18 + 3.88 = 57.06 CU. FT. (METER COND.)

METER CORR. = $57.06 \times \frac{865}{574} \times$ ____ = 85.99 CU. FT. (STACK COND.)

CONCENTRATION $\frac{0.0564 \text{ GM} \times 15.43}{85.99 \text{ CU. FT.}}$ = 0.010 GR./CU. FT. (STACK COND.)

CALCULATED DUST LOAD: LBS./HR. = $\frac{0.010 \text{ GR/C.F.} \times 115{,}000 \text{ CFM} \times 60}{7000}$ = 9.9

9.58 → 0.761
0.316 → 0.079

ETL Engineers Testing Laboratories, Inc.

JOB: PAUL-LIME-PLANT, INC., #3 KILN, JOB NO. [illegible]

STACK FLOWRATE

PITOT TUBE TRAVERSE

TEST NUMBER: 2				TEST NUMBER:			
DATE: 6-6-73	TIME:			DATE:	TIME:		
FLUE OR STACK TEMPERATURE (°F) 405				FLUE OR STACK TEMPERATURE (°F)			
POINT	H.	$\sqrt{H}$	VELOCITY FT./SEC.	POINT	H.	$\sqrt{H}$	VELOCITY FT./SEC.
PORT	#1						
1	2.20	1.483					
2	2.90	1.703					
3	3.60	1.897					
4	3.80	1.949					
PORT	#2						
1	2.00	1.414					
2	2.00	1.414					
3	2.70	1.643					
4	3.50	1.871					
PORT	#3						
1	1.70	1.304					
2	1.80	1.342					
3	2.70	1.643					
4	3.50	1.871					
PORT	#4						
1	1.60	1.265					
2	1.70	1.304					
3	2.50	1.581					
4	2.90	1.703					
AVERAGE VELOCITY (FT./SEC.)			120	AVERAGE VELOCITY (FT./SEC.)			
FLUE OR STACK AREA (SQ. FT.)			16.0	FLUE OR STACK AREA (SQ. FT.)			
GAS VOLUME (CFM)			115,000	GAS VOLUME (CFM)			
AVERAGE GAS VOLUME (CFM)							

GAS VELOCITY DATA

TEST NUMBER	2	
PITOT TUBE CORRECTION FACTOR - F_s	.83	
DENSITY OF GAS REF. TO AIR - Gd	1.0	
FLUE OR STACK PRESSURE ("Hg) - Pa	26.00	
H_2O BY VOL., %		

CALCULATIONS

TEST NUMBER: 2

$$V_s = 2.9 (\quad F_s \quad) \sqrt{\frac{29.92}{Pa} \times \frac{1.00}{Gd} (\quad T_s \quad)} \sqrt{H}$$

$$P_a \times G_d = 26.00 \times 1.0 = 26.00$$

$$V_s = 2.9 (.83) \sqrt{\frac{29.92 \times 1.00}{(26.00)} (865)} \sqrt{H}$$

$$V_s = (75.9) \sqrt{H}$$

PLANT CONDITIONS

MATERIAL PRODUCTION RATE

AVERAGE $\sqrt{H}$ = 1.587

SEE PAGE _____ FOR FLUE OR STACK TRAVERSE LAYOUT.

Engineers Testing Laboratories, Inc.

JOB: PAUL LIME PLANT, INC. DATE 6-7-73 TEST NO. 3

SAMPLING LOCATION: #5 KILN

PLANT CONDITIONS:

REFER TO BULLETIN WP-50 FOR TEST PROCEDURE, SAMPLING RATE AND FORMULAE USED:

TIME	SAMPLING POINT	GAS METER CU. FT.	GAS METER VAC. IN. Hg	GAS METER T. °F	METER RATE
PORT #1 0.0 MIN.	1	6.10	2	96	
7.5	2	9.19	3	96	
15.0	3	12.61	4	95	
22.5	4	16.54	3	98	
PORT #2 30	1	20.29	2	98	
37.5	2	23.25	2	100	
45	3	26.24	3	101	
52.5	4	29.67	5	102	
PORT #3 60	1	33.63	2	102	
67.5	2	36.42	3	103	
75	3	39.35	4	104	
82.5	4	42.79	5	105	
PORT #4 90	1	46.66	2	104	
97.5	2	49.27	3	106	
105	3	52.14	4	108	
112.5	4	55.46	5	110	
120		59.30		113	
		53.20		102	

FLUE OR STACK PRESSURE: INCHES OF Hg. ABL. 26.02

METER TEMP. °F 102

METER VOLUME (C.F.) 53.20

FLUE OR STACK TEMPERATURE (°F) 400

SAMPLE NOZZLE DIA. (INCHES) 1/8

COLLECTION, ELAPSED TIME OF TEST (MINUTES) 120

WET BULB TEMPERATURE = N/A

DRY BULB TEMPERATURE = N/A

WATER VAPOR BY CONDENSATION 6.6 % BY VOLUME

WEIGHING DATA

	PROBE	FILTER NO.	IMPINGER NO.
GROSS	27.5913	8.1080	27.4401
TARE	27.5741	8.0658	27.4396
NET	0.0172	0.0422	0.0005

PROBE	0.0172
FILTER NO.	0.0422
IMPINGER NO.	0.0005
TOTAL WEIGHT OF PARTICULATES	0.0599

DUST CONCENTRATION CALCULATIONS

TOTAL METER VOL. = 53.20 + 3.76 = 56.96 CU. FT. (METER COND.)

METER CORR. = 56.96 × 860/562 × ____ = 87.16 CU. FT. (STACK COND.)

CONCENTRATION = 0.0599 GM X 15.43 / 87.16 CU. FT. = 0.011 GR./CU. FT. (STACK COND.)

CALCULATED DUST LOAD: LBS./HR. = 0.011 GR/C.F. x 116,000 CFM X 60 / 7000 = 10.9

10.9 → 0.858

0.09 → 0.007

Engineers Testing Laboratories, Inc.

PITOT TUBE TRAVERSE

STACK FLOWRATE

TEST NUMBER: 3				TEST NUMBER:			
DATE: 6-7-73	TIME:			DATE:	TIME:		
FLUE OR STACK TEMPERATURE (°F) 400				FLUE OR STACK TEMPERATURE (°F)			
POINT	H.	$\sqrt{H}$	VELOCITY FT./SEC.	POINT	H.	$\sqrt{H}$	VELOCITY FT./SEC.
PORT #1							
1	2.20	1.483					
2	2.80	1.673					
3	3.70	1.924					
4	3.30	1.817					
PORT #2							
1	2.00	1.414					
2	2.00	1.414					
3	2.80	1.673					
4	3.70	1.924					
PORT #3							
1	1.70	1.304					
2	1.90	1.378					
3	2.80	1.673					
4	3.50	1.871					
PORT #4							
1	1.50	1.225					
2	1.80	1.342					
3	2.50	1.581					
4	3.40	1.844					
AVERAGE VELOCITY (FT./SEC.)			121	AVERAGE VELOCITY (FT./SEC.)			
FLUE OR STACK AREA (SQ. FT.)			16.0	FLUE OR STACK AREA (SQ. FT.)			
GAS VOLUME (CFM)			116,000	GAS VOLUME (CFM)			
AVERAGE GAS VOLUME (CFM)							

GAS VELOCITY DATA

TEST NUMBER	3	
PITOT TUBE CORRECTION FACTOR - F_s	.83	
DENSITY OF GAS REF. TO AIR - Gd	1.0	
FLUE OR STACK PRESSURE ("Hg) - Pa	26.02	
H_2O BY VOL., % CALCULATIONS	6.6	

TEST NUMBER: 3

$V_s = 2.9 (F_s) \sqrt{\frac{29.92}{Pa} \times \frac{1.00}{Gd} (T_s)} \sqrt{H}$

$P_a \times G_d = 26.02 \times 1.0 = 26.02$

$V_s = 2.9 (.83) \sqrt{\frac{29.92 \times 1.00}{(26.02)} (860)} \sqrt{H}$

$V_s = (75.7) \sqrt{H}$

PLANT CONDITIONS

MATERIAL PRODUCTION RATE

AVERAGE $\sqrt{H}$ = 1.596

SEE PAGE _____ FOR FLUE OR STACK TRAVERSE LAYOUT.

PAUL LIME PLANT, INC.
STACK EMISSIONS ON NO. 5 KILN
JOB NO. 343-279
INOIVCE NO. 40-1130

APPENDIX 1 - DETERMINATION OF STACK MOISTURE

A. WEIGHT OF WATER COLLECTED IN IMPINGERS

TEST		IMPINGER NO. 1	2	3	4	TOTAL
#1	AFTER	749.3	575.5	446.8	790.5	
	BEFORE	708.2	566.1	443.5	775.8	
	NET	41.1	9.4	3.3	14.7	68.5 GMS
#2	AFTER	750.8	578.8	447.0	762.3	
	BEFORE	709.8	571.7	444.4	747.6	
	NET	41.0	7.1	2.6	14.7	65.4 GMS
#3	AFTER	749.0	578.1	447.3	789.8	
	BEFORE	707.6	570.9	445.0	775.3	
	NET	41.4	7.2	2.3	14.5	65.4 GMS

B. CALCULATIONS OF % MOISTURE

$$\%H_2O = 100 \frac{V_V}{V_M + V_V}$$

V_M = DRY GAS METER VOLUME, METER CONDITIONS

V_V = WATER VAPOR VOLUME COLLECTED DURING TEST, CORRECTED TO METER CONDITIONS

$$V_V = (\text{GMS } H_2O)(0.00267) \frac{T_{METER}}{P_{METER}}$$

TEST	GMS H_2O COLLECTED	T_{METER}	P_{METER}	V_{METER}	V_V	$\%H_2O$
1	68.5	570°R	26.10 IN.HG	52.86 CF	3.99 CF	7.0%
2	65.4	574	26.00	53.18	3.86	6.8
3	65.4	562	26.10	53.20	3.76	6.6