**AP-42 Section Number:** 11.17

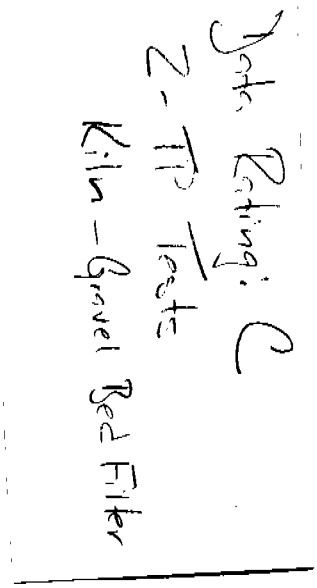
**Reference Number:** 32

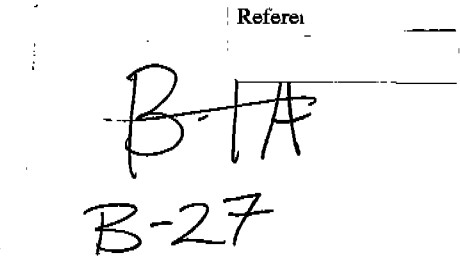
**Title:** Trip Report, Paul Lime Company, Douglas, AZ

Rovang, R. D.

US EPA

January 1973



4.3.1.6

ENVIRONMENTAL PROTECTION AGENCY
Office of Air Programs
Research Triangle Park, North Carolina 277

AP-42 Section 11.17
Reference 30
Report Sect. 4
Page 1

REPLY TO ATTN OF: OAQPS, ESED, ESB

DATE: June 27 1973

SUBJECT: Trip Report

TO: James F. Durham, Chief
Control Technology Section
Engineering Services Branch

I. Purpose

To investigate the first granular bed filter to go on line in the United States treating effluent gases from a lime kiln to remove particulates.

II. Place and Date

Paul Lime Company in Douglas, Arizona, on December 14, 1972.

III. Attendees

Howard Ames, Paul Lime Company - Plant Manager
Howard Gorball, Paul Lime Company
Bill Adams, EPA, State of Arizona
Alex Efimenko, EPA, State of Arizona
Richard Rovang, EPA, ESED

IV. Summary

The Paul Lime plant, which is located off Highway 80 between Bisbee and Douglas, Arizona, has been in operation for approximately seventy years. Five lime kilns are located at this facility, however, only the two largest units are in operation. These units are medium size producing 220 and 340 tons of lime per day respectively and both are gas fired. The plant is located immediately adjacent to the limestone quarry which yields rock composed of about 90 percent calcium carbonate. From the quarry, the rock goes directly to a crushing and screening operation from which emissions are controlled by use of bag filters. No visible emissions were evident from these filters. After the crushing and screening operation, the rock is either stock piled or goes to a kiln. The maximum size of this rock is one and one half inches in diameter. Most of the lime which leaves the kiln and cooler is sold in that form, however, some of it is pulverized and hydrated.

At the present time, the effluent from one kiln is controlled while the other is not. The controlled kiln, which is the smaller of the two (220 ton/day) and designated as the #4 kiln, uses a granular bed filter to reduce particulate emissions to the atmosphere. The kiln itself is

six years old and the granular bed filter has been in operation since April, 1972. This granular bed filter is the first of its kind in the United States and is manufactured and marketed by the Rex Chainbelt Company of Louisville, Kentucky.

The filter system at Paul Lime consists of eight granular beds in parallel which operate in 56-60,000 actual cubic feet of gas per minute at 700°F. The granular beds are made up of pea size quartz gravel four to five inches deep. The gravel is highly wear resistant and was claimed to never need replacement. Cost of the gravel is approximately $100/ton. The power which is required by this system is supplied by eight 7-1/2 hp motors which turn the agitator rakes and a 300 hp blower. Presently, there is a 25-26 inch pressure drop across the system but is expected to be reduced to 14-16 inches by the addition of two more beds. The labor involved in operating the system is almost negligible under normal operation and only low maintenance is required. The system was said to be checked about once a shift to insure proper operation. The existing collection system removes 149 pounds of particulates per hour. A sample of collected particulate was taken and analyzed by EPA for particulate size distribution using a Coulter Counter. The results of this analysis were put in graphical form and are attached. The mean particle size of the sample is about 11 microns, which is relatively large. The opacity of the stack was 20 percent during the visit with ambient temperatures in the thirties and the sky being partly cloudy. The plant manager indicated that this opacity was normal although at times minor puffing can be observed when cleaning cycles are switched, however, this was not observed during the visit.

Start-up and shutdown procedures for the filters were said to be relatively simple. When the filter beds are started up the gas stream initially bypasses the beds and the flow rate through the beds is gradually increased until full flow is obtained. This procedure generally takes about thirty minutes. The function of the gradual increase is to raise the temperature of the bed to avoid water condensation. If water condensation does occur in the bed, agglomeration of the gravel is likely due to the hydration of lime. If this happens the bed must be shutdown and cleaned by use of an air lance. The shutdown procedure consists of running the gravel rakes continuously for two hours after the gas stream has been eliminated to thoroughly clean the beds.

The granular bed filters occupied a small area relative to the amount of gas treated and had a total cost of $166,000. Installation of the existing gas cleaning equipment after the steel frame structure had been completed, had taken ten days using a three man crew. Total installation time was said to be one month. A granular bed filter will be installed on the larger kiln within the next two months and will treat 130,000-150,000 actual cubic feet of gas per minute. The unit will consist of fourteen dual bed filters in parallel for a total of twenty-eight filter beds in the system.

Particulate emission tests using EPA Method 5 were run which indicated that emissions after the filter were 0.05 gr/SCF or 15 lb/hr for a process weight of 15 tons/hour. A copy of this test was obtained (see attachment) and further test information on the cursching and screening operation will be sent. These tests were performed by Engineers Testing Laboratories, Inc. of Phoenix, Arizona. Seven additional tests were run by Paul Lime Co. which gave emission readings ranging from a minimum of 0.014 gr/ACF to a maximum of 0.033 gr/ACF. At standard conditions this would be a range of 0.021 to 0.052 gr/SCF.

Another granular bed filter has come on line during the first week of January, 1973. This unit is located in Waukesha, Wisconsin and operates on 55,000 acfm of gas at 600°F from an iron cupola. The gas comes off the cupola at approximately 1000°F but is cooled by a considerably long run of duct work before entering the filter. Two more granular bed filters are expected to come on line in April, 1973, in Tampa, Florida, at the General Portland Cement plant. These units will operate on gases from clinker coolers at 700°F and capacities of 180,000 and 100,000 acfm. In March of 1973, Harbison-Walker Refractory Company expects to have a granular bed filter on line in Eufaula, Alabama. This unit will be operating on a refractory kiln with 113,000 acfm of gas at 900°F. Emission data from these facilities should be obtained once in normal operation and tests are completed.

The use of granular bed filters to remove particulate matter from gas streams before being emitted to the atmosphere is especially applicable where high temperatures are involved. In this area, granular bed filters have a distinct advantage over fabric filters which are limited by the temperatures which can be withstood by the fabrics. Granular beds are limited only by the temperatures which can be withstood by the material of construction, which is usually mild steel. However, if extremely high temperatures are required, high temperature alloys can be used. From initial testing on single bed filters, it appears as though granular beds do not achieve as low of grain loading as do fabric filters. In addition, the ability of granular bed filters to efficiently collect smaller particles has yet to be demonstrated. Double bed filters may be more efficient, however, tests on these have not been run but should be completed within the next two months.

Richard D. Rovang
Control Technology Section
Engineering Services Branch

cc: Mr. D. Harmon
Mr. N. Plaks

Richard Forrey

**COULTER COUNTER® Model T** — **PARTICLE SIZE ANALYSIS** — .15 – 200μ LOG PROBABILITY

COULTER ELECTRONICS
590 W. 20TH ST.
HIALEAH, FLA. 33010

ORGANIZATION

OPERATOR R.O.

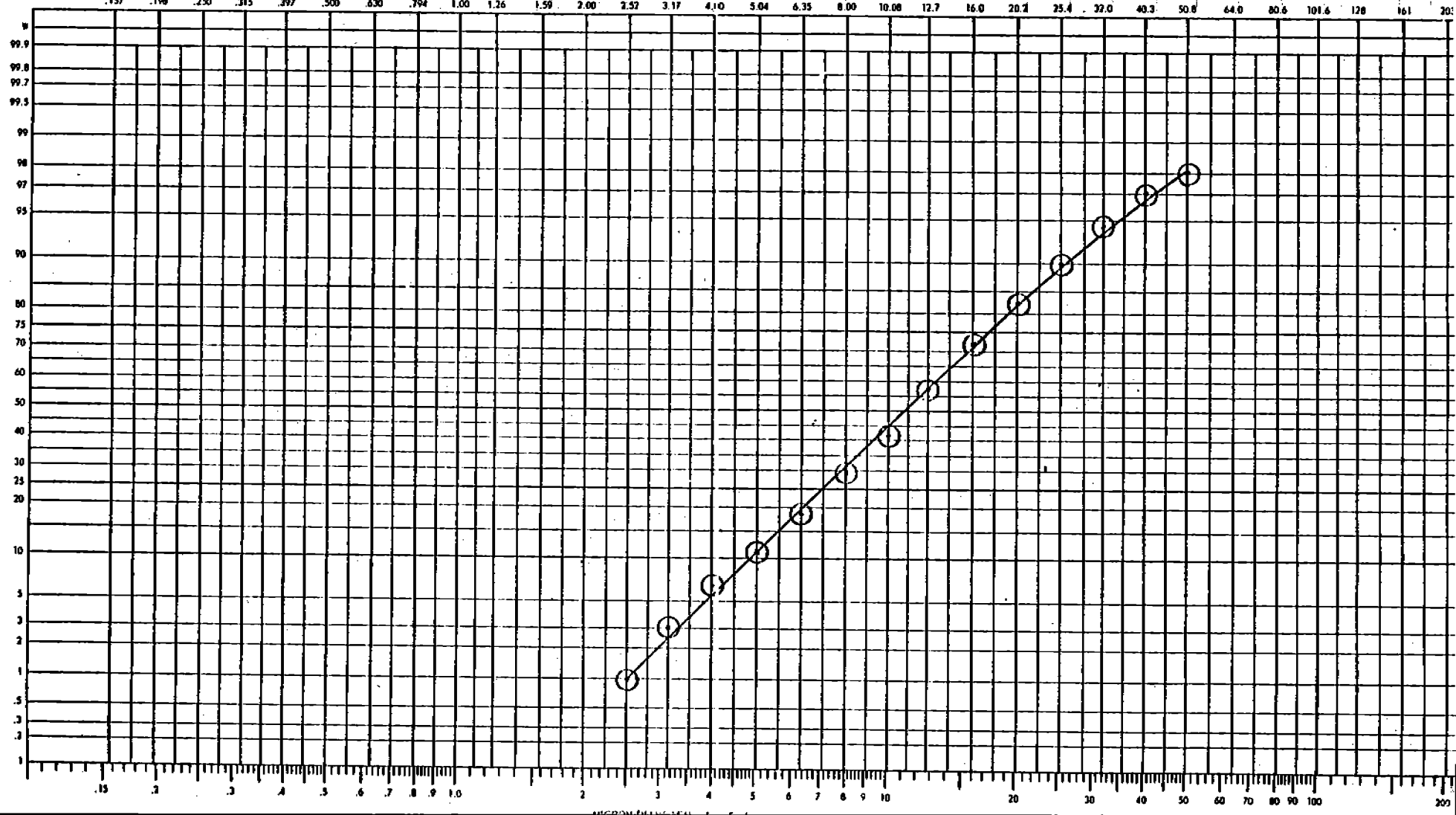
EQUIPMENT Model T

SAMPLE $CaCO_4$ & CaO ELECTROLYTE $Na_4P_2O_7$ DISPERSANT

$k = d\sqrt[3]{\frac{2\pi}{A}}$ $\frac{A_2}{A_1} = \left(\frac{d_2}{d_1}\right)^3$ when $W_2 = W_1$

| APER. SIZE | SERIAL | | PART DIA. | W | ± fA | A |
|---|---|---|---|---|---|---|
| 1401 | 6400 | | 19.5 | 4 | 3.2 | 200 |

| SAMPLE SETTINGS | | |
|---|---|---|
| DIA | W | ± fA |
| 30 | 4 | 3.2 |



Engineers Testing Laboratories, Inc.

2525 E. Indian School Rd. 264-4781 Phoenix, Arizona 85016

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H. E. HARTIG, P.S.
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REC'D. P. H.

SEP 2 - 1972

26 SEPTEMBER 1972

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

ATTENTION: HOWARD AMES, JR.
GENERAL MANAGER

RE: STACK EMISSIONS ANALYSIS ON NO. 4 KILN
RESAMPLE AFTER CHANGE OF FILTER
MEDIUM IN DUST CONTROL SYSTEM

JOB NO. 243-443
INVOICE NO. 40-807

ENCLOSED ARE THE RESULTS OF THE STACK EMISSIONS ANALYSIS PERFORMED SEPTEMBER 20, 1972 ON THE DUST COLLECTION SYSTEM FOR THE NUMBER 4 KILN OF YOUR LIME PLANT FOLLOWING THE CHANGE OF THE FILTER MEDIUM IN THE DUST CONTROL SYSTEM. THIS REPORT IS A SUPPLEMENT TO THE INITIAL STACK EMISSIONS ANALYSIS ON NO. 4 KILN REPORTED ON 29 JULY 1972 AS JOB NO. 240-386.

SUMMARY OF RESULTS

TEST NO. 4. . . . . 15 LBS. PARTICULATES PER HOUR
TEST NO. 5. . . . . 15 LBS. PARTICULATES PER HOUR

THE KILN OPERATED AT A RATE OF 15 TONS PER HOUR DURING THE TEST PERIOD. THE STATE OF ARIZONA PARTICULATE EMISSIONS STANDARD IS APPROXIMATELY 25 LBS. PER HOUR FOR THE 15 TONS PER HOUR PROCESS RATE.

RESPECTFULLY SUBMITTED,
ENGINEERS TESTING LABORATORIES, INC.

BY: R. L. Maurice
R. L. MAURICE, JR.

AND Peter F. Allard
PETER F. ALLARD, P.E.
9-27-72

/FJ

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

PAGE LIME PLANT, INC.
STACK EMISSIONS ANALYSIS ON NO. 4 KILN
JOB NO. 243-443

## INTRODUCTION

THE FILTER MEDIUM IN THE DUST COLLECTORS ON NO. 4 KILN HAS BEEN CHANGED SINCE THE INITIAL STACK EMISSIONS ANALYSIS PERFORMED ON 19 AND 20 JULY 1972. THIS REPORT, WHICH IS A SUPPLEMENT TO THE INITIAL ANALYSIS REPORTED ON 29 JULY 1972 AS JOB NO. 240-386, GIVES THE RESULTS OF SAMPLES OBTAINED ON 20 SEPTEMBER 1972 FOLLOWING THE CHANGE IN FILTER MEDIUM.

THE PROCESS FLOW IS AS DESCRIBED IN THE REPORT OF 29 JULY 1972.

## STACK DIMENSIONS, PORTS, AND SAMPLING POINTS

THE STACK DIMENSIONS, SAMPLING PORTS, AND SAMPLING POINTS WERE THE SAME AS IN THE INITIAL TEST.

## SAMPLING EQUIPMENT

THE SAMPLING EQUIPMENT USED WAS A MODEL 2343 "STAKSAMPLER", MANUFACTURED BY RESEARCH APPLIANCE COMPANY, ALLISON PARK, PENNSYLVANIA.

## SAMPLING TESTS AND CONDITIONS

THE DUST SAMPLE FOR TEST NUMBER 1 WAS COLLECTED FOR 7 MINUTES, 30 SECONDS AT EACH OF 16 SAMPLING POINTS FOR A TOTAL PERIOD OF 120 MINUTES. THE DUST SAMPLE FOR TEST NUMBER TWO WAS COLLECTED FOR 3 MINUTES, 45 SECONDS AT EACH OF 16 SAMPLING POINTS FOR A TOTAL OF 60 MINUTES.

## STACK FLOWRATE DETERMINATION

THE STACK FLOW RATE WAS DETERMINED BY THE PITOT TUBE MEASUREMENTS TAKEN DURING DUST SAMPLING.

THE CHANGE IN STACK FLOW RATES DURING THE BACKWASH CYCLE NOTED IN PREVIOUS TESTING WAS NOT OBSERVED DURING THESE TESTS. A BRIEF FLOWRATE CHANGE OF A FEW SECONDS WAS NOTED DURING THE CHANGE OVERS FROM NORMAL OPERATION TO BACKWASH. THIS CHANGE WAS JUDGED TO HAVE AN INSIGNIFICANT EFFECT ON STACK FLOWRATE AND WAS NOT INCLUDED IN STACK FLOWRATE CALCULATIONS.

THE STACK FLOWRATE WAS LOWER THAN THAT MEASURED DURING PREVIOUS TESTS, DUE TO A CHANGE IN FAN SPEED.

| TEST | DATE | T | P | CFM, STACK CONDITIONS |
|---|---|---|---|---|
| 2 | 7-19-72 | 340°F | 25.60 IN. HG | 60,700 |
| 3 | 7-20-72 | 370 | 25.58 | 58,700 |
| 4 | 9-20-72 | 360 | 25.80 | 51,300 |
| 5 | 9-20-72 | 360 | 25.64 | 51,500 |

STACK MOISTURE DETERMINATION

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

## Appendix 1. Determination of Stack Moisture

### A. Weight of Water Collected in Impingers

| Test | | Impinger No. 1 | 2 | 3 | 4 | Total |
|---|---|---|---|---|---|---|
| #4 | After | 768.5 gm | 582.8 gm | 457.0 gm | 745.8 gm | |
| | Before | 722.7 | 571.1 | 453.8 | 723.2 | |
| | Net | 45.8 | 11.7 | 3.2 | 22.6 | 83.3 gm |
| #5 | After | 740.2 gm | 575.6 gm | 457.1 gm | 807.8 gm | |
| | Before | 710.9 | 568.4 | 455.0 | 793.1 | |
| | Net | 29.3 | 7.2 | 2.1 | 14.7 | 53.3 gm |

### B. Calculation of % Moisture

$$\% H_2O = 100 \quad \frac{Vv}{Vm + Vv}$$

Vm = Dry Gas Meter Volume, meter conditions

Vv = Water Volume collected during test, corrected to meter conditions

$$Vv = (\text{gms. } H_2O)\ (0.00267)\ \frac{T \text{ meter, } {}^{o}R}{P \text{ meter, in. Hg}}$$

| Test | gms. $H_2O$ Collected | T meter | P meter | V meter | Vv | % $H_2O$ |
|---|---|---|---|---|---|---|
| 4 | 83.3 gm | 560°R | 25.80 in Hg | 81.66 cf | 4.83 | 5.58 |
| 5 | 53.3 | 569 | 25.64 | 40.07 | 3.16 | 7.29 |

MPLING LOCATION: [illegible]

ANT CONDITIONS: 15 TONS PER HOUR

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

| TIME | SAMPLING POINT | GAS METER | | | METER RATE |
|---|---|---|---|---|---|
| | | CU. FT. | VAC. IN. Hg | T. °F | |
| 0 | PORT 1 | 196.13 | | 74 | |
| :30 | 1 | 200.65 | 5 | 78 | |
| 5:00 | 2 | 205.70 | 7.5 | 84 | |
| 2:30 | 3 | 210.38 | 8 | 89 | |
| 0:00 | 4 | 216.36 | 7.5 | 93 | |
| 7:30 | 5 | 221.37 | 7.5 | 97 | |
| 5:00 | 6 | 226.45 | 7.5 | 101 | |
| 2:30 | 7 | 231.44 | 7.5 | 106 | |
| 0:00 | 8 | 236.40 | 7.5 | 106 | |
| ) | PORT 2 | | | 98 | |
| :30 | 1 | 240.80 | 5 | 103 | |
| 5:00 | 2 | 245.78 | 7.5 | 106 | |
| 2:30 | 3 | 251.15 | 9 | 111 | |
| 0:00 | 4 | 256.57 | 9 | 112 | |
| 7:30 | 5 | 261.97 | 9 | 115 | |
| 5:00 | 6 | 267.44 | 9 | 111 | |
| 2:30 | 7 | 272.90 | 9 | 110 | |
| 0:00 | 8 | 277.79 | 7.5 | 108 | |

FLUE OR STACK PRESSURE: INCHES OF Hg. ABS. 25.80

FLUE OR STACK TEMP. °F OR °C 360

METER VOL. (C.F.M.) 81.66

METER TEMP. (°F) 100

SAMPLE NOZZLE DIA. (INCHES) 0.188

COLLECTION, ELAPSED TIME OF TEST (MINUTES) 120

WET BULB TEMPERATURE = [illegible]

DRY BULB TEMPERATURE = 360

CALCULATED MOISTURE = 5.58 % BY VOLUME

WEIGHING DATA

| | CYCLONE NO. | FILTER NO. 1 | IMPINGER NO. 1 |
|---|---|---|---|
| GROSS | | 8.3563 | |
| TARE | | 8.1996 | |
| NET | | 0.1567 | 0.1263 |

CYCLONE NO.

FILTER NO. 0.1567

IMPINGER NO. 0.1263

TOTAL WEIGHT OF PARTICULATES .2830

DUST CONCENTRATION CALCULATIONS

TOTAL METER VOL. = 81.66 + 4.83 = 86.49 CU. FT. (METER COND.)

METER CORR. $86.49 \times \frac{1}{} \times \frac{820}{560} = 126.65$ CU. FT. (STACK COND.)

CONCENTRATION $\frac{.283 \text{ GM} \times 15.43}{126.65 \text{ CU. FT.}} = 0.034$ GR./CU. FT. (STACK COND.)

CALCULATED DUST LOAD: LBS./HR. = $\frac{0.034 \text{ GR/C.F.} \times 51,300 \text{ CFM} \times 60}{7000} = 15$

ETL Engineers Testing Laboratories, Inc.

PAUL LINE CO.
9/20/72

BACKGROUND
REF 27

TEST 4

FILTER: $0.1567 \text{ grams} \times 15.47 \frac{\text{grains}}{\text{gram}} \times \frac{1}{126.65 \text{ ft}^3} \times \left(\frac{57,300}{7000} \frac{\text{lb}}{\text{min}}\right) \frac{\text{ft}^3}{\text{gram}}$

$\times 60 \frac{\text{min}}{\text{hr}} = 8.41637 \frac{\text{lb PM}}{\text{hr}} \times \frac{1 \text{ hr}}{15 \text{ tons product}} = 0.56 \frac{\text{lb FILT PM}}{\text{ton product}}$

IMPINGER: $0.1263 \text{ grams} \times 15.47 \frac{\text{grains}}{\text{grams}} \times \frac{1}{126.65 \text{ ft}^3} \times \left(\frac{51,300}{7000} \frac{\text{lb}}{\text{min}}\right) \frac{\text{ft}^3}{\text{gram}}$

$\times 60 \frac{\text{min}}{\text{hr}} = 6.78358 \frac{\text{lb}}{\text{hr}} \times \frac{1 \text{ hr}}{15 \text{ tons product}} = 0.45 \frac{\text{lb IMP}}{\text{ton product}}$

TEST 5

FILTER: $0.0798 \text{ grams} \times 15.47 \frac{\text{grain}}{\text{gram}} \times \frac{1}{62.28 \text{ ft}^3} \times \left(\frac{51,500}{7000}\right) \frac{\text{lb}}{\text{min}} \frac{\text{ft}^3}{\text{gram}} \times \frac{60 \text{ min}}{\text{hr}}$

$= 8.74994 \frac{\text{lb}}{\text{hr}} \times \frac{1 \text{ hr}}{15 \text{ ton product}} = 0.5833 \frac{\text{lb FILT}}{\text{ton product}}$

IMPINGER: $0.0628 \text{ grams} \times 15.47 \frac{\text{grain}}{\text{gram}} \times \frac{1}{62.28 \text{ ft}^3} \times \left(\frac{51,500}{7000}\right) \frac{\text{lb}}{\text{min}} \frac{\text{ft}^3}{\text{gram}} \times \frac{60 \text{ min}}{\text{hr}} =$

$= 6.88592 \frac{\text{lb}}{\text{hr}} \times \frac{1 \text{ hr}}{15 \text{ ton product}} = 0.469 \frac{\text{lb inorganic PM}}{\text{ton product}}$

| | |
|---|---|
| FILT RANGE : 0.56 – 0.58 | AVG : 0.57 lb/ton |
| INORGAN : 0.45 – 0.47 | AVG : 0.46 lb/ton |

PLING LOCATION: PAUL SPEER, ARIZONA

N CONDITIONS: 15 TONS PER HOUR

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

| TIME | SAMPLING POINT | GAS METER | | | METER RATE |
|---|---|---|---|---|---|
| | | CU. FT. | VAC. IN. Hg | T. °F | |
| 0 | PORT 1 | 277.79 | | 96 | |
| :45 | 1 | 280.08 | 7 | 98 | |
| :30 | 2 | 282.56 | 8 | 101 | |
| 1:15 | 3 | 284.40 | 8 | 104 | |
| 5:00 | 4 | 287.65 | 9 | 105 | |
| 3:45 | 5 | 290.30 | 10 | 105 | |
| 2:30 | 6 | 292.15 | 10 | 105 | |
| 3:15 | 7 | 294.71 | 10 | 108 | |
| 0:00 | 8 | 297.89 | 10 | 111 | |
| 0 | PORT 2 | | | 107 | |
| :45 | 1 | 299.88 | 5 | 107 | |
| :30 | 2 | 302.22 | 9 | 110 | |
| 1:15 | 3 | 304.05 | 10 | 111 | |
| 5:00 | 4 | 307.32 | 12 | 114 | |
| 8:45 | 5 | 309.95 | 12 | 116 | |
| 2:30 | 6 | 311.91 | 13 | 117 | |
| 6:15 | 7 | 315.35 | 14 | 120 | |
| 0:00 | 8 | 317.86 | 15 | 120 | |

FLUE OR STACK PRESSURE: INCHES OF Hg. ABS. 25.64

FLUE OR STACK TEMP. °F OR °C 360

METER VOL. (C.F.M.) 40.07

METER TEMP. (°F) 109

SAMPLE NOZZLE DIA. (INCHES) 0.188

COLLECTION, ELAPSED TIME OF TEST (MINUTES) 60

WET BULB TEMPERATURE =

DRY BULB TEMPERATURE = 360

CALCULATED MOISTURE 7.29 % BY VOLUME

WEIGHING DATA

| | CYCLONE NO. | FILTER NO. 2 | IMPINGER NO. 2 |
|---|---|---|---|
| GROSS | | 8.0206 | |
| TARE | | 7.9408 | |
| NET | | 0.0798 | 0.0628 |

CYCLONE NO.

FILTER NO. 2 0.0798

IMPINGER NO. 2 0.0628

TOTAL WEIGHT OF PARTICULATES .1426

DUST CONCENTRATION CALCULATIONS

TOTAL METER VOL. = 40.07 + 3.15 = 43.22 CU. FT. (METER COND.)

METER CORR. = $43.22 \times \frac{1}{569} \times 820 = 62.28$ CU. FT. (STACK COND.)

CONCENTRATION $\frac{.1426 \text{ GM} \times 15.43}{62.28 \text{ CU. FT.}} = 0.035$ GR./CU. FT. (STACK COND.)

CALCULATED DUST LOAD LBS./HR. = $0.035 \text{ GR/C.F.} \times \frac{51,500 \text{ CFM} \times 60}{7000} = 15$

ETL Engineers Testing Laboratories, Inc.

# STACK FLOWRATE

| TEST NUMBER: 4 | | | |
|---|---|---|---|
| DATE: 9-20-72 TIME: | | | |
| FLUE OR STACK TEMPERATURE (°F) 360 | | | |
| POINT | H. | $\sqrt{H.}$ | VELOCITY FT./SEC. |
| PORT 1 | | | |
| 1 | 1.10 | 1.049 | |
| 2 | 1.50 | 1.225 | |
| 3 | 1.65 | 1.285 | |
| 4 | 1.50 | 1.225 | |
| 5 | 1.35 | 1.162 | |
| 6 | 1.40 | 1.183 | |
| 7 | 1.40 | 1.183 | |
| 8 | 1.30 | 1.140 | |
| | | | |
| | | | |
| AVERAGE | | 1.184 | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| AVERAGE VELOCITY (FT./SEC.) | | | 88.9 |
| FLUE OR STACK AREA (SQ. FT.) | | | 9.62 |
| GAS VOLUME (CFM) | | | 51300 |

| TEST NUMBER: | | | |
|---|---|---|---|
| DATE: TIME: | | | |
| FLUE OR STACK TEMPERATURE (°F) | | | |
| POINT | H. | $\sqrt{H.}$ | VELOCITY FT./SEC. |
| PORT 2 | | | |
| 1 | .97 | .985 | |
| 2 | 1.40 | 1.183 | |
| 3 | 1.55 | 1.245 | |
| 4 | 1.50 | 1.225 | |
| 5 | 1.50 | 1.225 | |
| 6 | 1.55 | 1.245 | |
| 7 | 1.60 | 1.265 | |
| 8 | 1.25 | 1.118 | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| AVERAGE VELOCITY (FT./SEC.) | | | |
| FLUE OR STACK AREA (SQ. FT.) | | | |
| GAS VOLUME (CFM) | | | |

AVERAGE GAS VOLUME (CFM)

GAS VELOCITY DATA

| | | |
|---|---|---|
| TEST NUMBER | 4 | |
| PITOT TUBE CORRECTION FACTOR - $F_s$ | 0.84 | |
| DENSITY OF GAS REF. TO AIR - Gd | 1 | |
| FLUE OR STACK PRESSURE ("Hg) - Po | 25.80 | |

$H_2O$ BY VOL., %

CALCULATIONS

TEST NUMBER: _____

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

$P_o \times G_d = 25.80 \times 1.00 = 25.80$

$$V_s = 2.9 \left( .84 \right) \sqrt{\frac{29.92 \times 1.00}{25.80} \left( .820 \right)} \sqrt{H}$$

$$V_s = \left( 75.1 \right) \sqrt{H}$$

PLANT CONDITIONS

MATERIAL PRODUCTION RATE

SEE PAGE _____ FOR FLUE OR STACK TRAVERSE LAYOUT.

PITOT TUBE TRAVERSE

TEST NUMBER: 5

DATE: 9-20-72 TIME:

FLUE OR STACK TEMPERATURE (°F) 360

| POINT | H. | $\sqrt{H}$ | VELOCITY FT./SEC. |
|---|---|---|---|
| PORT 1 | | | |
| 1 | 1.15 | 1.072 | |
| 2 | 1.40 | 1.183 | |
| 3 | 1.45 | 1.204 | |
| 4 | 1.55 | 1.245 | |
| 5 | 1.50 | 1.225 | |
| 6 | 1.45 | 1.204 | |
| 7 | 1.40 | 1.183 | |
| 8 | 1.35 | 1.162 | |
| | | 9.478 | |
| | | | |
| AVERAGE | | 1.185 | |
| | | | |
| | | | |
| AVERAGE | | 1.183 | |
| | | | |
| | | | |
| | | | |
| AVERAGE VELOCITY (FT./SEC.) | | | 89.2 |
| FLUE OR STACK AREA (SQ. FT.) | | | 9.62 |
| GAS VOLUME (CFM) | | | 51500 |

TEST NUMBER:

DATE: TIME:

FLUE OR STACK TEMPERATURE (°F)

| POINT | H. | $\sqrt{H}$ | VELOCITY FT./SEC. |
|---|---|---|---|
| PORT 2 | | | |
| 1 | 0.97 | .985 | |
| 2 | 1.25 | 1.118 | |
| 3 | 1.40 | 1.183 | |
| 4 | 1.50 | 1.225 | |
| 5 | 1.60 | 1.265 | |
| 6 | 1.50 | 1.225 | |
| 7 | 1.55 | 1.245 | |
| 8 | 1.45 | 1.204 | |
| | | 9.450 | |
| | | | |
| | | 1.181 | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| AVERAGE VELOCITY (FT./SEC.) | | | |
| FLUE OR STACK AREA (SQ. FT.) | | | |
| GAS VOLUME (CFM) | | | |

AVERAGE GAS VOLUME (CFM)

## STACK FLOWRATE

GAS VELOCITY DATA

| | | |
|---|---|---|
| TEST NUMBER | 5 | |
| PITOT TUBE CORRECTION FACTOR - $F_s$ | 0.84 | |
| DENSITY OF GAS REF. TO AIR - Gd | 1 | |
| FLUE OR STACK PRESSURE ("Hg) - Pa | 25.64 | |

$H_2O$ BY VOL., % CALCULATIONS

TEST NUMBER: _____

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

$P_a \times G_d =$ _____ X _____ = _____

$V_s = 2.9 ( .84 ) \sqrt{\frac{29.92 \times 1.00}{25.64} ( .820 )} \sqrt{H}$

$V_s = ( 75.4 ) \sqrt{H}$

PLANT CONDITIONS

MATERIAL PRODUCTION RATE

SEE PAGE _____ FOR FLUE OR STACK TRAVERSE LAYOUT.