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.

Background Report Reference

AP-42 Section Number: 11.17

Background Chapter: 4

Reference Number: 41

Title: Stack Sampling Report at Texas Lime, Cleburne Texas

Texas State Department of Health

Texas State Department of Health

August 1972

(41)

Sampling on #1 kiln non-isokinetic

see NEDS data (2 plants?)

Stack Sampling Report

at

Texas Lime
Cleburne, Texas
August 1-3, 1972

NOT USED
NO PROCESS DATA

Conducted by

Texas State Department of Health
Air Pollution Control Services
Technical Programs

TABLE OF CONTENTS

	Page
Introduction	1
Conclusion	1
Background Information	1
Summary of Results	2
Sample Calculations	4
Computer Printout	
Begins on page	10
Average results	
1. Number one lime kiln	16
2. Number three lime kiln	23
Appendices	
A. Laboratory Report	24
B. Sampling Data and Plant Operational Status	25

No. 1 Plant

Introduction

The two stacks at Texas Lime, Cleburne Texas were sampled to determine if the stacks were in compliance with Regulation I of the Texas Air Control Board covering particulate emissions.

Conclusion

At the time of sampling neither of the two stacks sampled were in violation of Regulation I for particulate emissions. The average pollutant mass rate for the number one lime kiln stack was 5.5 lbs/hr while the average allowable pollutant emission rate was 32.5 lbs/hr. The average pollutant mass rate for the number three lime kiln stack was 5.8 lbs/hr while the average allowable pollutant emission rate was 27.3 lbs/hr.

Background Information

The two stacks were sampled by a stack sampling team from the Technical Programs Group of the Air Pollution Control Services. Mr. John Key, Engineering Assistant I , was in charge of the stack sampling team.

The process of the two kilns at Texas Lime produces calcium oxide from calcium carbonate through a heating process. The abatement equipment for each of the two stacks are wet scrubbers. During the time of sampling the plant was operating at 100% of normal capacity.

New Regulations

The average allowable pollutant mass rate, as calculated by the new regulations, was 26.56 for the number one lime kiln and 31.30 lbs/hr for the number three lime kiln.

Comment

It is recognized that the divergence from a 100% isokinetic condition which was experienced in the sampling of the number one lime kiln stack is excessive to the standards normally demanded by this office. The wide margin by which this process was found to be within compliance limits however, did not justify a re-execution of the sampling process at this time.

Texas Lime Cleburne, Texas

Number One Lime Kiln

SUMMARY OF RESULTS

Average Percent Water	31.80	%
Average Specific Heat	.2860	Btu/lb °F
Average Density of Stack Gas	.05622	lb/ft^3
Average Velocity	15.97	ft/sec
Average Stack Temperature	150	°F

Results shown below were calculated according to Regulation I which covers particulate emissions.

	Traverse One	Traverse Two	Traverse Three	Traverse Four	Average Value
time date	1758-1858 8/1/72	0855-0955 8/2/72	1040-1140 8/2/72		
Mass Flow Rate of Stack, in tons/hr	45.34	44.40	44.63		44.79
Total Gas Emission Rate, in ft^3/hr	1.5916×10^6	1.5895×10^6	1.5988×10^6		1.5933×10^6
Effective Stack Height, in feet	116.6	116.6	116.7		116.6
Particulate Allowable Emission Rate in lb/hour (based on 100 $\mu g/M^3$)	32.5	32.5	32.6		32.5
Particulate Pollutant Mass Rate, in lb/hour (based on average)	6.827	5.100	4.716		5.548
Percent Isokinetic	120.1	125.0	124.4		123.2
Downwind Concentration at Xmax $\mu g/M^3$	20.99	15.68	14.47		17.05

Texas Lime Cleburne, Texas

Number Three Lime Kiln

SUMMARY OF RESULTS

Average Percent Water	27.72	%
Average Specific Heat	.2798	Btu/lb °F
Average Density of Stack Gas	.05743	lb/ft^3
Average Velocity	86.73	ft/sec
Average Stack Temperature	145	°F

Results shown below were calculated according to Regulation I which covers particulate emissions.

	Traverse One	Traverse Two	Traverse Three	Traverse Four	Average Value
time date	0900-0936 8/3/72	1038-1114 8/3/72	1205-1241 8/3/72		
Mass Flow Rate of Stack, in tons/hr	58.47	64.35	56.05		59.62
Total Gas Emission Rate, in ft^3/hr	2.0539×10^6	2.2359×10^6	1.9397×10^6		2.0765×10^6
Effective Stack Height, in feet	106.3	109.5	104.3		106.7
Particulate Allowable Emission Rate in lb/hour (based on 100 $\mu g/M^3$)	27.1	28.7	26.0		27.3
Particulate Pollutant Mass Rate, in lb/hour (based on average)	5.474	6.032	5.858		5.788
Percent Isokinetic	112.9	106.5	114.0		111.1
Downwind Concentration at Xmax $\mu g/M^3$	20.23	21.01	22.50		21.24

SAMPLE CALCULATIONS
(Number One Lime Kiln)

Data collected while taking the first traverse will be used to show how the calculations were performed.

First, the percent of water is calculated:

$$\text{Percent Water} = \frac{\dfrac{\text{weight } H_2O \text{ grams}}{18 \text{ grams/mole}} \times 24.1 \dfrac{\text{liters}}{\text{mole}}}{\dfrac{\text{weight } H_2O \text{ grams}}{18 \text{ grams/mole}} \times 24.1 \dfrac{\text{liters}}{\text{mole}} + \text{Dry Gas Volume in } ft^3 \times \dfrac{28.32 \text{ liters}}{ft^3} \times \dfrac{530^oR}{\text{Temp. meter } ^oR}} \times 100\%$$

$$\text{Percent Water} = \frac{\dfrac{180.8 \text{ gm}}{18 \text{ gm/mole}} \times 24.1 \dfrac{\text{liters}}{\text{mole}}}{\dfrac{180.8 \text{ gm}}{18 \text{ gm/mole}} \times 24.1 \dfrac{\text{liters}}{\text{mole}} + 21.85 \; ft^3 \times \dfrac{28.32 \text{ liters}}{ft^3} \times \dfrac{530}{557} \dfrac{^oR}{^oR}} \times 100\%$$

$$= \underline{\underline{29.13}} \%$$

The percent dry gas is the complement, **70.87** percent.

Next, the orsat analysis and the percent of water are used to calculate the molecular weight from a weighted average as follows:

$$\text{Molecular Weight} = \left(\frac{\%H_2O}{100}\right)\left(\begin{matrix}\text{Molecular}\\ \text{weight}\\ \text{of } H_2O\end{matrix}\right) + \left(\frac{\%\text{ Dry Gas}}{100} \times \sum_{i=1}^{i=4} \frac{\%\text{ Xi}}{100}\left(\begin{matrix}\text{Molecular}\\ \text{weight}\\ \text{of Xi}\end{matrix}\right)\right)$$

$$\text{Molecular Weight} = \frac{29.13}{100} \times 18 + \left(\frac{70.87}{100}\right)\left(0.102 \times 44 + 0.109 \times 32 + 0.00 \times 28 + 0.789 \times 28\right) = \underline{\underline{26.55}}$$

Note that the numbers; 18, 44, 32, 28, 28; are the molecular weights of H_2O CO_2, O_2, CO, N_2 respectively. Molecular weight of the stack gas is considered accurate to two significant figures only. Xi stands for one of the gases, CO_2, O_2, CO, N_2, the percent of which is determined from an Orsat Test.

Now, the density is calculated from perfect gas law considerations:

$$\text{density in } \frac{\text{lbs}}{\text{ft}^3} = \frac{\left(\begin{array}{c}\text{molecular}\\ \text{weight in}\\ \text{lb/lbm-mole}\end{array}\right)\left(\begin{array}{c}\text{stack}\\ \text{press. in}\\ \text{inches Hg}\end{array}\right)\left(\frac{70.73\ \text{lb/ft}^2}{\text{inches Hg}}\right)}{\left(1545.33\ \frac{\text{ft lb}}{\text{lbm-mole}\ ^{\circ}\text{R}}\right)\left(\begin{array}{c}\text{stack temp}\\ \text{in } ^{\circ}\text{R}\end{array}\right)}$$

$$\text{density in } \frac{\text{lbs}}{\text{ft}^3} = \frac{\left(26.55\ \frac{\text{lb}}{\text{lbm-mole}}\right)\left(28.6\ \text{inches Hg}\right)\left(\frac{70.73\ \text{lb/ft}^2}{\text{inches Hg}}\right)}{\left(1545.33\ \frac{\text{ft lb}}{\text{lbm-mole}\ ^{\circ}\text{R}}\right)\left(610\ ^{\circ}\text{R}\right)} = \underline{\underline{.05697}}\ \frac{\text{lbs}}{\text{ft}^3}$$

The buoyance term in the equation for effective stack height will require the heat capacity, or "specific heat" of the stack gas, this is also found from a weighted sum. Specific heat is a function of temperature and molecular weight. The equations and constants used below have been taken from "Chemical Process Principles" Part II, second edition. Specific heat, Cp, is calculated for each of the gases associated with the orsat test. Note that Ts refers to the stack temperature in degrees Rankine.

$$Cp \text{ for } H_2O = 0.4274 + 1.416 \times 10^{-5}(Ts) + 4.319 \times 10^{-8}(Ts^2) - 8.173 \times 10^{-12}(Ts^3)$$

$$Cp \text{ for } CO_2 = 0.1208 + 18.03 \times 10^{-5}(Ts) - 5.864 \times 10^{-8}(Ts^2) + 6.95 \times 10^{-12}(Ts^3)$$

$$Cp \text{ for } O_2 = 0.1902 + 6.304 \times 10^{-5}(Ts) - 1.726 \times 10^{-8}(Ts^2) + 1.679 \times 10^{-12}(Ts^3)$$

$$Cp \text{ for } CO = 0.2401 + 0.7936 \times 10^{-5}(Ts) + 1.364 \times 10^{-8}(Ts^2) - 3.288 \times 10^{-12}(Ts^3)$$

$$Cp \text{ for } N_2 = 0.2464 - 0.7442 \times 10^{-5}(Ts) + 2.126 \times 10^{-8}(Ts^2) - 4.199 \times 10^{-12}(Ts^3)$$

Substituting the stack temperature of 610.0 °R into the equations above gives Cp for H_2O equal to 0.4503 , Cp for CO_2 equal to 0.2105 , Cp for O_2 equal to 0.2226 , Cp for CO equal to 0.2493 , and Cp for N_2 equal to 0.2488 ; the units are Btu/lb°F. A weighted sum is now performed with weighting factors based on the orsat test and the percent of water present in the stack gas. Cp for the stack gas is found as follows:

$$\text{Cp for stack gas} = \left(\frac{\%H_2O}{100}\right)\left(\text{Cp}_{H_2O}\ \frac{\text{Btu}}{\text{lb}^{\circ}\text{F}}\right)\left(\frac{18\ \text{lb/lb mole}}{\text{Molecular wt. stack gas}}\right) + \left(\frac{\%\ \text{Dry Gas}}{100}\right) \times \sum_{i=1}^{i=4}\left(\frac{\%Xi}{100}\right)$$

$$\left(\text{Cp Xi}\ \frac{\text{Btu}}{\text{lb}^{\circ}\text{F}}\right)\left(\frac{\text{Molecular Wt. Xi}}{\text{Molecular Wt. Stack gas}}\right)$$

$$\text{Cp for stack gas} = \left(\frac{29.13}{100}\right)(.4503)\left(\frac{18}{26.55}\right) + (.7087)\left(0.102 \times 0.2105 \times \frac{44}{26.55} + 0.109 \times 0.2226 \times \frac{32}{26.55} + 0.000 \times 0.2493 \times \frac{28}{26.55} + 0.789 \times 0.2493 \times \frac{28}{26.55}\right) = \underline{\underline{.2819}}\ \frac{\text{Btu}}{\text{lb}^{\circ}\text{F}}$$

Average velocity will be needed in the velocity term in the equation for effective stack height and for calculation of the total gas emission rate (TGER). Average velocity for the traverse is calculated as follows:

$$\text{Average Velocity in ft/sec} = (85.48) \times \begin{pmatrix}\text{Pitot}\\ \text{Tube}\\ \text{Corr.}\\ \text{Factor}\end{pmatrix} \sqrt{\frac{\text{Stack Temp } ^{\circ}R \times \text{Aver. } \Delta p \text{ inches } H_2O}{\text{Molecular Weight} \times \text{stack press. inches Hg}}}$$

Note that the "average" Δp must be calculated by first taking the sum of the square roots of the Δp's, then dividing by the number of Δp's, and finally squaring this number.

The following table is presented to show these calculations:

Δp	.08	.09	.09	.09	.09	.08	.065	.06	.06	.05	.05	.05
$\sqrt{\Delta p}$	.285	.30	.30	.30	.30	.285	.255	.245	.245	.224	.224	.224

Δp							
$\sqrt{\Delta p}$							

Sum of $\sqrt{\Delta p}$ = 3.187

$$\text{Aver. } \Delta p = \left(\frac{3.187}{12}\right)^2 = 0.0705 \text{ inches } H_2O$$

Now the average velocity is calculated:

$$\text{Average Velocity at Sample Port} = 85.48 \times .7855 \times \sqrt{\frac{610 \times .0705}{26.55 \times 28.6}} = \underline{\underline{15.98}} \text{ feet/second}$$

Next, the Total Gas Emission Rate is calculated:

$$\text{TGER cu ft/hr} = \frac{\pi \begin{pmatrix}\text{Dia}\\ \text{stack}\\ \text{ft}\end{pmatrix}^2 \begin{pmatrix}3600\\ \text{sec/hr}\end{pmatrix} \begin{pmatrix}\text{Aver.}\\ \text{Vel.}\\ \text{ft/sec}\end{pmatrix}}{4}$$

$$\text{TGER} = \frac{\pi \times (5.94)^2 \text{ft}^2 \begin{pmatrix}3600\\ \text{sec/hr}\end{pmatrix} \begin{pmatrix}15.98\\ \text{ft/sec}\end{pmatrix}}{4} = \underline{\underline{1.594 \times 10^6 \text{ ft}^3/\text{hr}}}$$

The mass flow rate, Qm, is equal to the product of the TGER times the density.

$Qm = (1.594 \times 10^6 \text{cuft/hr})(.05697 \text{lbs/cuft}) = \underline{9.08 \times 10^4 \text{lbs/hr}}$

Effective stack height, He, can now be calculated from:

$He = H + 0.1203(VeDe) + 2.471 \times 10^{-6}\ Qm\ Cp\ (T-68)$

where He is the effective stack height in feet, H is the physical stack height, VeDe is the product of velocity and stack exit diameter, Qm is the mass flow rate, Cp is the specific heat and T is the stack temperature in degrees Fahrenheit. (Note that some stacks have a smaller diameter at the exit than at the sample port. Velocity at the exit is equal to the velocity at the sample port times the square of the ratio: diameter at the sample port divided by the diameter at the exit.) The units are those that have been used in the above calculations. These results are now substituted into the equation for effective stack height.

$He = 100.0 + 0.1203(15.98 \times 5.94) + 2.471 \times 10^{-6} \times 9.08 \times 10^4$

$\times .2819\ (150.-68) = \underline{116.6}$ feet

The allowable emission rate* (based on 100 $\mu g/M^3$ downwind) is equal to He^2 times 2.394×10^{-3}.

For this example:

allowable emission rate at X max $= (116.6)^2 \times 2.394 \times 10^{-3} = \underline{32.5 \text{ lbs/hr}}$

X max is the downwind distance for which the concentration "downwind" is theoretically maximum, consequently the allowable emission rate at this point is minimum.

$X\ max = 11.73\ He^{1.143}$

$X\ max = 11.73\ (116.6)^{1.143} = \underline{2697.9 \text{ ft}}$

* Allowable emission rate is defined in Regulation I (appendix C, page I-C1) of the Texas Air Control Board. The constant, 2.394×10^{-3}, corresponds to that downwind distance for which the curve on page I-C5 of Regulation I changes from a vertical straight line to a curved line. At this point, X, downwind distance, is equal to $11.73\ He^{1.143}$.

The pollutant mass rate will now be calculated by the area ratio method (PMRa) and by the concentration method (PMRc). First, the area ratio is calculated:

$$\frac{\text{Area Stack}}{\text{Area Nozzle}} = \frac{27.71167 \quad ft^2}{4.895 \quad x\ 10^{-4} ft^2} = .0566 \quad x\ 10^4\ ft.^3$$

Now the pollutant mass rate, PMRa, can be calculated:

$$PMRa = \frac{As}{An} \times \frac{(\text{grams particulate caught})}{\theta \text{ hours} \times 453.5924 \text{ gm/lb}}$$

$$PMRa = \frac{.0566 \quad x\ 10^4 (0.0597 \quad \text{grams})}{1 \quad \text{hour} \quad x\ 453.5924 \text{ gm/lb}} = \underline{\underline{7.45 \quad \text{lb/hr}}}$$

Calculation of pollutant mass rate based on concentration (PMRc) requires calculation of the concentration in the stack:

$$\text{Concentration, } C = \frac{\text{grams particulate caught}}{\text{Vol. through nozzle stack cond.}} \times 453.5924 \text{ gm/lb}$$

Before the concentration can be calculated, the volume through the nozzle at stack conditions must be calculated as follows:

$$\text{Vol. through nozzle} = \frac{\text{Vol. meter cond.} \times \frac{Ts}{Tm} \times \frac{Pm}{Ps}}{\text{Dry Gas Fraction}}$$

$$\text{Vol. through nozzle} = \frac{21.85 \quad ft^3 \times 610 \quad {}^oR \times 28.6 \quad \text{in Hg}}{.7087 \quad \times 557 \quad {}^oR \times 28.6 \quad \text{in Hg}} = 33.76\ ft^3$$

Now the concentration is:

$$C = \frac{.0597 \quad gm}{33.76\ ft^3 \times 453.5924 \text{ gm/lb}} = .38986 \quad x\ 10^{-5}\ lb/ft^3$$

and the pollutant mass rate (PMRc) can be calculated as follows:

$$PMRc = \begin{pmatrix} \text{area} \\ \text{stack} \end{pmatrix} \times \begin{pmatrix} \text{Aver.} \\ \text{Vel.} \end{pmatrix} \times \begin{pmatrix} 3600 \\ \text{sec/hr} \end{pmatrix} \times C$$

$$PMRc = (27.712\ ft^2)\ (15.98 \quad ft/sec)(3600\ sec/hr)(38986 \times 10^{-5}\ lb/ft^3)$$

$$PMRc = \underline{\underline{6.215 \quad lb/hr}}$$

The average pollutant mass rate is found from:

$$\text{Aver. PMR} = \frac{PMRa + PMRc}{2} = \frac{7.45 + 6.215}{2} = \underline{6.833 \quad \text{lbs/hr}}$$

Percent isokinetic is the ratio of PMRa to PMRc:

$$\text{Percent Isokinetic} = 100\% \times \frac{PMRa}{PMRc} = 100 \times \frac{7.45}{6.215} = \underline{119.87 \quad \%}$$

For this example, the downwind concentration will be calculated from the pollutant mass rate based on **mixed particle size.**

$$DWC = \frac{PMRc}{\text{Allowable Emission Rate}} \times 100 = \frac{6.833}{32.5} \times 100 = \underline{21.02 \quad \mu g/M^3}$$

The preceeding sample calculations have been included to demonstrate how the computer program processes the raw data. Slight differences between the computer printout values and these sample calculation values are due to the greater number of significant figures carried by the computer between each step of the calculation.

REGULATION I

INPUT DATA REPORT N13003

TEXAS LIME CO. CLEBURNE TEXAS

#1 LIME KILN STACK (THREE TRAVERSES)

TRAVERSE #1 TAKEN 1 AUGUST 1972 1758

TIME REQ. FOR TRAVERSE 60.00 MINUTES

BAROMETRIC PRESS 28.600 INCHES MERCURY ABSO

PRESS, DRYGAS METER 28.600 INCHES MERCURY ABSO

PRESS, STATIC, STACK 0.000 INCHES WATER GAUGE

PRESS DROPS, PITOT TUBE INCHES WATER GAUGE

0.080	0.090	0.090	0.090	0.090	0.080
0.065	0.060	0.060	0.050	0.050	0.050

TEMP, AMBIENT 85. DEGREES FAHRENHEIT

TEMP, DRYGAS METER 97. DEGREES FAHRENHEIT

TEMP, STACK, AVERAGE 150. DEGREES FAHRENHEIT

ORSAT ANALYSIS: CO2= 0.102 O2= 0.109 CO= 0.000 N2= 0.789

AREA OF NOZZLE 0.4895E-03 SQUARE FEET

PITOT TUBE CALIB FACTOR 0.7855

DISTANCE TO NEAREST PROP. LINE 300.0 FEET

PHYSICAL STACK HEIGHT 100.00 FEET

SAMPLE VOLUME, DRYGAS METER 21.85 CUBIC FEET

MASS OF WATER CAUGHT 180.8 GRAMS

MASS OF PARTICULATE CAUGHT 0.0597 GRAMS

OVERRIDE MOISTURE FRACTION 0.000

OVERRIDE, VELOCITY 0.0 FEET PER SECOND

DIAMETER OF STACK, EXIT 5.940 FEET

DIAMETER OF STACK, SAMPLE PORT 5.940 FEET

PARTICLE SIZE FLAG - MIXED

REGULATION I

CALCULATION RESULTS REPORT N13003

TEXAS LIME CO. CLEBURNE TEXAS

#1 LIME KILN STACK (THREE TRAVERSES)

TRAVERSE #1 TAKEN 1 AUGUST 1972 1758

29.13 PERCENT WATER 70.87 PERCENT DRYGAS

FOR COMPARISON ONLY BW2= 0.000 SPECIFIC GRAVITY= 0.917 AIR=1.00

SPECIFIC HEATS AT SAMPLE POINT TEMPERATURE BTU/LB DEG. F
H2O= 0.4503 CO2= 0.2105 O2= 0.2226 CO= 0.2493
N2= 0.2488 COMBINED SPHEAT= 0.2816

MOLECULAR WEIGHT 26.55 DENSITY 0.05698 LBS/CUFT

AVERAGE VELOCITY 15.95 FEET PER SECOND

MASS FLOW RATE 0.90688625E 05 LBS/HOUR

VOL FLOW RATE 0.15916180E 07 CUFT/HOUR - ACFH

NOZZLE VOLUME 33.767 CUBIC FEET

EFFECTIVE STACK HEIGHT 116.6 FEET

ALLOWABLE EMISSION RATE AT XMAX 32.5 LBS/HOUR

DOWNWIND DISTANCE, XMAX 2699.1 FEET

ALLOWABLE EMISSION RATE, REG. I, PROP. LINE 0.32533630E 02 LBS/HOUR

POLLUTANT MASS RATE, AREA RATIO 7.451 LBS/HOUR

CONCENTRATION 0.38977605E-05 LBS/CUFT

POLLUTANT MASS RATE, CONCENTRATION 6.204 LBS/HOUR

PERCENT ISOKINETIC 120.1 PERCENT

POLLUTANT MASS RATES AVERAGED 6.827 LBS/HOUR

DOWNWIND CONCENTRATION 20.99 MICROGRAMS/CUBIC METER

REGULATION I

INPUT DATA REPORT N13003

TEXAS LIME CO. CLEBURNE TEXAS

#1 LIME KILN STACK (THREE TRAVERSES)

TRAVERSE # 2 TAKEN 2 AUGUST 1972 0855

TIME REQ. FOR TRAVERSE 60.00 MINUTES

BAROMETRIC PRESS 28.550 INCHES MERCURY ABSO

PRESS, DRYGAS METER 28.550 INCHES MERCURY ABSO

PRESS, STATIC, STACK 0.000 INCHES WATER GAUGE

PRESS DROPS, PITOT TUBE INCHES WATER GAUGE

0.080	0.090	0.090	0.090	0.090	0.080
0.070	0.060	0.050	0.050	0.050	0.040

TEMP, AMBIENT 76. DEGREES FAHRENHEIT

TEMP, DRYGAS METER 84. DEGREES FAHRENHEIT

TEMP, STACK, AVERAGE 150. DEGREES FAHRENHEIT

ORSAT ANALYSIS: CO2= 0.102 O2= 0.109 CO= 0.000 N2= 0.789

AREA OF NOZZLE 0.4895E-03 SQUARE FEET

PITOT TUBE CALIB FACTOR 0.7855

DISTANCE TO NEAREST PROP. LINE 300.0 FEET

PHYSICAL STACK HEIGHT 100.00 FEET

SAMPLE VOLUME, DRYGAS METER 20.95 CUBIC FEET

MASS OF WATER CAUGHT 213.1 GRAMS

MASS OF PARTICULATE CAUGHT 0.0454 GRAMS

OVERRIDE MOISTURE FRACTION 0.000

OVERRIDE, VELOCITY 0.0 FEET PER SECOND

DIAMETER OF STACK, EXIT 5.940 FEET

DIAMETER OF STACK, SAMPLE PORT 5.940 FEET

PARTICLE SIZE FLAG - MIXED

REGULATION I

CALCULATION RESULTS REPORT N13003

TEXAS LIME CO. CLEBURNE TEXAS

#1 LIME KILN STACK (THREE TRAVERSES)

TRAVERSE # 2 TAKEN 2 AUGUST 1972 0855

33.05 PERCENT WATER 66.95 PERCENT DRYGAS

FOR COMPARISON ONLY BW2= 0.000 SPECIFIC GRAVITY= 0.901 AIR=1.00

SPECIFIC HEATS AT SAMPLE POINT TEMPERATURE BTU/LB DEG. F
H2O= 0.4503 CO2= 0.2105 O2= 0.2226 CO= 0.2493
N2= 0.2488 COMBINED SPHEAT= 0.2880

MOLECULAR WEIGHT 26.08 DENSITY 0.05587 LBS/CUFT

AVERAGE VELOCITY 15.93 FEET PER SECOND

MASS FLOW RATE 0.88802812E 05 LBS/HOUR

VOL FLOW RATE 0.15895200E 07 CUFT/HOUR

NOZZLE VOLUME 35.087 CUBIC FEET

EFFECTIVE STACK HEIGHT 116.6 FEET

ALLOWABLE EMISSION RATE AT XMAX 32.5 LBS/HOUR

DOWNWIND DISTANCE, XMAX 2698.9 FEET

ALLOWABLE EMISSION RATE, REG. I, PROP. LINE 0.32529754E 02 LBS/HOUR

POLLUTANT MASS RATE, AREA RATIO 5.666 LBS/HOUR

CONCENTRATION 0.28525974E-05 LBS/CUFT

POLLUTANT MASS RATE, CONCENTRATION 4.534 LBS/HOUR

PERCENT ISOKINETIC 125.0 PERCENT

POLLUTANT MASS RATES AVERAGED 5.100 LBS/HOUR

DOWNWIND CONCENTRATION 15.68 MICROGRAMS/CUBIC METER

REGULATION I

INPUT DATA REPORT N13003

TEXAS LIME CO. CLEBURNE TEXAS

#1 LIME KILN STACK (THREE TRAVERSES)

TRAVERSE #3 WAS TAKEN 2 AUGUST 1972 1040

TIME REQ. FOR TRAVERSE 60.00 MINUTES

BAROMETRIC PRESS 28.550 INCHES MERCURY ABSO

PRESS, DRYGAS METER 28.550 INCHES MERCURY ABSO

PRESS, STATIC, STACK 0.000 INCHES WATER GAUGE

PRESS DROPS, PITOT TUBE INCHES WATER GAUGE

0.090	0.090	0.090	0.090	0.090	0.080
0.070	0.060	0.050	0.050	0.050	0.040

TEMP, AMBIENT 80. DEGREES FAHRENHEIT

TEMP, DRYGAS METER 90. DEGREES FAHRENHEIT

TEMP, STACK, AVERAGE 150. DEGREES FAHRENHEIT

ORSAT ANALYSIS: CO2= 0.102 O2= 0.109 CO= 0.000 N2= 0.789

AREA OF NOZZLE 0.4895E-03 SQUARE FEET

PITOT TUBE CALIB FACTOR 0.7855

DISTANCE TO NEAREST PROP. LINE 300.0 FEET

PHYSICAL STACK HEIGHT 100.00 FEET

SAMPLE VOLUME, DRYGAS METER 21.16 CUBIC FEET

MASS OF WATER CAUGHT 214.6 GRAMS

MASS OF PARTICULATE CAUGHT 0.0419 GRAMS

OVERRIDE MOISTURE FRACTION 0.000

OVERRIDE, VELOCITY 0.0 FEET PER SECOND

DIAMETER OF STACK, EXIT 5.940 FEET

DIAMETER OF STACK, SAMPLE PORT 5.940 FEET

PARTICLE SIZE FLAG - MIXED

REGULATION I

CALCULATION RESULTS REPORT N13003

TEXAS LIME CO. CLEBURNE TEXAS

#1 LIME KILN STACK (THREE TRAVERSES)

TRAVERSE #3 WAS TAKEN 2 AUGUST 1972 1040

33.23 PERCENT WATER 66.77 PERCENT DRYGAS

FOR COMPARISON ONLY BW2= 0.000 SPECIFIC GRAVITY= 0.900 AIR=1.00

SPECIFIC HEATS AT SAMPLE POINT TEMPERATURE BTU/LB DEG. F
H2O= 0.4503 CO2= 0.2105 O2= 0.2226 CO= 0.2493
N2= 0.2488 COMBINED SPHEAT= 0.2883

MOLECULAR WEIGHT 26.06 DENSITY 0.05582 LBS/CUFT

AVERAGE VELOCITY 16.03 FEET PER SECOND

MASS FLOW RATE 0.89250437E 05 LBS/HOUR

VOL FLOW RATE 0.15988450E 07 CUFT/HOUR

NOZZLE VOLUME 35.146 CUBIC FEET

EFFECTIVE STACK HEIGHT 116.7 FEET

ALLOWABLE EMISSION RATE AT XMAX 32.6 LBS/HOUR

DOWNWIND DISTANCE, XMAX 2701.5 FEET

ALLOWABLE EMISSION RATE, REG. I, PROP. LINE 0.32584640E 02 LBS/HOUR

POLLUTANT MASS RATE, AREA RATIO 5.229 LBS/HOUR

CONCENTRATION 0.26283196E-05 LBS/CUFT

POLLUTANT MASS RATE, CONCENTRATION 4.202 LBS/HOUR

PERCENT ISOKINETIC 124.4 PERCENT

POLLUTANT MASS RATES AVERAGED 4.716 LBS/HOUR

DOWNWIND CONCENTRATION 14.47 MICROGRAMS/CUBIC METER

REGULATION I

AVERAGE RESULTS REPORT N13003

TEXAS LIME CO. CLEBURNE TEXAS

#1 LIME KILN STACK (THREE TRAVERSES)

TEMP, STACK 150. DEGREES FAHRENHEIT

31.80 PERCENT WATER 68.20 PERCENT DRYGAS

FOR COMPARISON ONLY BW2= 0.000 SPECIFIC GRAVITY= 0.906 AIR=1.00

SPECIFIC HEATS AT SAMPLE POINT TEMPERATURE BTU/LB DEG. F
H2O= 0.4503 CO2= 0.2105 O2= 0.2226 CO= 0.2493
N2= 0.2486 COMBINED SPHEAT= 0.2860

MOLECULAR WEIGHT 26.23 DENSITY 0.05622 LBS/CUFT

AVERAGE VELOCITY 15.97 FEET PER SECOND

MASS FLOW RATE 0.89580625E 05 LBS/HOUR

VOL FLOW RATE 0.15933270E 07 CUFT/HOUR

NOZZLE VOLUME 34.667 CUBIC FEET

EFFECTIVE STACK HEIGHT 116.6 FEET

ALLOWABLE EMISSION RATE AT XMAX 32.5 LBS/HOUR

DOWNWIND DISTANCE, XMAX 2699.9 FEET

ALLOWABLE EMISSION RATE, REG. I, PROP. LINE 0.32549331E 02 LBS/HOUR

POLLUTANT MASS RATE, AREA RATIO 6.116 LBS/HOUR

CONCENTRATION 0.31262252E-05 LBS/CUFT

POLLUTANT MASS RATE, CONCENTRATION 4.980 LBS/HOUR

PERCENT ISOKINETIC 123.2 PERCENT

POLLUTANT MASS RATES AVERAGED 5.548 LBS/HOUR

DOWNWIND CONCENTRATION 17.05 MICROGRAMS/CUBIC METER

REGULATION I

INPUT DATA REPORT N13003

TEXAS LIME CO. CLEBURNE TEXAS

#3 LIME KILN STACK (THREE TRAVERSES TAKEN)

TRAVERSE #1 TAKEN 3 AUGUST 1972 0900

TIME REQ. FOR TRAVERSE 36.00 MINUTES

BAROMETRIC PRESS 28.600 INCHES MERCURY ABSO

PRESS, DRYGAS METER 28.600 INCHES MERCURY ABSO

PRESS, STATIC, STACK 0.000 INCHES WATER GAUGE

PRESS DROPS, PITOT TUBE INCHES WATER GAUGE

1.700	2.100	2.200	2.300	2.100	1.800
1.800	2.000	2.000	1.800	1.600	1.300

TEMP, AMBIENT 74. DEGREES FAHRENHEIT

TEMP, DRYGAS METER 87. DEGREES FAHRENHEIT

TEMP, STACK, AVERAGE 145. DEGREES FAHRENHEIT

ORSAT ANALYSIS: CO2= 0.081 O2= 0.131 CO= 0.000 N2= 0.786

AREA OF NOZZLE 0.1347E-03 SQUARE FEET

PITOT TUBE CALIB FACTOR 0.8160

DISTANCE TO NEAREST PROP. LINE 300.0 FEET

PHYSICAL STACK HEIGHT 70.00 FEET

SAMPLE VOLUME, DRYGAS METER 17.92 CUBIC FEET

MASS OF WATER CAUGHT 154.8 GRAMS

MASS OF PARTICULATE CAUGHT 0.0320 GRAMS

OVERRIDE MOISTURE FRACTION 0.000

OVERRIDE, VELOCITY 0.0 FEET PER SECOND

DIAMETER OF STACK, EXIT 2.910 FEET

DIAMETER OF STACK, SAMPLE PORT 2.910 FEET

PARTICLE SIZE FLAG - MIXED

REGULATION I

CALCULATION RESULTS REPORT N13003

TEXAS LIME CO. CLEBURNE TEXAS

#3 LIME KILN STACK (THREE TRAVERSES TAKEN)

TRAVERSE #1 TAKEN 3 AUGUST 1972 0900

29.65 PERCENT WATER 70.35 PERCENT DRYGAS

FOR COMPARISON ONLY BW2= 0.000 SPECIFIC GRAVITY= 0.909 AIR=1.00

SPECIFIC HEATS AT SAMPLE POINT TEMPERATURE BTU/LB DEG. F
H2O= 0.4500 CO2= 0.2100 O2= 0.2224 CO= 0.2492
N2= 0.2487 COMBINED SPHEAT= 0.2829

MOLECULAR WEIGHT 26.32 DENSITY 0.05694 LBS/CUFT

AVERAGE VELOCITY 85.78 FEET PER SECOND

MASS FLOW RATE 0.11694431E 06 LBS/HOUR

VOL FLOW RATE 0.20539120E 07 CUFT/HOUR

NOZZLE VOLUME 28.174 CUBIC FEET

EFFECTIVE STACK HEIGHT 106.3 FEET

ALLOWABLE EMISSION RATE AT XMAX 27.1 LBS/HOUR

DOWNWIND DISTANCE, XMAX 2429.6 FEET

ALLOWABLE EMISSION RATE, REG. I, PROP. LINE 0.27064376E 02 LBS/HOUR

POLLUTANT MASS RATE, AREA RATIO 5.806 LBS/HOUR

CONCENTRATION 0.25039817E-05 LBS/CUFT

POLLUTANT MASS RATE, CONCENTRATION 5.143 LBS/HOUR

PERCENT ISOKINETIC 112.9 PERCENT

POLLUTANT MASS RATES AVERAGED 5.474 LBS/HOUR

DOWNWIND CONCENTRATION 20.23 MICROGRAMS/CUBIC METER

REGULATION I

INPUT DATA REPORT N13003

TEXAS LIME CO. CLEBURNE TEXAS

#3 LIME KILN STACK (THREE TRAVERSES TAKEN)

TRAVERSE #2 TAKEN 3 AUGUST 1972 1038

TIME REQ. FOR TRAVERSE 36.00 MINUTES

BAROMETRIC PRESS 28.600 INCHES MERCURY ABSO

PRESS, DRYGAS METER 28.600 INCHES MERCURY ABSO

PRESS, STATIC, STACK 0.000 INCHES WATER GAUGE

PRESS DROPS, PITOT TUBE INCHES WATER GAUGE

1.750	2.250	2.600	2.600	2.400	2.500
2.450	2.200	2.550	2.450	2.150	1.350

TEMP, AMBIENT 74. DEGREES FAHRENHEIT

TEMP, DRYGAS METER 97. DEGREES FAHRENHEIT

TEMP, STACK, AVERAGE 145. DEGREES FAHRENHEIT

ORSAT ANALYSIS: CO2= 0.081 O2= 0.131 CO= 0.000 N2= 0.788

AREA OF NOZZLE 0.1347E-03 SQUARE FEET

PITOT TUBE CALIB FACTOR 0.8160

DISTANCE TO NEAREST PROP. LINE 300.0 FEET

PHYSICAL STACK HEIGHT 70.00 FEET

SAMPLE VOLUME, DRYGAS METER 19.40 CUBIC FEET

MASS OF WATER CAUGHT 145.9 GRAMS

MASS OF PARTICULATE CAUGHT 0.0343 GRAMS

OVERRIDE MOISTURE FRACTION 0.000

OVERRIDE, VELOCITY 0.0 FEET PER SECOND

DIAMETER OF STACK, EXIT 2.910 FEET

DIAMETER OF STACK, SAMPLE PORT 2.910 FEET

PARTICLE SIZE FLAG - MIXED

REGULATION I

CALCULATION RESULTS REPORT N13003

TEXAS LIME CO. CLEBURNE TEXAS

#3 LIME KILN STACK (THREE TRAVERSES TAKEN)

TRAVERSE #2 TAKEN 3 AUGUST 1972 1038

27.20 PERCENT WATER 72.80 PERCENT DRYGAS

FOR COMPARISON ONLY BW2= 0.000 SPECIFIC GRAVITY= 0.919 AIR=1.00

SPECIFIC HEATS AT SAMPLE POINT TEMPERATURE BTU/LB DEG. F
H2O= 0.4500 CO2= 0.2100 O2= 0.2224 CO= 0.2492
N2= 0.2487 COMBINED SPHEAT= 0.2790

MOLECULAR WEIGHT 26.60 DENSITY 0.05756 LBS/CUFT

AVERAGE VELOCITY 93.38 FEET PER SECOND

MASS FLOW RATE 0.12870494E 06 LBS/HOUR

VOL FLOW RATE 0.22358670E 07 CUFT/HOUR

NOZZLE VOLUME 28.946 CUBIC FEET

EFFECTIVE STACK HEIGHT 109.5 FEET

ALLOWABLE EMISSION RATE AT XMAX 28.7 LBS/HOUR

DOWNWIND DISTANCE, XMAX 2513.3 FEET

ALLOWABLE EMISSION RATE, REG. I, PROP. LINE 0.28716430E 02 LBS/HOUR

POLLUTANT MASS RATE, AREA RATIO 6.223 LBS/HOUR

CONCENTRATION 0.26124289E-05 LBS/CUFT

POLLUTANT MASS RATE, CONCENTRATION 5.841 LBS/HOUR

PERCENT ISOKINETIC 106.5 PERCENT

POLLUTANT MASS RATES AVERAGED 6.032 LBS/HOUR

DOWNWIND CONCENTRATION 21.01 MICROGRAMS/CUBIC METER

REGULATION I

INPUT DATA REPORT N13003

TEXAS LIME CO. CLEBURNE TEXAS

#3 LIME KILN STACK (THREE TRAVERSES TAKEN)

TRAVERSE #3 TAKEN 3 AUGUST 1972 1205

TIME REQ. FOR TRAVERSE 36.00 MINUTES

BAROMETRIC PRESS 28.600 INCHES MERCURY ABSO

PRESS, DRYGAS METER 28.600 INCHES MERCURY ABSO

PRESS, STATIC, STACK 0.000 INCHES WATER GAUGE

PRESS DROPS, PITOT TUBE INCHES WATER GAUGE

1.700	2.300	2.600	2.600	1.900	1.500
1.300	2.600	2.500	1.400	1.200	0.160

TEMP, AMBIENT 82. DEGREES FAHRENHEIT

TEMP, DRYGAS METER 91. DEGREES FAHRENHEIT

TEMP, STACK, AVERAGE 145. DEGREES FAHRENHEIT

ORSAT ANALYSIS: CO2= 0.081 O2= 0.131 CO= 0.000 N2= 0.788

AREA OF NOZZLE 0.1347E-03 SQUARE FEET

PITOT TUBE CALIB FACTOR 0.8160

DISTANCE TO NEAREST PROP. LINE 300.0 FEET

PHYSICAL STACK HEIGHT 70.00 FEET

SAMPLE VOLUME, DRYGAS METER 18.03 CUBIC FEET

MASS OF WATER CAUGHT 131.0 GRAMS

MASS OF PARTICULATE CAUGHT 0.0344 GRAMS

OVERRIDE MOISTURE FRACTION 0.000

OVERRIDE, VELOCITY 0.0 FEET PER SECOND

DIAMETER OF STACK, EXIT 2.910 FEET

DIAMETER OF STACK, SAMPLE PORT 2.910 FEET

PARTICLE SIZE FLAG - MIXED

REGULATION 1

CALCULATION RESULTS REPORT N13003

TEXAS LIME CO. CLEBURNE TEXAS

#3 LIME KILN STACK (THREE TRAVERSES TAKEN)

TRAVERSE #3 TAKEN 3 AUGUST 1972 1205

26.31 PERCENT WATER 73.69 PERCENT DRYGAS

FOR COMPARISON ONLY Bw2= 0.000 SPECIFIC GRAVITY= 0.923 AIR=1.00

SPECIFIC HEATS AT SAMPLE POINT TEMPERATURE BTU/LB DEG. F
H2O= 0.4500 CO2= 0.2100 O2= 0.2224 CO= 0.2492
N2= 0.2487 COMBINED SPHEAT= 0.2776

MOLECULAR WEIGHT 26.71 DENSITY 0.05779 LBS/CUFT

AVERAGE VELOCITY 81.01 FEET PER SECOND

MASS FLOW RATE 0.11209531E 06 LBS/HOUR

VOL FLOW RATE 0.19396710E 07 CUFT/HOUR

NOZZLE VOLUME 26.667 CUBIC FEET

EFFECTIVE STACK HEIGHT 104.3 FEET

ALLOWABLE EMISSION RATE AT XMAX 26.0 LBS/HOUR

DOWNWIND DISTANCE, XMAX 2376.3 FEET

ALLOWABLE EMISSION RATE, REG. I, PROP. LINE 0.26033187E 02 LBS/HOUR

POLLUTANT MASS RATE, AREA RATIO 6.241 LBS/HOUR

CONCENTRATION 0.28227623E-05 LBS/CUFT

POLLUTANT MASS RATE, CONCENTRATION 5.475 LBS/HOUR

PERCENT ISOKINETIC 114.0 PERCENT

POLLUTANT MASS RATES AVERAGED 5.858 LBS/HOUR

DOWNWIND CONCENTRATION 22.50 MICROGRAMS/CUBIC METER

REGULATION I

AVERAGE RESULTS REPORT N13003

TEXAS LIME CO. CLEBURNE TEXAS

#3 LIME KILN STACK (THREE TRAVERSES TAKEN)

TEMP, STACK 145. DEGREES FAHRENHEIT

27.72 PERCENT WATER 72.28 PERCENT DRYGAS

FOR COMPARISON ONLY BW2= 0.000 SPECIFIC GRAVITY= 0.917 AIR=1.00

SPECIFIC HEATS AT SAMPLE POINT TEMPERATURE BTU/LB DEG. F
H2O= 0.4500 CO2= 0.2100 O2= 0.2224 CO= 0.2492
N2= 0.2487 COMBINED SPHEAT= 0.2798

MOLECULAR WEIGHT 26.54 DENSITY 0.05743 LBS/CUFT

AVERAGE VELOCITY 86.73 FEET PER SECOND

MASS FLOW RATE 0.11924819E 06 LBS/HOUR

VOL FLOW RATE 0.20764830E 07 CUFT/HOUR

NOZZLE VOLUME 27.996 CUBIC FEET

EFFECTIVE STACK HEIGHT 106.7 FEET

ALLOWABLE EMISSION RATE AT XMAX 27.3 LBS/HOUR

DOWNWIND DISTANCE, XMAX 2439.8 FEET

ALLOWABLE EMISSION RATE, REG. I, PROP. LINE 0.27271331E 02 LBS/HOUR

POLLUTANT MASS RATE, AREA RATIO 6.090 LBS/HOUR

CONCENTRATION 0.26463977E-05 LBS/CUFT

POLLUTANT MASS RATE, CONCENTRATION 5.466 LBS/HOUR

PERCENT ISOKINETIC 111.1 PERCENT

POLLUTANT MASS RATES AVERAGED 5.786 LBS/HOUR

DOWNWIND CONCENTRATION 21.24 MICROGRAMS/CUBIC METER

APPENDIX A

TEXAS STATE DEPARTMENT OF HEALTH
Air Pollution Control Services
820 East 53rd Street
Austin, Texas

Laboratory Report

Sample: Texas Lime Company
Cleburne, Texas

Laboratory # ACL 440

Delivered By: John Key

Description:

Date: August 3, 1972

Probe Wash, Filters, and Impingers
for particulate analysis

LABORATORY ANALYSIS

Run	Probe Wash Weight (gm)	Filter Weight (gm)	Impinger Weight (gm)
		Lime Kiln #1	
1	0.0113	0.0179	0.0305
2	0.0093	0.0136	0.0225
3	0.0069	0.0148	0.0202
		Lime Kiln #3	
1	0.0122	0.0068	0.0130
2	0.0087	0.0084	0.0172
3	0.0079	0.0084	0.0181

September 5, 1972
Date Reported

James Cunningham

APPENDIX B

Texas Air Control Board
1100 West 49th Street
Austin, Texas - 78756

Date 3 August 1972

SAMPLING DATA AND PLANT OPERATIONAL STATUS

Firm Name Texas Lime Co.
Location of Plant Cleburne, Texas
Type of Operation Quicklime

SAMPLING DATA*

Type of Sample	Location	Duration
Isokinetic [Run #1]	#1 Kiln	From 5:58 PM to 6:58 PM
Isokinetic [Run #2]	#1 Kiln	From 8:55 AM to 9:55 AM
Isokinetic [Run #3]	#1 Kiln	From 10:40 AM to 11:40 AM

Special Conditions None

I certify that the above sample(s) ~~is~~(are) representative of conditions at the time of the investigation:

Signature John W. Kay
Title Engineering Assistant I

PLANT OPERATIONAL STATUS (During the sampling period)**

Process	Percent Capacity	Abatement Controls
Lime Manufacture	100	Wet Scrubbers

Special Conditions

I certify that the above statement is true to the best of my knowledge and belief:

Signature Floyd J. Carroll
Title General Manager

* To be completed and acknowledged by Air Control Program representative.
** To be completed and acknowledged by plant representative. It is understood that all the above information will be considered confidential.

Texas Air Control Board
1100 West 49th Street
Austin, Texas - 78756

Date 3 AUGUST 1972

SAMPLING DATA AND PLANT OPERATIONAL STATUS

Firm Name TEXAS LIME CO.
Location of Plant CLEBURNE, TEXAS
Type of Operation QUICKLIME

SAMPLING DATA*

Type of Sample	Location	Duration
ISOKINETIC [RUN #1]	#3 KILN	From 9:00 AM to 9:36 AM
ISOKINETIC [RUN #2]	#3 KILN	From 10:38 AM to 11:14 AM
ISOKINETIC [RUN #3]	#3 KILN	From 12:05 PM to 12:41 PM

Special Conditions NONE

I certify that the above sample(s) ~~is~~(are) representative of conditions at the time of the investigation:

Signature [illegible]
Title ENGINEERING ASSISTANT

PLANT OPERATIONAL STATUS (During the sampling period)**

Process	Percent Capacity	Abatement Controls
LIME MANUFACTURE	100	WET SCRUBBERS

Special Conditions

I certify that the above statement is true to the best of my knowledge and belief:

Signature Floyd J. Carroll
Title Plant Mgr.

* To be completed and acknowledged by Air Control Program representative.
** To be completed and acknowledged by plant representative. It is understood that all the above information will be considered confidential.