

STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL REGULATION

Receipt # 117506
AC 16-142989
\$100.00



DER

DEC 09 1987

BAQM

APPLICATION TO OPERATE/CONSTRUCT AIR POLLUTION SOURCES

SOURCE TYPE: No. 3 Lime Kiln [] New¹ [X] Existing¹

APPLICATION TYPE: [] Construction [] Operation [X] Modification

COMPANY NAME: Jefferson Smurfit Corporation COUNTY: Duval

Identify the specific emission point source(s) addressed in this application (i.e. Lime Kiln No. 4 with Venturi Scrubber; Peaking Unit No. 2, Gas Fired) No. 3 Lime Kiln/Lime Silo

SOURCE LOCATION: Street 1915 Wigmore Street City Jacksonville

UTM: East Zone 17: 439.8 North 3359.4

Latitude 30 ° 22 ' 00 "N Longitude 81 ° 37 ' 30 "W

APPLICANT NAME AND TITLE: J. F. Mixson, Vice-President and General Manager

APPLICANT ADDRESS: P.O. Box 150, Jacksonville, Florida 32201

SECTION I: STATEMENTS BY APPLICANT AND ENGINEER

A. APPLICANT

I am the undersigned owner or authorized representative* of Jefferson Smurfit Corp.

I certify that the statements made in this application for a construction permit are true, correct and complete to the best of my knowledge and belief. Further, I agree to maintain and operate the pollution control source and pollution control facilities in such a manner as to comply with the provision of Chapter 403, Florida Statutes, and all the rules and regulations of the department and revisions thereof. I also understand that a permit, if granted by the department, will be non-transferable and I will promptly notify the department upon sale or legal transfer of the permitted establishment.

*Attach letter of authorization

Signed: J. F. Mixson
J. F. Mixson, Vice-President and General Manager
Name and Title (Please Type)

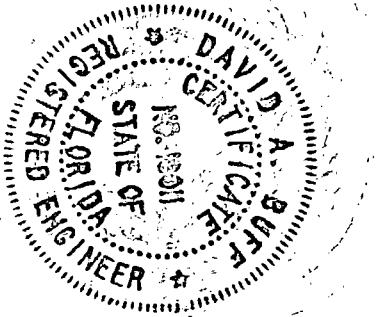
Date: 12-8-87 Telephone No. (904) 353-3611

B. PROFESSIONAL ENGINEER REGISTERED IN FLORIDA (where required by Chapter 471, F.S.)

This is to certify that the engineering features of this pollution control project have been designed/examined by me and found to be in conformity with modern engineering principles applicable to the treatment and disposal of pollutants characterized in the permit application. There is reasonable assurance, in my professional judgment, that

¹ See Florida Administrative Code Rule 17-2.100(57) and (104)

the pollution control facilities, when properly maintained and operated, will discharge an effluent that complies with all applicable statutes of the State of Florida and the rules and regulations of the department. It is also agreed that the undersigned will furnish, if authorized by the owner, the applicant a set of instructions for the proper maintenance and operation of the pollution control facilities and, if applicable, pollution sources.



Signed David A. Buff
 David A. Buff
 Name (Please Type)
 KBN Engineering and Applied Sciences, Inc.
 Company Name (Please Type)
 P.O. Box 14288, Gainesville, Florida 32604
 Mailing Address (Please Type)

Florida Registration No. 19011 Date: 12-7-87 Telephone No. (904) 375-8000

SECTION II: GENERAL PROJECT INFORMATION

A. Describe the nature and extent of the project. Refer to pollution control equipment, and expected improvements in source performance as a result of installation. State whether the project will result in full compliance. Attach additional sheet if necessary.

See Attachment A

B. Schedule of project covered in this application (Construction Permit Application Only)
 Start of Construction upon permit issuance Completion of Construction 6 months after permit issuance

C. Costs of pollution control system(s): (Note: Show breakdown of estimated costs only for individual components/units of the project serving pollution control purposes. Information on actual costs shall be furnished with the application for operation permit.)

Venturi scrubber: \$580,000

Lime silo baghouse: \$55,000

TRS collection system including ductwork: \$375,000

TRS monitoring system: \$250,000

D. Indicate any previous DER permits, orders and notices associated with the emission point, including permit issuance and expiration dates.

Permit: AC 16-095614

Issued: 10/1/85

Expires: 4/30/88

E. Requested permitted equipment operating time: hrs/day 24; days/wk 7; wks/yr 52;
if power plant, hrs/yr _____; if seasonal, describe: _____

F. If this is a new source or major modification, answer the following questions.
(Yes or No) Not Applicable

1. Is this source in a non-attainment area for a particular pollutant? _____
 - a. If yes, has "offset" been applied? _____
 - b. If yes, has "Lowest Achievable Emission Rate" been applied? _____
 - c. If yes, list non-attainment pollutants. _____
2. Does best available control technology (BACT) apply to this source?
If yes, see Section VI. _____
3. Does the State "Prevention of Significant Deterioration" (PSD)
requirement apply to this source? If yes, see Sections VI and VII. _____
4. Do "Standards of Performance for New Stationary Sources" (NSPS)
apply to this source? _____
5. Do "National Emission Standards for Hazardous Air Pollutants"
(NESHAP) apply to this source? _____

- H. Do "Reasonably Available Control Technology" (RACT) requirements apply
to this source? _____ No
- a. If yes, for what pollutants? _____
 - b. If yes, in addition to the information required in this form,
any information requested in Rule 17-2.650 must be submitted.

Attach all supportive information related to any answer of "Yes". Attach any justifi-
cation for any answer of "No" that might be considered questionable.

SECTION III: AIR POLLUTION SOURCES & CONTROL DEVICES (Other than Incinerators)

A. Raw Materials and Chemicals Used in your Process, if applicable:

Description	Contaminants		Utilization Rate - lbs/hr	Relate to Flow Diagram
	Type	% Wt		
Lime mud	Particulate	100	57,300	A
Lime from kiln	Particulate	100	22,920	B
Purchased Lime	Particulate	100	42,400	C

- B. Process Rate, if applicable: (See Section V, Item 1) To Lime Silo
 From Kiln: 22,920
 From Truck: 42,400
1. Total Process Input Rate (lbs/hr): 57,300 lime mud
2. Product Weight (lbs/hr): 22,920 lime

C. Airborne Contaminants Emitted: (Information in this table must be submitted for each emission point, use additional sheets as necessary)

Name of Contaminant	Emission ¹		Allowed Emission Rate per Rule 17-2	Allowable ³ Emission lbs/hr	Potential ⁴ Emission		Relate to Flow Diagram
	Maximum lbs/hr	Actual T/yr			lbs/yr	T/yr	
PM(TSP)	31.2	136.7	0.13 gr/dscf*	31.2	31.2	136.7	D
PM10	30.7	134.4	NA	NA	30.7	134.4	D
TRS	1.2	5.3	8 ppm, dry*	1.2	1.2	5.3	D
SO ₂	10.4	45.6	NA	NA	10.4	45.6	D
NO _x	86.5	378.9	NA	NA	86.5	378.9	D

*Corrected to 10% O₂

¹See Section V, Item 2.

²Reference applicable emission standards and units (e.g. Rule 17-2.600(5)(b)2. Table II, E. (1) - 0.1 pounds per million BTU heat input)

³Calculated from operating rate and applicable standard.

⁴Emission, if source operated without control (See Section V, Item 3).

SECTION III: AIR POLLUTION SOURCES & CONTROL DEVICES (Other than Incinerators)

A. Raw Materials and Chemicals Used in your Process, if applicable:

Description	Contaminants		Utilization Rate - lbs/hr	Relate to Flow Diagram
	Type	% Wt		

B. Process Rate, if applicable: (See Section V, Item 1)

1. Total Process Input Rate (lbs/hr): _____
2. Product Weight (lbs/hr): _____

C. Airborne Contaminants Emitted: (Information in this table must be submitted for each emission point, use additional sheets as necessary)

Name of Contaminant	Emission ¹		Allowed Emission Rate per Rule 17-2	Allowable ³ Emission lbs/hr	Potential ⁴ Emission		Relate to Flow Diagram
	Maximum lbs/hr	Actual T/yr			lbs/XX hr	T/yr	
CO	34.4	13.8	NA	NA	34.4	13.8	D
VOC	7.0	20.7	NA	NA	7.0	20.7	D
PM(TSP)	0.15	0.66	NA	0.15	0.15	0.66	E
PM10	0.15	0.66	NA	NA	0.15	0.66	E

¹See Section V, Item 2.

²Reference applicable emission standards and units (e.g. Rule 17-2.600(5)(b)2. Table II, E. (1) - 0.1 pounds per million BTU heat input)

³Calculated from operating rate and applicable standard.

⁴Emission, if source operated without control (See Section V, Item 3).

D. Control Devices: (See Section V, Item 4)

Name and Type (Model & Serial No.)	Contaminant	Efficiency	Range of Particles Size Collected (in microns) (If applicable)	Basis for Efficiency (Section V Item 5)
Airpol Venturi Scrubber	Particulates	99.3%	Submicron and above	See Att.D
	TRS	50%	NA	See Att.D
Lime Silo Baghouse:	Particulate	99.9 %	Submicron and above	See Att.D

E. Fuels

Type (Be Specific)	Consumption*		Maximum Heat Input (MMBTU/hr)
	avg/hr	max./hr	
No.6 Fuel Oil	430	535 gal/hr	78.62
Natural gas	0.063	0.07862	78.62

*Units: Natural Gas--MMCF/hr; Fuel Oils--gallons/hr; Coal, wood, refuse, other--lbs/hr.

Fuel Analysis: No.6 Fuel Oil

Percent Sulfur: 2.5% max Percent Ash: 0.1 typical

Density: 8.1 lbs/gal Typical Percent Nitrogen: 0.5 typical

Heat Capacity: 18,150 BTU/lb 147,000 BTU/gal

Other Fuel Contaminants (which may cause air pollution): _____

F. If applicable, indicate the percent of fuel used for space heating.

Annual Average Not Applicable Maximum _____

G. Indicate liquid or solid wastes generated and method of disposal.

All liquid wastes are recycled back into process. Small amounts of

solid waste from the dregs filter and lime slaker are disposed of in an existing
on-site landfill

Lime Kiln Scrubber/Lime Silo Baghouse

H. Emission Stack Geometry and Flow Characteristics (Provide data for each stack):

Stack Height: 199/85 ft. Stack Diameter: 4.5/1.1 ft.
 Gas Flow Rate: 38,256/600 ACFM 23,725/570 DSCFM Gas Exit Temperature: 153/Ambient °F.
 Water Vapor Content: 28/5 % Velocity: 40.1/16.7 FPS

SECTION IV: INCINERATOR INFORMATION

Not Applicable

Type of Waste	Type 0 (Plastics)	Type I (Rubbish)	Type II (Refuse)	Type III (Garbage)	Type IV (Pathological)	Type V (Liq. & Gas By-prod.)	Type VI (Solid By-prod.)
Actual lb/hr Incinerated							
Uncontrolled (lbs/hr)							

Description of Waste _____

Total Weight Incinerated (lbs/hr) _____ Design Capacity (lbs/hr) _____

Approximate Number of Hours of Operation per day _____ day/wk _____ wks/yr. _____

Manufacturer _____

Date Constructed _____ Model No. _____

	Volume (ft) ³	Heat Release (BTU/hr)	Fuel		Temperature (°F)
			Type	BTU/hr	
Primary Chamber					
Secondary Chamber					

Stack Height: _____ ft. Stack Diameter: _____ Stack Temp. _____

Gas Flow Rate: _____ ACFM _____ DSCFM* Velocity: _____ FPS

*If 50 or more tons per day design capacity, submit the emissions rate in grains per standard cubic foot dry gas corrected to 50% excess air.

Type of pollution control device: Cyclone Wet Scrubber Afterburner
 Other (specify) _____

Brief description of operating characteristics of control devices: _____

Ultimate disposal of any effluent other than that emitted from the stack (scrubber water, ash, etc.):

NOTE: Items 2, 3, 4, 6, 7, 8, and 10 in Section V must be included where applicable.

SECTION V: SUPPLEMENTAL REQUIREMENTS

Please provide the following supplements where required for this application.

1. Total process input rate and product weight -- show derivation [Rule 17-2.100(127)]
See Attachment A
2. To a construction application, attach basis of emission estimate (e.g., design calculations, design drawings, pertinent manufacturer's test data, etc.) and attach proposed methods (e.g., FR Part 60 Methods 1, 2, 3, 4, 5) to show proof of compliance with applicable standards. To an operation application, attach test results or methods used to show proof of compliance. Information provided when applying for an operation permit from a construction permit shall be indicative of the time at which the test was made.
See Attachment B
3. Attach basis of potential discharge (e.g., emission factor, that is, AP42 test).
See Attachment B
4. With construction permit application, include design details for all air pollution control systems (e.g., for baghouse include cloth to air ratio; for scrubber include cross-section sketch, design pressure drop, etc.)
See Attachment D
5. With construction permit application, attach derivation of control device(s) efficiency. Include test or design data. Items 2, 3 and 5 should be consistent: actual emissions = potential (1-efficiency).
See Attachment D
6. An 8 1/2" x 11" flow diagram which will, without revealing trade secrets, identify the individual operations and/or processes. Indicate where raw materials enter, where solid and liquid waste exit, where gaseous emissions and/or airborne particles are evolved and where finished products are obtained.
See Attachment A
7. An 8 1/2" x 11" plot plan showing the location of the establishment, and points of airborne emissions, in relation to the surrounding area, residences and other permanent structures and roadways (Example: Copy of relevant portion of USGS topographic map).
Attached
8. An 8 1/2" x 11" plot plan of facility showing the location of manufacturing processes and outlets for airborne emissions. Relate all flows to the flow diagram.
Attached

9. The appropriate application fee in accordance with Rule 17-4.05. The check should be made payable to the Department of Environmental Regulation.
10. With an application for operation permit, attach a Certificate of Completion of Construction indicating that the source was constructed as shown in the construction permit.

SECTION VI: BEST AVAILABLE CONTROL TECHNOLOGY

Not Applicable

- A. Are standards of performance for new stationary sources pursuant to 40 C.F.R. Part 60 applicable to the source?

Yes No

Contaminant	Rate or Concentration

- B. Has EPA declared the best available control technology for this class of sources (If yes, attach copy)

Yes No

Contaminant	Rate or Concentration

- C. What emission levels do you propose as best available control technology?

Contaminant	Rate or Concentration

- D. Describe the existing control and treatment technology (if any).

- | | |
|---------------------------|--------------------------|
| 1. Control Device/System: | 2. Operating Principles: |
| 3. Efficiency:* | 4. Capital Costs: |

*Explain method of determining

5. Useful Life:

6. Operating Costs:

7. Energy:

8. Maintenance Cost:

9. Emissions:

Contaminant

Rate or Concentration

Contaminant	Rate or Concentration

10. Stack Parameters

- a. Height: ft.
- b. Diameter: ft.
- c. Flow Rate: ACFM
- d. Temperature: °F.
- e. Velocity: FPS

E. Describe the control and treatment technology available (As many types as applicable use additional pages if necessary).

1.

- a. Control Device:
- b. Operating Principles:
- c. Efficiency:¹
- d. Capital Cost:
- e. Useful Life:
- f. Operating Cost:
- g. Energy:²
- h. Maintenance Cost:
- i. Availability of construction materials and process chemicals:
- j. Applicability to manufacturing processes:
- k. Ability to construct with control device, install in available space, and operate within proposed levels:

2.

- a. Control Device:
- b. Operating Principles:
- c. Efficiency:¹
- d. Capital Cost:
- e. Useful Life:
- f. Operating Cost:
- g. Energy:²
- h. Maintenance Cost:
- i. Availability of construction materials and process chemicals:

¹Explain method of determining efficiency.

²Energy to be reported in units of electrical power - KWH design rate.

j. Applicability to manufacturing processes:

k. Ability to construct with control device, install in available space, and operate within proposed levels:

3.

a. Control Device:

b. Operating Principles:

c. Efficiency:¹

d. Capital Cost:

e. Useful Life:

f. Operating Cost:

g. Energy:²

h. Maintenance Cost:

i. Availability of construction materials and process chemicals:

j. Applicability to manufacturing processes:

k. Ability to construct with control device, install in available space, and operate within proposed levels:

4.

a. Control Device:

b. Operating Principles:

c. Efficiency:¹

d. Capital Costs:

e. Useful Life:

f. Operating Cost:

g. Energy:²

h. Maintenance Cost:

i. Availability of construction materials and process chemicals:

j. Applicability to manufacturing processes:

k. Ability to construct with control device, install in available space, and operate within proposed levels:

F. Describe the control technology selected:

1. Control Device:

2. Efficiency:¹

3. Capital Cost:

4. Useful Life:

5. Operating Cost:

6. Energy:²

7. Maintenance Cost:

8. Manufacturer:

9. Other locations where employed on similar processes:

a. (1) Company:

(2) Mailing Address:

(3) City:

(4) State:

¹Explain method of determining efficiency.

²Energy to be reported in units of electrical power - KWH design rate.

(5) Environmental Manager:

(6) Telephone No.:

(7) Emissions:¹

Contaminant

Rate or Concentration

(8) Process Rate:¹

b. (1) Company:

(2) Mailing Address:

(3) City:

(4) State:

(5) Environmental Manager:

(6) Telephone No.:

(7) Emissions:¹

Contaminant

Rate or Concentration

(8) Process Rate:¹

10. Reason for selection and description of systems:

¹Applicant must provide this information when available. Should this information not be available, applicant must state the reason(s) why.

SECTION VII - PREVENTION OF SIGNIFICANT DETERIORATION

Not Applicable

A. Company Monitored Data

1. _____ no. sites _____ TSP _____ () SO₂* _____ Wind spd/dir

Period of Monitoring _____ / _____ / _____ to _____ / _____ / _____
month day year month day year

Other data recorded _____

Attach all data or statistical summaries to this application.

*Specify bubbler (B) or continuous (C).

2. Instrumentation, Field and Laboratory

a. Was instrumentation EPA referenced or its equivalent? [] Yes [] No

b. Was instrumentation calibrated in accordance with Department procedures?
[] Yes [] No [] Unknown

B. Meteorological Data Used for Air Quality Modeling

1. _____ Year(s) of data from _____ / _____ / _____ to _____ / _____ / _____
month day year month day year

2. Surface data obtained from (location) _____

3. Upper air (mixing height) data obtained from (location) _____

4. Stability wind rose (STAR) data obtained from (location) _____

C. Computer Models Used

1. _____ Modified? If yes, attach description.

2. _____ Modified? If yes, attach description.

3. _____ Modified? If yes, attach description.

4. _____ Modified? If yes, attach description.

Attach copies of all final model runs showing input data, receptor locations, and principle output tables.

D. Applicants Maximum Allowable Emission Data

Pollutant	Emission Rate
TSP	_____ grams/sec
SO ²	_____ grams/sec

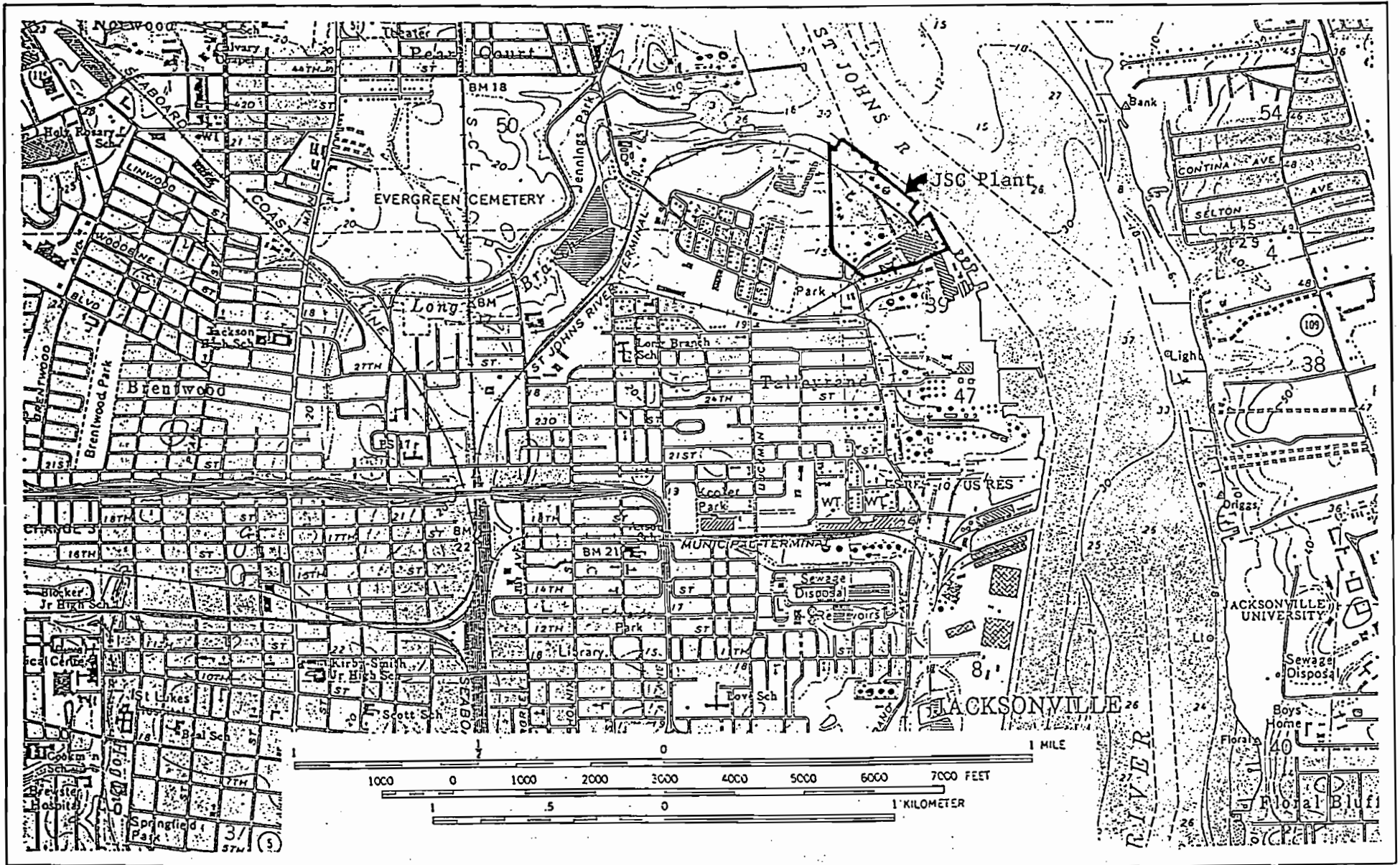
E. Emission Data Used in Modeling

Attach list of emission sources. Emission data required is source name, description of point source (on NEDS point number), UTM coordinates, stack data, allowable emissions, and normal operating time.

F. Attach all other information supportive to the PSD review.

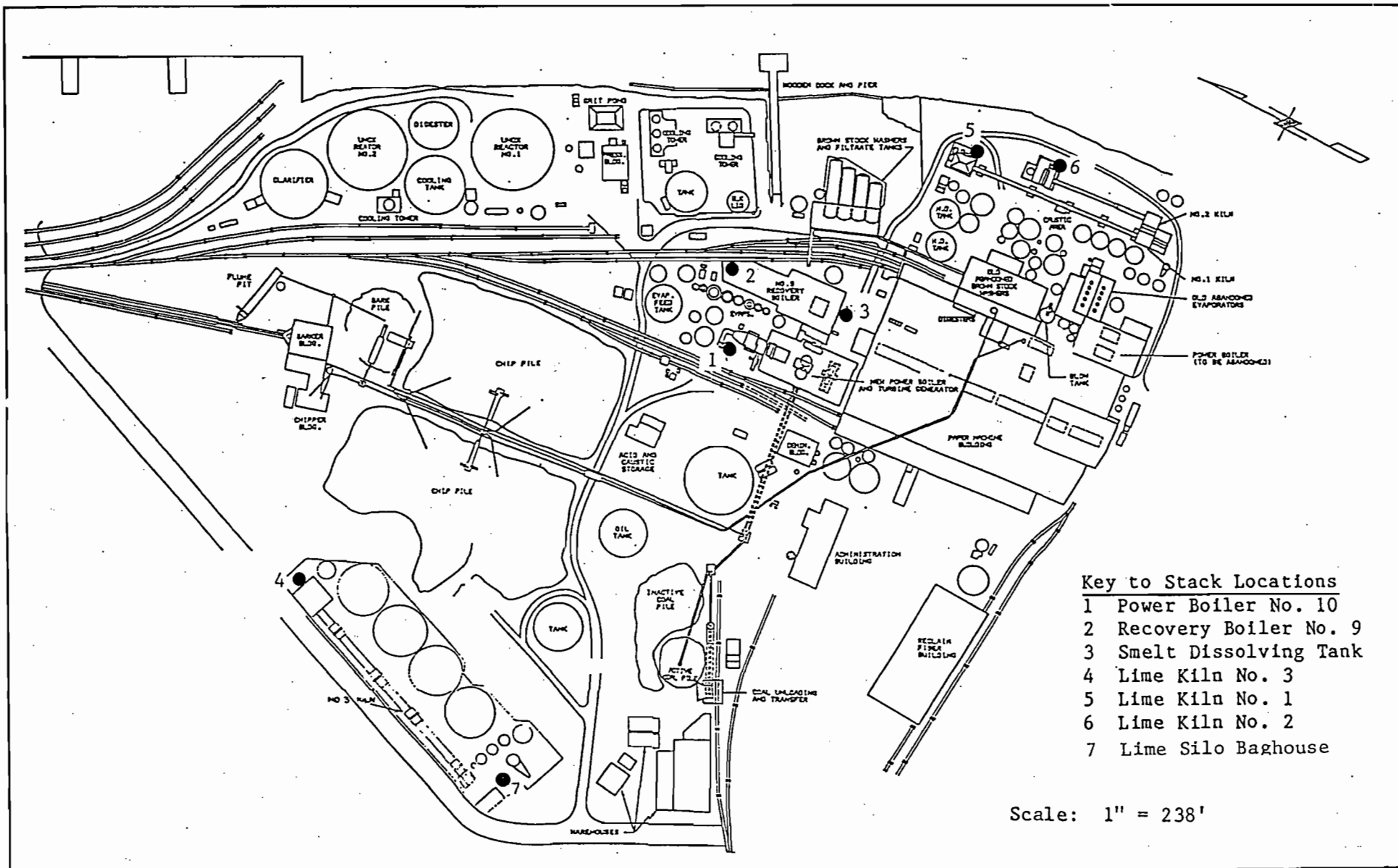
G. Discuss the social and economic impact of the selected technology versus other applicable technologies (i.e., jobs, payroll, production, taxes, energy, etc.). Include assessment of the environmental impact of the sources.

H. Attach scientific, engineering, and technical material, reports, publications, journals, and other competent relevant information describing the theory and application of the requested best available control technology.



Site Location Map of Jefferson Smurfit Corporation





- Key to Stack Locations
- 1 Power Boiler No. 10
 - 2 Recovery Boiler No. 9
 - 3 Smelt Dissolving Tank
 - 4 Lime Kiln No. 3
 - 5 Lime Kiln No. 1
 - 6 Lime Kiln No. 2
 - 7 Lime Silo Baghouse

Scale: 1" = 238'

Plot Plan of Jefferson Smurfit Facility and Stack Locations

KBN

ATTACHMENT A
PROJECT DESCRIPTION

1.0 INTRODUCTION

Jefferson Smurfit Corporation (JSC) of Jacksonville, Florida is requesting an increase in the permitted capacity of the No. 3 Lime Kiln from 220 tons per day (TPD) of lime to 275 TPD of lime. The lime kiln is now operating under the Florida Department of Environmental Regulation (FDER) Construction Permit No. AC16-095614, which was issued on October 1, 1985 and modified on November 14, 1986. Associated with the proposed increase in lime production capacity of the No. 3 Lime Kiln will be an increase in the maximum process rate of the Lime Silo.

A complete, new construction permit application has been prepared to support the requested production rate increase. This permitting approach was considered to be the best for several reasons. First, the new No. 3 Lime Kiln is still operating under the construction permit issued by the FDER. An operating permit has not yet been issued. Secondly, review of the basis of the emission rates for several pollutants revealed that more appropriate emission factors should have been used to estimate maximum emissions. As a result, the basis for all regulated pollutant emissions have been reviewed, and revised emission estimates are presented in Attachment B. The requested higher production rate results in minor changes to the information presented in the original application. A flow diagram of the process is presented in Figure A-1.

The No. 3 Lime Kiln at JSC replaced two old, inefficient lime kilns which previously supported the pulp manufacturing operation. The old lime bins, slaker, and associated causticizing equipment were also replaced. Emission reductions from the shutdown of these sources have been developed and are presented in Attachment C. Creditable emission reductions from several of these sources, such as the lime bins and lime slaker, were not quantified in the original application for the No. 3 Lime Kiln.

A comparison of the emission increases from the No. 3 Lime Kiln system and the contemporaneous emission reductions at the JSC facility was performed to determine Prevention of Significant Deterioration (PSD) and nonattainment area (NA) new source review applicability. The applicable rules of FDER and the U.S. Environmental Protection Agency (USEPA) were considered in developing the PSD source applicability analysis. This analysis is presented in Section 2.0 which follows.

This application also requests approval to vent non-condensable total reduced sulfur (TRS) gases from the proposed new digesting system at JSC to the No. 3 Lime Kiln for incineration. Design information related to the TRS gases expected from the new digesting system were presented in the air construction permit application for the digesting system submitted recently to FDER. Additional information is provided in Attachment D to this application for the No. 3 Lime Kiln.

2.0 NEW SOURCE REVIEW APPLICABILITY

A comparison of the maximum annual emissions from the No. 3 Lime Kiln system, operating at 275 TPD, and the creditable emission offsets from the shutdown of the old equipment, is presented in Table A-1. Also shown are the net changes in emissions resulting from the project. The net emissions increases were based upon the definition of "net emissions increase" in Rule 17-2.500(2)(e)1, which reads:

A modification to a facility results in a net emissions increase when, for a pollutant regulated under the Act, the sum of all of the contemporaneous creditable increases and decreases in the actual emissions of the facility, including the increase in emissions of the modification itself and any increases and decreases in quantifiable fugitive emissions, is greater than zero.

The definition of "net emissions increase" under the NA new source review rules [Rule 17-2.510(2)(e)1] is essentially identical to the above definition.

As indicated in Table A-1, the No. 3 Lime Kiln project results in net increases in emissions which are all below the PSD and NA new source review significant emission rates. The PSD and NA new source review significant emission rates are defined in FAC, Rule 17-2.500 and Rule 17-2.510. Since the net emission increases resulting from the project are all less than the significant emission rates for all pollutants, the No. 3 Lime Kiln system is not subject to PSD/NA new source review.

The last line of Table A-1 shows the "unused" emission reductions which can be credited towards future projects at JSC, within the defined contemporaneous period. The basis for this conclusion lies in the definition of "contemporaneous emissions changes" and "creditable emissions changes". "Contemporaneous emissions changes" is defined in Rule 17-2.500(2)(e)3 as:

An increase in the actual emissions or in the quantifiable fugitive emissions of a facility is contemporaneous with a particular modification if it occurs within the period beginning five years prior to the date on which the owner or operator of the facility submits a complete application for a permit to modify the facility and ending on the date on which the owner or operator of the modified facility projects the new or modified sources to begin operation. The date on which any increase in the actual emissions or in the quantifiable fugitive emissions of the facility occurs is the date on which the owner or operator of the facility begins, or projects to begin, operation of the source(s) resulting in the increase. The date on which any decrease in the actual emissions or in the quantifiable fugitive emissions of the facility occurs is the date on which the owner or operator of the facility completes, or is committed to complete through a federally enforceable permit condition, a physical change in or change in the method of operation of the facility resulting in the decrease.

The definition of "contemporaneous emissions decreases" under NA new source review requirements, Rule 17-2.510(2)(e)3, is identical to the above definition.

In regards to a request to modify the No. 3 Lime Kiln permit, the associated contemporaneous period would begin five years prior to the date on which JSC submits a complete application to modify the source. Assuming a complete application is submitted by January 1, 1988, the contemporaneous period would extend back to at least January 1, 1983. The contemporaneous period would end when the new No. 3 Lime Kiln begins operating at the higher production rate. Within this period, Lime Kilns 1 and 2 and the old causticizing system will have shut down as required by the federally enforceable No. 3 Lime Kiln construction permit. Therefore, all of the emissions reductions from the Nos. 1 and 2 Lime Kilns and old causticizing system, as shown in Table A-1, have occurred during the "contemporaneous" period associated with this request to modify the No. 3 Lime Kiln permit.

Concerning "creditable emissions changes", Rule 17-2.500(4)(a) requires that:

An increase or decrease in the actual emissions or in the quantifiable fugitive emissions of a facility is creditable if:

- (i) The Department has not relied on it in issuing a permit under the provisions of Rule 17-2.500 or EPA has not relied on it in issuing a permit under the provisions of 40 CFR 52.21, which permit is in effect when the increase in emissions of the modification occurs; or
- (ii) The Department has not relied on it in demonstrating attainment, defining reasonable further progress, or issuing a permit under the provisions of Rule 17-2.17 (repealed), 17-2.510, or 17-2.650, which permit is in effect when the increase in emissions of the modification occurs.

Rule 17-2.500(e)(4)(c)(ii) further requires that a decrease in emissions be federally enforceable in order to be creditable. Rule 17-2.510(e)(4) provides requirements for nonattainment areas which parallel the above rules for attainment areas.

In issuing a new construction permit for the No. 3 Lime Kiln system at JSC, FDER only needs to rely on that portion of the creditable emission reductions which resulted in the net emissions increases being below the significant emission rates (and therefore not subject to new source review). Therefore, the unused emission reductions shown in Table A-1 are creditable reductions which can be used by JSC on a future modification, if the modification occurs within the contemporaneous time period. *Windy*

Other sources operating normally under their respective permits at the JSC facility have not been included in the source applicability analysis. Changes in actual emissions at such sources are specifically excluded from the definition of modification by Rule 17-2.100(118). This rule defines "modification" as:

Any physical change in, change in the method of operation of, or addition to a stationary source or facility which increases the actual emissions of any air pollutant regulated under this Chapter, including any not previously emitted, from any source or facility. A physical change in or change in the method of operation shall not include:

(b) An increase in the hours of operation or in production rate of a source, unless such change would be prohibited under any federally enforceable permit condition which was established after January 6, 1975.

As a result, increases or decreases in actual emissions at other sources at JSC due to year-to-year variability are not considered in determining if the proposed modification is subject to new source review requirements, as long as such sources were operated within their respective permit limitations. *Windy*

3.0 NSPS APPLICABILITY

The No. 3 Lime Kiln is subject to and will comply with the New Source Performance Standards for lime kilns under 40 CFR 60, Subpart BB. The following emission limitations must be met under the NSPS:

Particulate matter: 0.13 gr/dscf, corrected to 10% O₂, liquid fuel
0.067 gr/dscf, corrected to 10% O₂, gaseous fuel
Total reduced sulfur: 8 ppm by volume, dry basis, corrected to 10% O₂

The No. 3 Lime Kiln has been tested at the higher 275 TPD (11.46 TPH) production rate, and has demonstrated it can meet the NSPS limits.

4.0 PROCESS INPUT AND OUTPUT RATES

A. Lime Kiln

Maximum lime production rate = 275 TDP = 11.46 TPH

Production factor = 0.4 to 0.55 lb lime product/lb lime mud feed

Maximum lime mud feed rate = 11.46 TPH lime x lb lime mud/0.4 lb lime
= 28.65 TPH lime mud (dry)
= 57,300 lb/hr lime mud (dry)

B. Lime Silo

1. From Lime Kiln

Maximum loading rate from the kiln is the maximum lime kiln production rate of 11.46 TPH.

2. From Truck Unloading (purchased lime)

Maximum truck unloading rate of purchased lime is 42,400 lb/hr

5.0 HEAT INPUT AND FUEL CONSUMPTION RATES

Maximum heat rate = 6.86×10^6 Btu/ton lime produced

Maximum lime production = 275 TPD = 11.46 TPH

Maximum heat input rate = 6.86×10^6 Btu/ton lime x 11.46 TPH
= 78.62×10^6 Btu/hr

Minimum No. 6 Fuel Oil heating value = 147,000 Btu/gal

Minimum natural gas heating value = 1,000 Btu/scf

Maximum No. 6 Fuel oil consumption:

78.62×10^6 Btu/hr / 147,000 Btu/gal = 535 gal/hr

Maximum natural gas consumption:

78.62×10^6 Btu/hr / 1,000 Btu/scf = 78,620 scf/hr

Table A-1 Summary of Net Emission Changes, Jefferson Smurfit Corporation
No. 3 Lime Kiln Project

Source	Annual Emissions (TPY)						
	PM	PM10	SO ₂	TRS	CO	NO _x	VOC
<u>PSD SIGNIFICANCE LEVEL</u>	25	15	40	10	100	40	40
<u>EMISSIONS FROM EXISTING SOURCES SHUT DOWN</u>							
No. 1 and 2 Lime Kilns	113.0	111.1	26.9	94.2	12.3	401.1	13.0
Kiln Leaks	9.8	1.6	-	-	-	-	-
Slaker	3.8	3.6	-	-	-	-	-
Line Conveying, Transfer & Storage (RACT) or uncontrolled	12.9	4.8	-	-	-	-	-
Subtotal	139.5	121.1	26.9	94.2	12.3	401.1	13.0
<u>TOTAL EMISSIONS AVAILABLE FOR NEW SOURCES WITHOUT CAUSING PSD REVIEW</u>	164.5	136.1	66.9 69.9	104.2	112.3	441.1	53.0
<u>PROPOSED NEW SOURCES</u>							
No. 3 Lime Kiln	136.7	134.4	45.6	5.3	13.8	378.9	20.7
Kiln Leaks NO	2.2	0.4	-	-	-	-	-
Lime Silo	0.7	0.7	-	-	-	-	-
Subtotal	139.6	135.5	45.6	5.3	13.8	378.9	20.7
<u>UNUSED CONTEMPORANEOUS EMISSIONS REDUCTIONS AVAILABLE FOR FUTURE USE</u>	24.9	0.6	21.3 24.3	98.9	98.5	62.2	32.3

	PM	PM10	SO ₂	TRS	CO	NO _x	VOC
Now	137.4		45.6	5.3	13.8	378.9	20.7
was	94.3		36.5	3.5	120.5	169.7	14.9
	+43.1		+9.1	+1.8			+4.8
	NA						

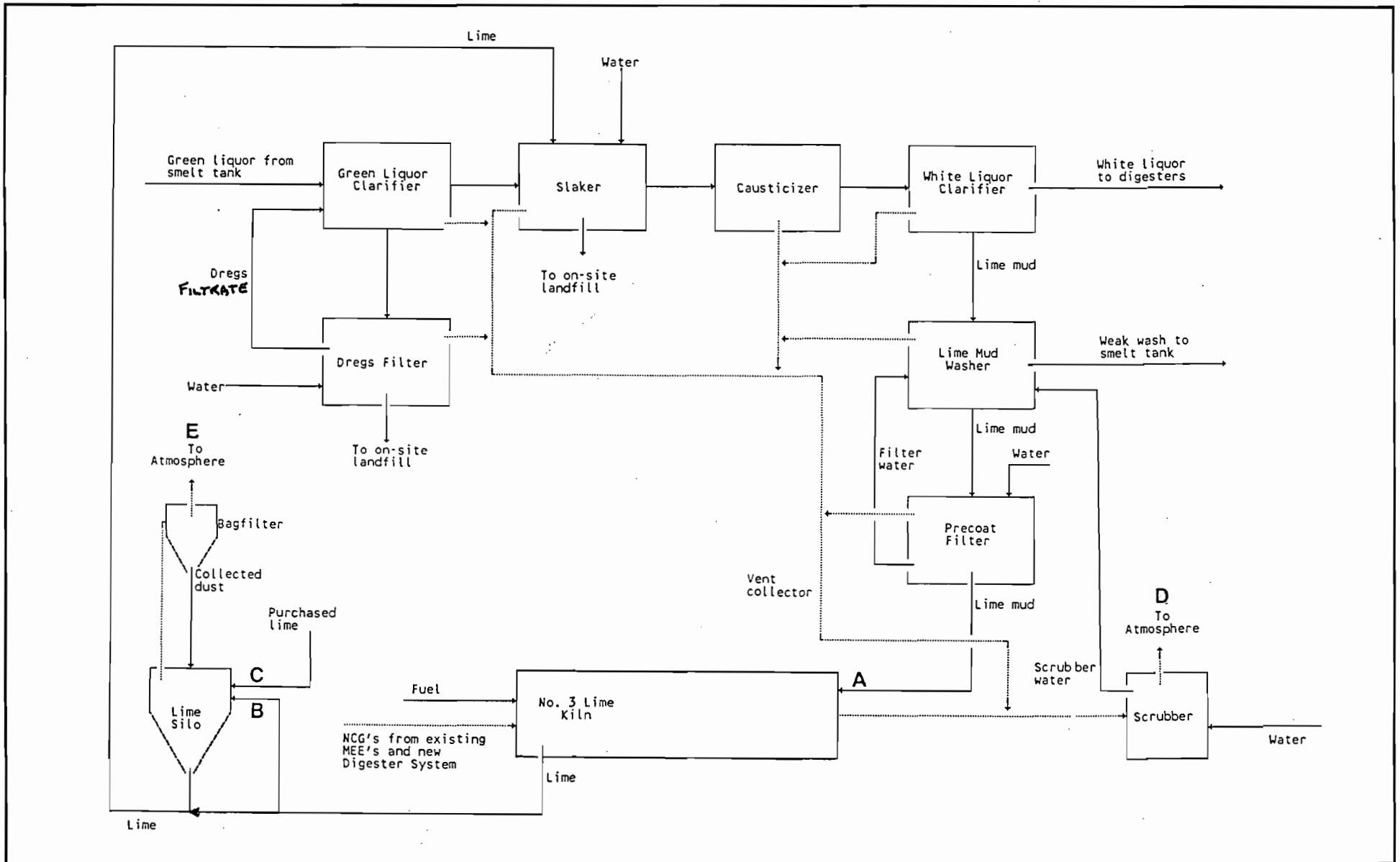


Figure A-1. Process Flow Diagram, No. 3 Lime Kiln System

Notes:
 — Material flow
 Gas flow



ATTACHMENT B

**BASIS FOR MAXIMUM EMISSIONS FROM
NO.3 LIME KILN AND LIME SILO BAG FILTER**

I. PARTICULATE MATTER

A. PM (TSP)

PM(TSP) represents total particulate matter emissions from the lime kiln. The NSPS for lime kilns at kraft pulp mills (40 CFR 60, Subpart BB) is 0.13 gr/dscf, corrected to 10% O₂, when burning fuel oil, and 0.067 gr/dscf, corrected to 10% O₂, when burning natural gas. The NSPS level will not be exceeded by the new kiln.

1. Maximum Hourly Emissions

Total gas flow from kiln @ 275 TPD lime and 6.86×10^6 Btu/ton lime:

$$\begin{aligned} \text{No. 6 Fuel oil} &= 14,687 \text{ dscfm @ } 0\% \text{ O}_2 \text{ } 2\% \\ &= 28,039 \text{ dscfm @ } 10\% \text{ O}_2 \text{ } 25,364 \end{aligned}$$

$$\begin{aligned} \text{PM(TSP)} &= 28,039 \text{ dscfm} \times 0.13 \text{ gr/dscf} / 7,000 \text{ gr/lb} \times 60 \text{ min/hr} \\ &= 31.2 \text{ lb/hr} \end{aligned}$$

$$\begin{aligned} \text{Natural gas} &= 14,058 \text{ dscfm @ } 0\% \text{ O}_2 \text{ } 2\% \\ &= 26,838 \text{ dscfm @ } 10\% \text{ O}_2 \text{ } 24,282 \end{aligned}$$

$$\begin{aligned} \text{PM(TSP)} &= 26,838 \text{ dscfm} \times 0.067 \text{ gr/dscf} / 7,000 \text{ gr/lb} \times 60 \text{ min/hr} \\ &= 15.4 \text{ lb/hr} \end{aligned}$$

2. Maximum Annual Emissions

Maximum annual emissions are based upon emitting at the maximum hourly rate for each hour of the year:

$$31.2 \text{ lb/hr} \times 8,760 \text{ hr/yr} / 2,000 \text{ lb/ton} = 136.7 \text{ TPY}$$

B. PM10

That fraction of PM(TSP) which has an aerodynamic particle size diameter of 10 um and less is referred to as PM10. AP-42, Section 10.1, Chemical Wood Pulping (10/86), contains information related to PM10 emissions from lime kilns controlled by a venturi scrubber. The AP-42 data show that PM10 emissions from such sources represent 98.3% of PM(TSP) emissions.

$$\text{Maximum hourly emissions} = 31.2 \text{ lb/hr} \times 0.983 = 30.7 \text{ lb/hr}$$

$$\text{Maximum annual emissions} = 136.7 \text{ TPY} \times 0.983 = 134.4 \text{ TPY}$$

II. TOTAL REDUCED SULFUR

Maximum emissions are based upon the NSPS for lime kilns at kraft pulp mills (40 CFR 60, Subpart BB): 8 ppm by volume, dry basis, corrected to 10% O₂. Maximum flue gas flow rate at maximum lime production rate of 275 TPD (11.46 TPH) = 28,039 dscfm @ 10% O₂ (based upon No. 6 fuel oil burning).

$$PVC = mRT \quad m = PVC/RT$$

$$R = 1,545 \text{ ft-lb}_f/\text{lb}_{\text{mole}}\text{-}^\circ\text{R}$$

$$\text{Molecular weight TRS (as H}_2\text{S)} = 34 \text{ lb}_m/\text{lb}_{\text{mole}}$$

$$R = 45.44 \text{ ft-lb}_f/\text{lb}_m\text{-}^\circ\text{R}$$

$$C = 8 \text{ ppm}$$

$$m = \frac{2116.8 \text{ lb}_f}{\text{ft}^2} \times \frac{28,039 \text{ ft}^3}{\text{min}} \times \frac{8}{10^6} \times \frac{\text{lb}_m\text{-}^\circ\text{R}}{45.44 \text{ ft-lb}_f} \times \frac{1}{528^\circ\text{R}} \times \frac{60 \text{ min}}{\text{hr}}$$

$$= 1.2 \text{ lb/hr TRS as H}_2\text{S}$$

110

$$1.2 \text{ lb/hr} \times 8,760 \text{ hr/yr} / 2,000 \text{ lb/ton} = 5.3 \text{ TPY TRS as H}_2\text{S}$$

= 4.36

III. SULFUR DIOXIDE

An SO₂ emission factor of 0.2 lb/ton ADUP produced is considered a maximum for the No. 3 Lime Kiln. The proposed new digesting system at JSC is designed for a total pulp production of 1250. *should be on basis of previous batch level of op.*

$$\text{Maximum hourly SO}_2 = 1,250 \text{ TPD} / 24 \text{ hr/day} \times 0.2 \text{ lb/ton}$$

$$= 10.4 \text{ lb/hr}$$

$$10.4 \text{ lb/hr} \times 8,760 \text{ hr/yr} / 2,000 \text{ lb/ton} = 45.6 \text{ TPY}$$

An SO₂ emission test conducted on the No. 3 Lime Kiln shows SO₂ emissions to be well below the 10.4 lb/hr level. TRS gases from the proposed new digester system at JSC will be tied into the No. 3 Lime Kiln for incineration at a later date. The SO₂ generated in the kiln due to incineration of TRS gases is expected to increase SO₂ emissions only slightly above present levels, due to the SO₂ absorbing capacity of the lime kiln. If test data indicate that SO₂ emissions are exceeding the 10.4 lb/hr level, caustic addition to the scrubber water will be implemented to lower SO₂ emissions to acceptable levels.

also
✓MEE's contribution

IV. NITROGEN OXIDES

NO_x emissions from the No. 3 Lime Kiln were based upon the same emission factor equation as used to calculate NO_x from the existing lime kilns. The equation was taken from a study performed by NCASI on lime kilns at pulp mills. The study found a linear relationship between NO_x emissions and combustion zone temperature over the range of 1,850°F to 2,250°F. The relationship is expressed according to the following equation:

$$1 \text{ lb NO}_x / 10^6 \text{ Btu} = [2.17 \times 10^{-3} \times T(^{\circ}\text{F})] - 3.58$$

The operating combustion zone temperature for the No. 3 Lime Kiln is 2,150°F. Substituting this temperature into the above equation yields an emission factor of 1.1 lb/10⁶ Btu. This emission factor is considered to be the most appropriate factor for the No. 3 Lime Kiln. Refer to Attachment C regarding NO_x emission estimates for the existing kilns at JSC for a further discussion. Maximum heat input to the No. 3 Lime Kiln will be 78.62 x 10⁶ Btu/hr, based upon a maximum lime production rate of 275 TPD (11.46 TPH) and a maximum heat rate of 6.86 x 10⁶ Btu/ton of lime produced.

$$\begin{aligned} \text{Maximum hourly NO}_x \text{ emissions} &= 78.62 \times 10^6 \text{ Btu/hr} \times 1.1 \text{ lb}/10^6 \text{ Btu} \\ &= 86.5 \text{ lb/hr} \end{aligned}$$

$$\begin{aligned} \text{Maximum annual NO}_x &= 86.5 \text{ lb/hr} \times 8,760 \text{ hr/yr} / 2,000 \text{ lb/ton} \\ &= 378.9 \text{ TPY} \end{aligned}$$

V. CARBON MONOXIDE

Maximum annual emissions of CO from the No. 3 Lime Kiln were based upon an emission factor of 0.04 lb/10⁶ Btu. This is the same emission factor used to estimate CO from the existing kilns. The factor was derived from NCASI study of CO emissions from lime kilns at pulp mills (Technical Bulletin No. 416). The factor represents an average emission level. It is therefore considered appropriate for annual emission calculations.

$$\begin{aligned} \text{Maximum annual heat input to kiln} & \\ &= 78.62 \times 10^6 \text{ Btu/hr} \times 8,760 \text{ hr/yr} \\ &= 6.89 \times 10^{11} \text{ Btu/yr} \end{aligned}$$

Annual emissions

$$\begin{aligned} &= 6.89 \times 10^{11} \text{ Btu/yr} \times 0.04 \text{ lb}/10^6 \text{ Btu} / 2,000 \text{ lb/ton} \\ &= 13.8 \text{ TPY} \end{aligned}$$

The NCASI study found that the maximum 1-hour CO emission rate measured from the kilns, where adequate data were obtained (Kilns A and B), was approximately 3.0 lb/ton lime produced. This emission factor and the maximum lime production rate of 11.46 TPH was used to estimate the maximum 1-hour CO emission rate from the No. 3 Lime Kiln.

$$11.46 \text{ TPH lime} \times 3.0 \text{ lb/ton} = 34.4 \text{ lb/hr}$$

VI. VOLATILE ORGANIC COMPOUNDS

Maximum emissions of VOC from the No. 3 Lime Kiln were based upon a NCASI study (Technical Bulletin No. 358). Of the three kilns tested in this study, Kilns A and C were considered most representative of the No. 3 Lime Kiln. All three kilns were equipped with wet scrubbers for particulate control but only Kilns A and C used fresh water for scrubbing. Kilns A and C exhibited average VOC emissions of 0.060 and 0.024 lb/10⁶ Btu, respectively. The higher level of 0.060 lb/10⁶ Btu was used to estimate annual emissions from the No. 3 Lime Kiln.

$$6.89 \times 10^{11} \text{ Btu/yr} \times 0.060 \text{ lb}/10^6 \text{ Btu} / 2,000 \text{ lb/ton} = 20.7 \text{ TPY}$$

The maximum 1-hour VOC emission rate was based upon the highest measured emission rate from either Kiln A or C when burning oil (NCASI study). This maximum emission rate was 0.089 lb/10⁶ Btu.

$$\text{Maximum heat input for kiln} = 78.62 \times 10^6 \text{ Btu/hr}$$

$$78.62 \times 10^6 \text{ Btu/hr} \times 0.089 \text{ lb}/10^6 \text{ Btu} = 7.0 \text{ lb/hr}$$

VII. KILN LEAKS

NO

A. PM (TSP)

The No. 3 Lime Kiln has seals at the ends of the kiln which are much improved over those on the existing kilns. In addition, air leaks at the I.D. fan and in ductwork is negligible. For the existing

kilns, kiln leaks were estimated to be 1/1000 of the total air flow from the kilns (see Attachment C). Air leakage from the No. 3 Lime Kiln is estimated to be at least a factor of 10 lower than the existing kilns, or 1/10,000 of the total air flow through the No. 3 Lime Kiln.

*1/10
Draft induced
vs
forced*

Maximum air flow through kiln = 23,725 dscfm
Maximum kiln air leakage = 23,725 / 10,000 = 2.4 dscfm
Kiln design outlet dust loading = 22 gr/dscf
PM(TSP) emissions = 2.4 dscfm x 22 gr/dscf / 7,000 gr/lb x 60 min/hr
= 0.5 lb/hr
0.5 lb/hr x 8,760 hr/yr / 2,000 lb/ton = 2.2 TPY

B. PM10

AP-42, Section 10.1, Chemical Wood Pulping (10/86), contains information related to uncontrolled PM emissions from lime kilns. The AP-42 data show that PM10 emissions represent 16.8% of uncontrolled PM(TSP) emissions.

$$0.5 \text{ lb/hr} \times 0.168 = 0.08 \text{ lb/hr}$$
$$2.2 \text{ TPY} \times 0.168 = 0.4 \text{ TPY}$$

VIII. LIME SILO BAG FILTER

A. PM(TSP)

Maximum emissions from the bag filter serving the lime silo are based upon the design flow rate of 600 acfm (570 dscfm) and 0.03 gr/dscf

$$570 \text{ dscfm} \times 0.03 \text{ gr/dscf} / 7,000 \text{ gr/lb} \times 60 \text{ min/hr}$$
$$= 0.15 \text{ lb/hr}$$
$$0.15 \text{ lb/hr} \times 8,760 \text{ hr/yr} / 2,000 \text{ lb/ton} = 0.66 \text{ TPY}$$

B. PM10

It was conservatively assumed that all the PM(TSP) emissions are of the PM10 size category. Therefore, PM10 emissions are the same as the PM(TSP) emissions calculated above.

ATTACHMENT C

QUANTIFICATION OF CONTEMPORANEOUS
EMISSIONS REDUCTIONS

ND

I. NO. 1 AND NO. 2 LIME KILNS

A. PARTICULATE MATTER (TSP)

In the original application, actual total particulate matter [PM(TSP)] emissions from No. 1 and No. 2 Lime Kilns at JSC were based on compliance test data from 1984 and actual kiln operating hours for calendar year 1984. Emissions from No. 1 Lime Kiln were 34.36 TPY, while those from No. 2 Lime Kiln were 78.65 TPY, for a total of 113.0 TPY from both kilns. These are considered to be the creditable PM(TSP) emission reductions for the kilns. The emissions were based upon the following:

No. 1 Lime Kiln - 9.13 lb/hr avg., 44.8 wks/yr
No. 2 Lime Kiln - 19.63 lb/hr avg., 47.7 wks/yr

B. PARTICULATE MATTER (PM10)

PM10 emissions represent that portion of total particulate matter having an aerodynamic particle size diameter of 10 um and less. Since PM10 was not a regulated pollutant at the time of the original application, PM10 emissions were not addressed in the original application. USEPA has recently published information in AP-42, Section 10.1, Chemical Wood Pulping (10/86), which allows PM10 emissions to be estimated from lime kilns in the pulp and paper industry (reference attached). The lime kilns at JSC were controlled by venturi scrubbers. The USEPA document indicates that 98.3% of PM emissions from lime kilns equipped with venturi scrubbers are less than 10 um in diameter. Based upon this information, PM10 emissions from the lime kilns are estimated as follows:

No. 1 Lime Kiln - 34.36 TPY x 0.983 = 33.78 TPY
No. 2 Lime Kiln - 78.65 TPY x 0.983 = 77.31 TPY
Total both kilns = 33.78 + 77.31 = 111.1 TPY

C. TOTAL REDUCED SULFUR (TRS)

TRS emissions were estimated in the original application on the basis of AP-42 emission factors. The factor used was from Section 10.1, Chemical Wood Pulping (4/77), and was 0.75 lb/ton of air-dried unbleached pulp (ADUP) produced by the mill (0.5 lb/ton H₂S, and 0.25 lb/ton reduced sulfur compounds). Total pulp produced at the mill in 1984 was 269,140 tons ADUP, as reported on the Annual Operation Report to FDER. This resulted in a total TRS emission rate from the kilns of 100.93 TPY.

Section 10.1 in AP-42 was revised in 10/86 and now contains a slightly lower factor for TRS of 0.7 lb/ton ADUP. Applying this revised factor to the 1984 pulp production results in the following TRS emissions:

$$269,140 \text{ TPY ADUP} \times 0.7 \text{ lb/ton} / 2,000 \text{ lb/ton} = 94.2 \text{ TPY}$$

D. SULFUR DIOXIDE (SO₂)

Actual emissions of SO₂ from the lime kilns were estimated in the original application on the basis of the AP-42 emission factor [Section 10.1 (4/77)] and pulp production. The AP-42 factor was 0.2 lb/ton ADUP, and the resulting SO₂ emissions were 26.92 TPY. This AP-42 factor has not been revised and the original SO₂ emission estimates remain valid.

E. NITROGEN OXIDES (NO_x)

The original application presented NO_x emission estimates for the lime kilns based upon a factor of 1 lb/ton ADUP. This factor resulted in NO_x emissions of 134.59 TPY, based upon 1984 pulp production. The present version of AP-42, Section 10.1, Chemical Wood Pulping (10/86), states that indications are that NO_x emissions from lime kilns are on the order of 1 lb/ton. The AP-42 section references a NCASI study conducted to investigate NO_x emissions from lime kilns at pulp mills (Technical Bulletin No. 107). Review of

the NCASI study, however, indicates NOx emissions to be much higher than would result from the AP-42 factor. The NCASI study was evaluated therefore to develop a more appropriate factor for the JSC lime kilns.

JSC's old lime kilns were oil-fired. Five lime kilns at different locations were evaluated in the NCASI study, two of which were oil-fired (Site 1 and Site 2 kilns). NOx emissions from the two kilns averaged 0.85 lb/10⁶ Btu and 0.155 lb/10⁶ Btu, respectively. Combustion zone temperature in these two kilns was not measured.

Because the dynamics of thermal NOx generation demonstrate that NOx emissions increase with increasing combustion zone temperature, NCASI studied the relationship between NOx emissions and combustion zone temperature at one site (Site 5 kiln). This kiln was gas fired. The kiln exhibited a mean NOx emission rate of 0.78 lb/10⁶ Btu at a mean combustion zone temperature of 2053°F. NOx emissions were found to vary linearly with combustion zone temperature over the range of 1850°F to 2250°F, according to the following equation:

$$1 \text{ lb NOx}/10^6 \text{ Btu} = [2.17 \times 10^{-3} \times T(^{\circ}\text{F})] - 3.58$$

A high correlation coefficient of 0.965 was obtained based upon the measured data.

Because of the strong correlation between NOx emissions and combustion zone temperature found in the NCASI study, the above equation was considered to be the most representative factor for the JSC kilns. The equation may actually underestimate NOx emissions since it is based upon gas firing, and oil firing would contribute additional fuel NOx to the thermal NOx emissions. In regard to the Site 1 and Site 2 kilns evaluated in the NCASI study, combustion zone temperature was not measured, and therefore there is

no way to determine the representativeness of the NOx data from these kilns.

Basis for calculations changed since original evaluation

The combustion zone temperature in the lime kilns at JSC were maintained between 2250°F and 2300°F. Substituting the lower temperature into the above equation yields an NOx emission factor of 1.30 lb/10⁶ Btu. Heat input to the JSC kilns were based upon the fuel oil consumption reported in the 1984 Annual Operation Report submitted to FDER. Calculations are presented below:

No. 1 Lime Kiln - 2,004,000 gal x 149,900 Btu/gal = 3.00 x 10¹¹ Btu
No. 2 Lime Kiln - 2,113,000 gal x 149,900 Btu/gal = 3.17 x 10¹¹ Btu
Total = 6.17 x 10¹¹ Btu

NOx emissions = 6.17 x 10¹¹ Btu/yr x 1.30 lb/10⁶ Btu / 2,000 lb/ton
= 401.TPY

F. CARBON MONOXIDE (CO)

CO emissions from the No. 1 and No. 2 Lime Kilns at JSC were originally based upon the old AP-42 factor of 10 lb/ton ADUP [AP-42, Section 10.1 (4/77)]. This resulted in CO emissions of 1,345.9 TPY. However, the recently revised Section 10.1 of AP-42 (10/86) indicates much lower emissions from lime kilns (0.1 lb/ton ADUP). The revised AP-42 factor is based upon a recent NCASI study (Technical Bulletin No. 416). This document was therefore reviewed to determine a more appropriate CO emissions factor for the old kilns at JSC.

The NCASI study presented CO emission data from two lime kilns. Emissions from the two kilns were very similar, averaging 0.038 lb/10⁶ Btu and 0.041 lb/10⁶ Btu heat input. The average factor for the two kilns is 0.04 lb/10⁶ Btu, and this factor was considered to be representative of the old JSC lime kilns. Revised

emission calculations, based upon the heat input to the kilns in 1984, are presented below:

$$6.17 \times 10^{11} \text{ Btu/yr} \times 0.04 \text{ lb}/10^6 \text{ Btu} / 2,000 \text{ lb/ton} = 12.3 \text{ TPY}$$

G. VOLATILE ORGANIC COMPOUNDS (VOC)

USEPA Publication AP-42, Section 10.1, Chemical Wood Pulping (10/86) does not contain a VOC emission factor for lime kilns. NCASI, however, has conducted a study of non-methane VOC emissions from kraft process lime kilns (Technical Bulletin No. 358). Three kilns were tested. Kilns A and C were most like the old JSC kilns, as they had venturi scrubbers for PM control which used fresh water. The kilns exhibited average VOC emissions of 0.06 lb/10⁶ Btu (Kiln A) and 0.024 lb/10⁶ Btu (Kiln C). The average VOC emission rate for the two kilns, 0.042 lb/10⁶ Btu, was used as the basis of VOC emissions from the JSC kilns:

$$6.17 \times 10^{11} \text{ Btu/yr} \times 0.042 \text{ lb}/10^6 \text{ Btu} / 2,000 \text{ lb/ton} = 13.0 \text{ TPY}$$

II. EXISTING KILN LEAKS

Discussions with JSC personnel and inspection of the No. 1 and No. 2 Lime Kilns at JSC indicate that leaks of exhaust gases occurred at the cold end of the kilns. Visible emissions of dust were observed at the kiln seals, I.D. fan and at man-hole covers when the kilns were operating. Fugitive PM emissions were estimated for these leaks by first estimating the uncontrolled PM entrained in the exhaust gases, and then estimating the fraction of total kiln exhaust gases which escaped through the leaks.

A. PM(TSP)

PM entrained in the kiln exhaust gases (before the venturi scrubber) were estimated using emission factors presented in AP-42, Section 8.15, Lime Manufacturing (10/86). This section presents an uncontrolled PM emission rate for rotary kilns of 350 lb/ton lime produced. Applying this factor to the total 1984 lime production from the two kilns at JSC yields the following:

No. 1 Lime Kiln production:	27,355 TPY
No. 2 Lime Kiln production:	<u>28,815 TPY</u>
Total:	56,170 TPY

Uncontrolled PM emissions:

$56,170 \text{ TPY} \times 350 \text{ lb/ton} / 2,000 \text{ lb/ton} = 9,830 \text{ TPY}$

Based upon compliance tests conducted on the kilns in 1984, the exhaust flow from the No. 1 Kiln was approximately 14,000 dscfm and from the No. 2 Kiln was approximately 17,000 dscfm, or an average of 15,500 dscfm. It is estimated that the kiln leaks accounted for at least 1/1000 of the total gas flow, or 15.5 dscfm from each kiln. Therefore, the total fugitive PM emissions due to kiln leaks are 1/1000 of the total uncontrolled PM emissions entrained in the exhaust gas stream:

$9,830 \text{ TPY} / 1,000 = 9.8 \text{ TPY}$

B. PM10

Particle size data for lime kilns are presented in AP-42, Section 10.1, Chemical Wood Pulping (10/86). AP-42 states that 16.8% of uncontrolled PM emissions from lime kilns are less than 10 um in diameter. Based upon this information, PM10 emissions due to kiln leaks were estimated as follows:

$$9.8 \text{ TPY} \times 0.168 = 1.6 \text{ TPY}$$

III. EXISTING LIME SLAKER

One slaker operated at the JSC mill. The slaker was an atmospheric hydrator and was controlled by a water spray. All lime produced from the lime kiln, as well as all purchased lime, was processed by the slaker.

A. PM(TSP)

Presented in AP-42, Section 8.15, Lime Manufacturing, is a PM emission factor of 0.1 lb/ton lime produced for atmospheric hydrators, or 0.125 lb/ton of lime feed to the hydrator. The emission factor based upon lime feed was used to estimate actual emissions from the slaker. Lime production from the lime kiln in 1984 and actual purchased lime amounts for 1984 were used, as shown below:

Lime production - No. 1 Lime Kiln:	27,355 TPY
Lime production - No. 2 Lime Kiln:	28,815 TPY
Purchased lime:	<u>3,991 TPY</u>
Total:	60,161 TPY

$$60,161 \text{ TPY} \times 0.125 \text{ lb/ton} / 2,000 \text{ lb/ton} = 3.8 \text{ TPY}$$

B. PM10

Information related to the particle size distribution of PM emissions from slakers was not found in the available literature. Therefore, Appendix C.2 of AP-42 (10/86), Generalized Particle Size Distributions, was reviewed and was found to contain general particle size distribution data for hydration processes (Category 9). The particle size data indicates that PM10 emissions constitute approximately 94% of total PM emissions from hydration processes. These data are considered to be the best currently available to estimate PM10 emissions from the lime slakers. The calculation of PM10 emissions, based upon the total PM emissions, is as follows: $3.8 \text{ TPY} \times 0.94 = 3.6 \text{ TPY}$

IV. EXISTING LIME BINS - CONVEYING, TRANSFER AND STORAGE

The two old lime kilns at JSC were supported by drag chain conveyors which conveyed the dry lime product from the kilns to the slaker and lime bins. Two lime bins located adjacent to each other received lime from the kilns by means of a bucket elevator. The lime bins also received purchased lime pneumatically. The lime bins were uncontrolled and vented directly to the atmosphere. The lime bins also fed a small day bin, which supplied lime feed to the slaker.

A schematic of the system is shown in Figure C-1. Lime from No. 1 Kiln dropped into the drag conveyor, passed through one transfer point, dropped into a reversible drag conveyor, and then dropped into one of two bucket elevators. Lime from No. 2 Kiln dropped into the drag conveyor, passed through two transfer points, and then dropped into the reversible drag conveyor before entering the bucket elevator.

All lime produced in the kilns passed through one of the bucket elevators and then was routed either directly to the slaker day bin or to the lime bins via a common header. Lime stored in the lime bins would drop from the bins onto a drag conveyor and then onto the reversible drag conveyor which fed the bucket elevators. The bucket elevators would lift the lime to the common header and the lime would fall by gravity to the day bin. A screw conveyor was used to feed lime from the day bin to the slaker.

Approximately 80% of lime produced in the kilns was routed directly to the day bin which fed the slaker. The remaining 20% of total lime production was routed to the slaker through the lime bins. All purchased lime was fed pneumatically to the lime bins.

Fugitive dust emissions from the lime transfer, conveying and storage operations were estimated using the generalized emissions factor equation for a continuous drop operation contained in USEPA Publication

AP-42, Section 11.2.3, Aggregate Handling and Storage Piles (10/86).

The recommended equation for a continuous drop operation is as follows:

$$E = k (0.0018) \frac{s}{5} \frac{U}{5} \frac{H}{10} \text{ lb/ton} \left(\frac{M}{2} \right)^2$$

where,

E = emission factor

k = particle size multiplier

s = material silt content (%)

U = mean wind speed (mph)

H = drop height (ft)

M = material moisture content (%)

The particle size multiplier, k, is 1.0 for total suspended particulate [PM(TSP)], and 0.37 for PM10. The moisture content (M) and silt content (s) of lime produced from the kilns is 0.5% and 60%, respectively. The mean wind speed, U, in Jacksonville is 8.6 mph. These parameters remain the same for each of the transfer operations. The drop height varies for several of the transfer points, resulting in a different emission factor for the operations. The resulting uncontrolled emission factors for each operation are shown in Table C-1.

The control technology utilized in the lime system consisted solely of enclosures. Enclosures were used on each transfer point. Estimated control efficiencies for enclosures applied to material transfer operations range from 70% to 90% (refer to "Workbook on Estimation of Emissions and Dispersion Modeling for Fugitive Particulate Sources" - reference attached). On the basis of JSC operator observations, the most significant dust source associated with the system was the reversible drag conveyor-to-bucket elevator transfer point. The enclosure for this operation was considered to result in a 70% control efficiency, while all other enclosures were estimated to achieve an 85% control efficiency.

The drag chain conveyors used to convey the lime throughout the system were extremely dusty operations. The chains in the conveyor literally drag the lime in the direction of flow. The lime is continually disturbed and abraded, which has the potential to create significant amounts of fugitive dust due to the low moisture content and high silt content of the lime. The enclosures surrounding the conveyors were not airtight and leaked in several places.

*std. operating
5% or 0.038 lb/dscft
2:1 ?
0.039 lb/dscft
B.A.C.*

A literature review of fugitive dust emission factors revealed no factors are available for drag chain conveyors. As a result, uncontrolled dust emissions from the conveyors were assumed to be equivalent to two additional conveyor transfer points. As shown in Table C-1, each conveyor transfer point results in an uncontrolled emission factor of 0.119 lb/ton for PM(TSP) and 0.044 lb/ton for PM10. Thus, the total emission factor for conveying is 0.238 lb/ton for PM(TSP) and 0.088 lb/ton for PM10. Enclosures surrounding the drag conveyors are considered to have provided a 90% control efficiency. Emission estimates are shown in Table C-1.

Lime balls were frequently formed in the old kilns. These lime balls were required to be raked out of the kiln discharge point, and then hauled to a nearby dumpster for disposal. Lime ball losses from the old kilns are conservatively estimated at 2 tons/day lime (730 TPY). Disposal of the lime balls caused significant dust emissions when removed from the kilns and when dropped into a dumpster for disposal. Fugitive emissions were estimated for the drop operation based upon the AP-42 factor for a batch drop operation:

$$E = k (0.0018) \frac{s}{5} \frac{U}{5} \frac{H}{5} \text{ lb/ton}$$

$$\frac{\left(\frac{M}{2}\right)^2 \left(\frac{Y}{6}\right)^{0.33}}$$

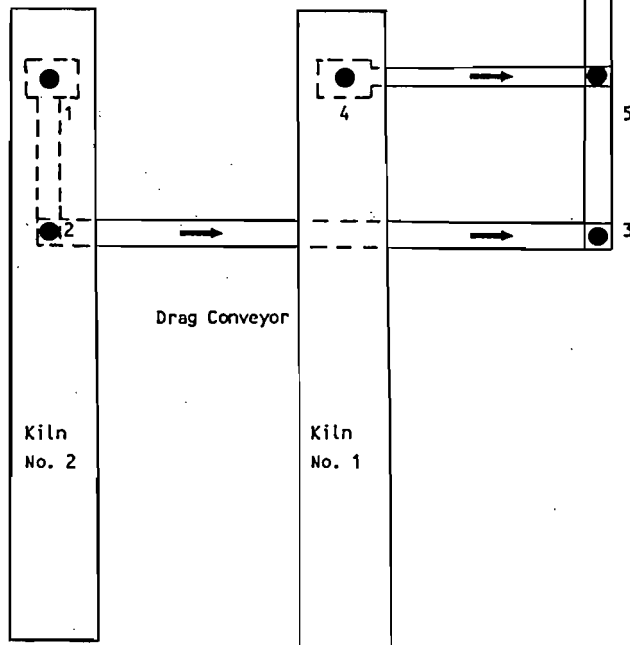
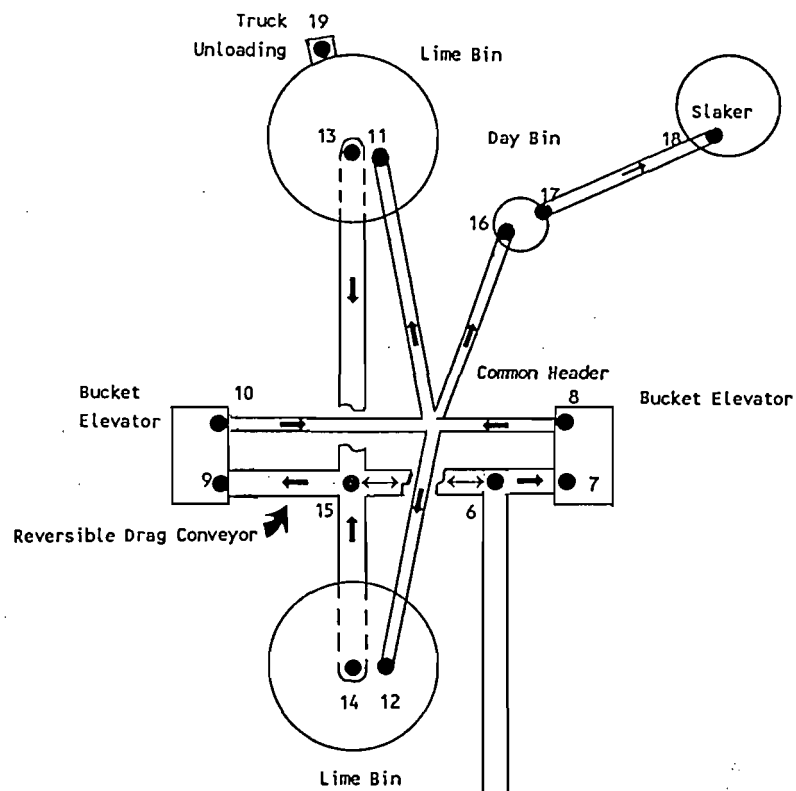
where, Y = dumping device capacity (yd³)

All other parameters are the same as defined in the previously discussed AP-42 factor for a continuous drop operation. Each lime ball comprised a volume of about 0.75 ft³. However, a volume of 2.75 yd³ was used as the value for Y in the above equation, since this is the minimum volume which the equation is based upon. A control efficiency of 50% was considered appropriate for a dumpster which is enclosed on three sides but is open on top.

Fugitive PM(TSP) and PM10 emissions from the lime handling system, based upon the estimated emission factors, control efficiencies, and actual lime processed in 1984, are presented in Table C-1.

Table C-1. Fugitive PM and PM10 Emissions From Old Causticizing System

No.	Source Description	Drop Height (ft)	Uncontrolled Emission Factor (lb/ton)		Control Eff. (%)	Controlled Emission Factor (lb/ton)		Lime Processed (TPY)	Fugitive Emissions (TPY)		
			PM(TSP)	PM10		PM(TSP)	PM10		PM(TSP)	PM10	
Lime From Kilns to Load Chute											
1	No. 2 LK Discharge	5	0.297	0.110	85	0.045	0.016	28,815	0.64	0.24	
2	Conveyor transfer point	3	0.178	0.066	85	0.027	0.010	28,815	0.39	0.14	
3	Conveyor transfer point	3	0.178	0.066	85	0.027	0.010	28,815	0.39	0.14	
4	No. 1 LK Discharge	5	0.297	0.110	85	0.045	0.016	27,355	0.61	0.23	
5	Conveyor transfer point	3	0.178	0.066	85	0.027	0.010	27,355	0.37	0.14	
6	Transfer to reversible drag conveyor	3	0.178	0.066	85	0.027	0.010	56,170	0.75	0.28	
7,9	Conveyor to bucket elevator	5	0.297	0.110	70	0.089	0.033	56,170	2.50	0.93	
8,10	Bucket elev. to load chute	3	0.178	0.066	85	0.027	0.010	56,170	0.75	0.28	
Lime Directly to Day Bin											
16	Load chute to Day Bin	5	0.297	0.110	85	0.045	0.016	44,936	1.00	0.37	
17	Day Bin to screw conveyor	3	0.178	0.066	85	0.027	0.010	44,936	0.60	0.22	
18	Screw conveyor to Slaker	5	0.297	0.110	85	0.045	0.016	44,936	1.00	0.37	
Lime to Lime Bins											
11,12	Load chute to Lime Bin	10	0.594	0.220	85	0.089	0.033	11,234	0.50	0.19	
13,14	Lime Bins to conveyor	5	0.297	0.110	85	0.045	0.016	11,234	0.25	0.09	
15	Transfer to reversible drag conveyor	3	0.178	0.066	85	0.027	0.010	11,234	0.15	0.06	
7,9	Conveyor to bucket elevator	5	0.297	0.110	70	0.089	0.033	11,234	0.50	0.19	
8,10	Bucket elev. to load chute	3	0.178	0.066	85	0.027	0.010	11,234	0.15	0.06	
16	Load chute to Day Bin	5	0.297	0.110	85	0.045	0.016	11,234	0.25	0.09	
17	Day Bin to screw conveyor	3	0.178	0.066	85	0.027	0.010	11,234	0.15	0.06	
18	Screw conveyor to Slaker	5	0.297	0.110	85	0.045	0.016	11,234	0.25	0.09	
Purchased Lime from Trucks											
19	Purchased lime to Lime Bin	10	0.594	0.220	85	0.089	0.033	3,991	0.18	0.07	
13,14	Lime Bins to conveyor	5	0.297	0.110	85	0.045	0.016	3,991	0.09	0.03	
15	Transfer to reversible drag conveyor	3	0.178	0.066	85	0.027	0.010	3,991	0.05	0.02	
7,9	Conveyor to bucket elevator	5	0.297	0.110	70	0.089	0.033	3,991	0.18	0.07	
8,10	Bucket elev. to load chute	3	0.178	0.066	85	0.027	0.010	3,991	0.05	0.02	
16	Load chute to Day Bin	5	0.297	0.110	85	0.045	0.016	3,991	0.09	0.03	
17	Day Bin to screw conveyor	3	0.178	0.066	85	0.027	0.010	3,991	0.05	0.02	
18	Screw conveyor to Slaker	5	0.297	0.110	85	0.045	0.016	3,991	0.09	0.03	
Drag Chain Conveyors											
	Lime conveying	-	0.238	0.088	90	0.024	0.009	56,170	0.67	0.25	
Waste Lime Disposal											
	Lime balls	10	1.538	0.569	50	0.769	0.285	730	0.28	0.10	
									TOTALS =	12.94	4.79



Note: ● Indicates transfer point

Figure C-1. Schematic of Old Lime Transfer System at JSC



ATTACHMENT D

CONTROL EQUIPMENT DESIGN INFORMATION

I. VENTURI SCRUBBER

Scrubber design data

Attached drawing is schematic of Airpol, Inc., venturi scrubber system.

Design parameters are presented below:

Scrubbing water flow rate to venturi section: 375 gpm @ 350 psig
175 gpm @ 2 psig

Make-up water requirements: 140 gpm

Pressure drop across venturi = 3-10 in. H₂O

Maximum inlet gas flow rate: 40,300 acfm @ 350 °F
18,400 dscfm

Maximum inlet particulate loading = 22 gr/dscf

Maximum outlet particulate loading = 0.13 gr/dscf (oil-firing)
= 0.067 gr/dscf (gas-firing)

Scrubber efficiency calculation

1. Particulate Matter

Kiln design outlet grain loading = 22 gr/dscf

Maximum outlet gas flow rate (burning fuel oil)
= 23,725 dscfm

Particulate to scrubber:

$23,725 \text{ dscfm} \times 22 \text{ gr/dscf} / 7,000 \text{ gr/lb} \times 60 \text{ min/hr}$
= 4,474 lb/hr

Maximum particulate emissions at scrubber outlet = 31.2 lb/hr

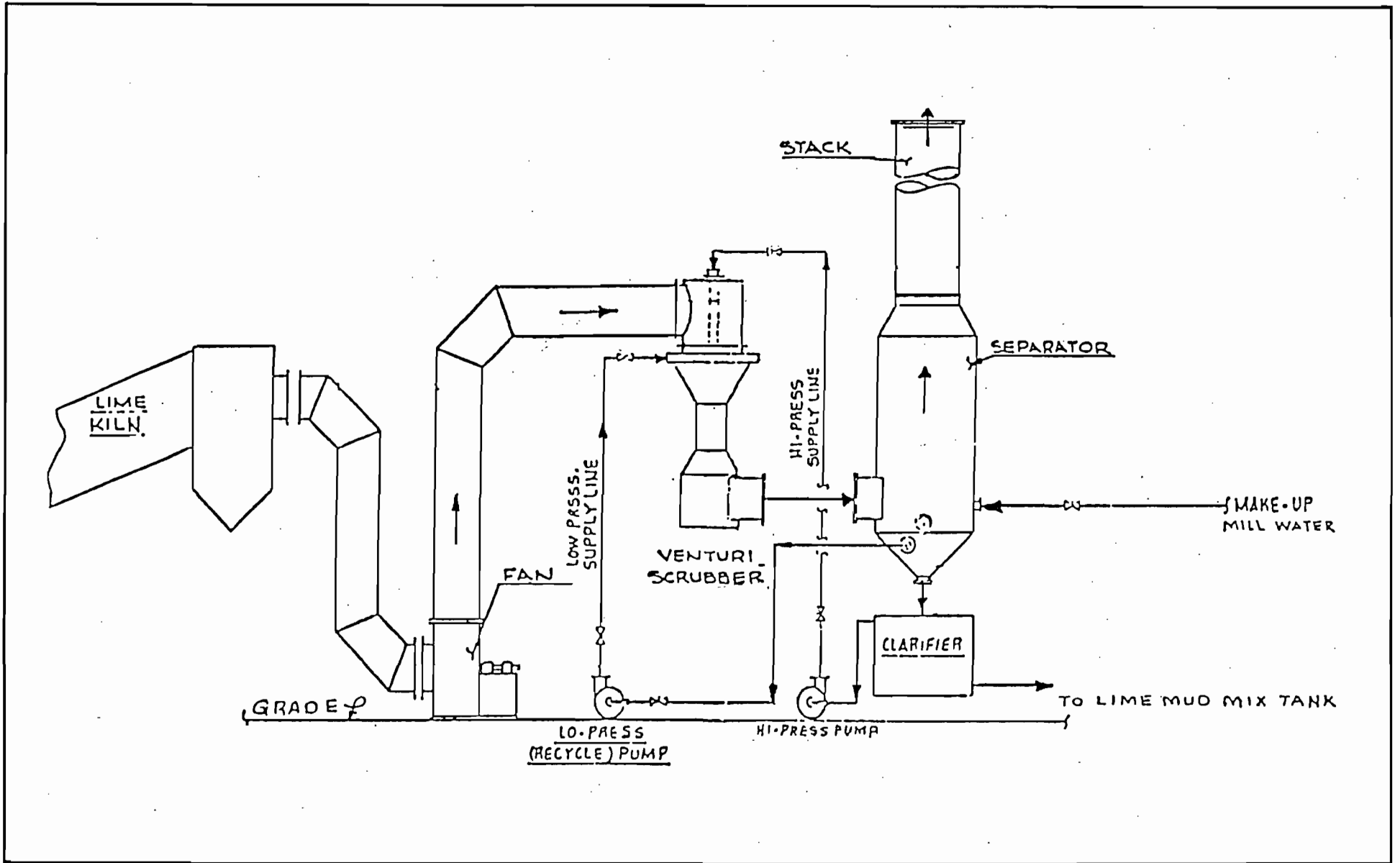
Removal Efficiency = $[(4,474 - 31.2) / 4,474] \times 100 = 99.3\%$

2. Total Reduced Sulfur

Kiln design outlet TRS loading = 16 ppm dry @ 10% O₂

Scrubber outlet maximum TRS loading = 8 ppm dry @ 10% O₂

Removal efficiency = $[(16-8) / 16] \times 100 = 50\%$



Schematic of No. 3 Lime Kiln Venturi Scrubber System



II. LIME SILO BAGHOUSE

A schematic of the lime silo baghouse and associated control points is presented in the attached drawing.

Manufacturer: MikroPul

Model No: 16S8TR

Design flow rate = 600 acfm @ ambient temperature
= 570 dscfm

Filter area = 151 ft²

Air/Cloth ratio = 4:1

Bag material = Nomex, 16 oz

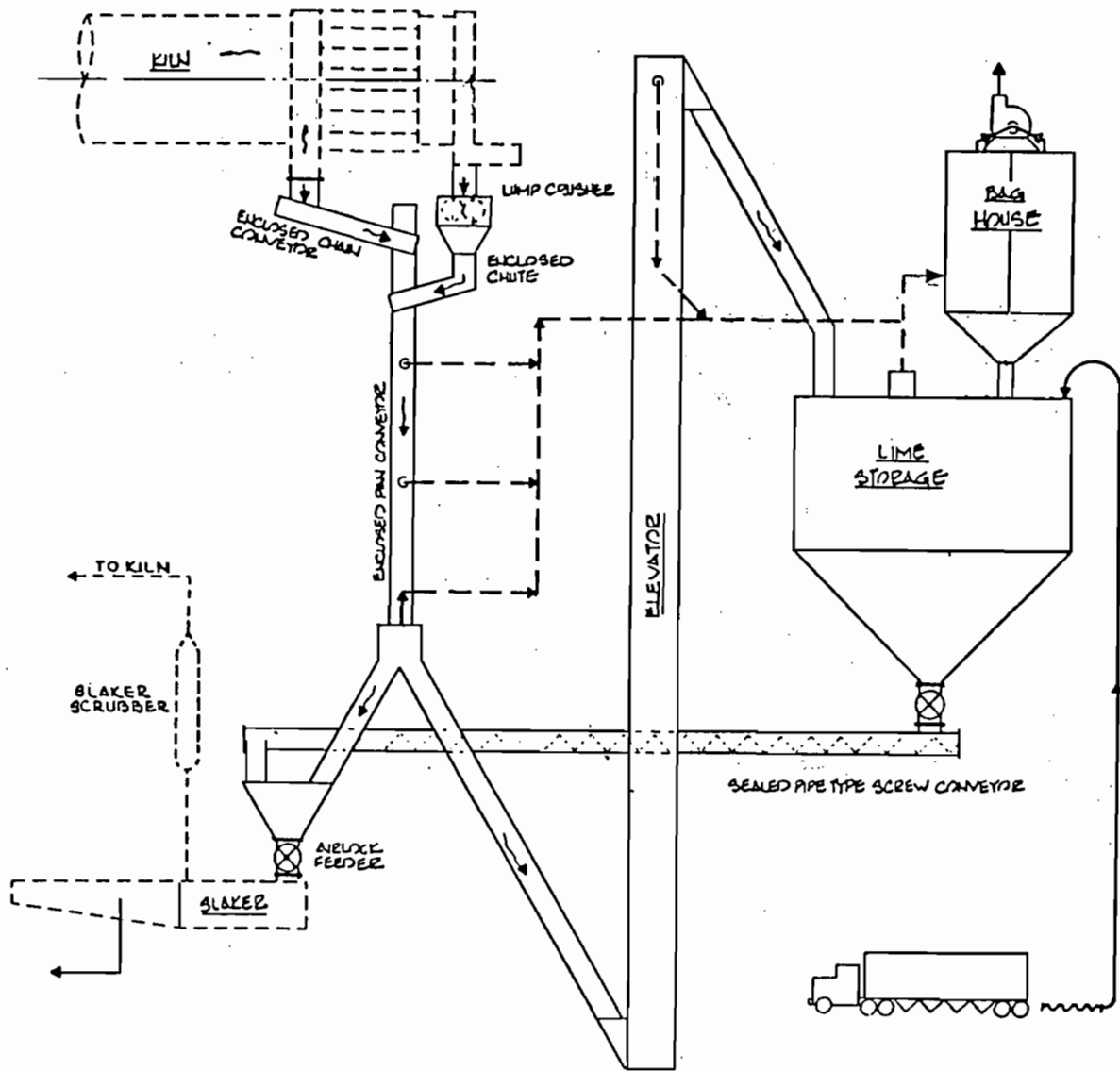
Maximum inlet dust loading = 43 gr/acf

$43 \text{ gr/acf} \times 600 \text{ acfm} / 7,000 \text{ gr/lb} \times 60 \text{ min/hr} = 221.1 \text{ lb/hr}$

Cleaning method = Reverse pulse air

Maximum outlet dust loading = 0.03 gr/dscf
= 0.15 lb/hr

Removal efficiency = $[(221.1 - 0.15) / 221.1] \times 100 = 99.9\%$



Notes: — Material flow
 - - - Gas flow

Schematic of Lime Silo Baghouse System



III. TRS INCINERATION

Non-condensable TRS gases from the new digesting system at JSC will be vented to the No. 3 Lime Kiln for incineration. The existing Multiple Effect Evaporators at the plant are already vented to the No. 3 Lime Kiln for incineration. The following design flows of non-condensable gases and TRS have been estimated for the new digesting system:

	Maximum Hourly Rate <u>(@89.08 TPH pulp)</u>	Maximum Daily Rate <u>(@52.08 TPH pulp)</u>
Gas flow rate	1,326 acfm	775 acfm
TRS flow rate from digesters	935 lb/hr	547 lb/hr

The estimated TRS flow rate from the new digesting system is taken from the New Digesters 1-5 permit application, and are based upon a conventional hot blow system. As a result, the TRS flow is considered to be overestimated for the cold blow system. TRS emissions from the No. 3 Lime Kiln will not exceed the 8 ppm, dry basis, corrected to 10% O₂, when incinerating the TRS from the new digester system.

REFERENCES

EXCERPTS FROM AP-42 SECTIONS

10.1 CHEMICAL WOOD PULPING

10.1.1 General

Chemical wood pulping involves the extraction of cellulose from wood by dissolving the lignin that binds the cellulose fibers together. The four processes principally used in chemical pulping are kraft, sulfite, neutral sulfite semichemical (NSSC), and soda. The first three display the greatest potential for causing air pollution. The kraft process alone accounts for over 80 percent of the chemical pulp produced in the United States. The choice of pulping process is determined by the desired product, by the wood species available, and by economic considerations.

10.1.2 Kraft Pulping

Process Description¹ - The kraft pulping process (See Figure 10.1-1) involves the digesting of wood chips at elevated temperature and pressure in "white liquor", which is a water solution of sodium sulfide and sodium hydroxide. The white liquor chemically dissolves the lignin that binds the cellulose fibers together.

There are two types of digester systems, batch and continuous. Most kraft pulping is done in batch digesters, although the more recent installations are of continuous digesters. In a batch digester, when cooking is complete, the contents of the digester are transferred to an atmospheric tank usually referred to as a blow tank. The entire contents of the blow tank are sent to pulp washers, where the spent cooking liquor is separated from the pulp. The pulp then proceeds through various stages of washing, and possibly bleaching, after which it is pressed and dried into the finished product. The "blow" of the digester does not apply to continuous digester systems.

The balance of the kraft process is designed to recover the cooking chemicals and heat. Spent cooking liquor and the pulp wash water are combined to form a weak black liquor which is concentrated in a multiple effect evaporator system to about 55 percent solids. The black liquor is then further concentrated to 65 percent solids in a direct contact evaporator, by bringing the liquor into contact with the flue gases from the recovery furnace, or in an indirect contact concentrator. The strong black liquor is then fired in a recovery furnace. Combustion of the organics dissolved in the black liquor provides heat for generating process steam and for converting sodium sulfate to sodium sulfide. Inorganic chemicals present in the black liquor collect as a molten smelt at the bottom of the furnace.

The smelt is dissolved in water to form green liquor, which is transferred to a causticizing tank where quicklime (calcium oxide) is added to convert the solution back to white liquor for return to the digester system. A lime mud precipitates from the causticizing tank, after which it is calcined in a lime kiln to regenerate quicklime.

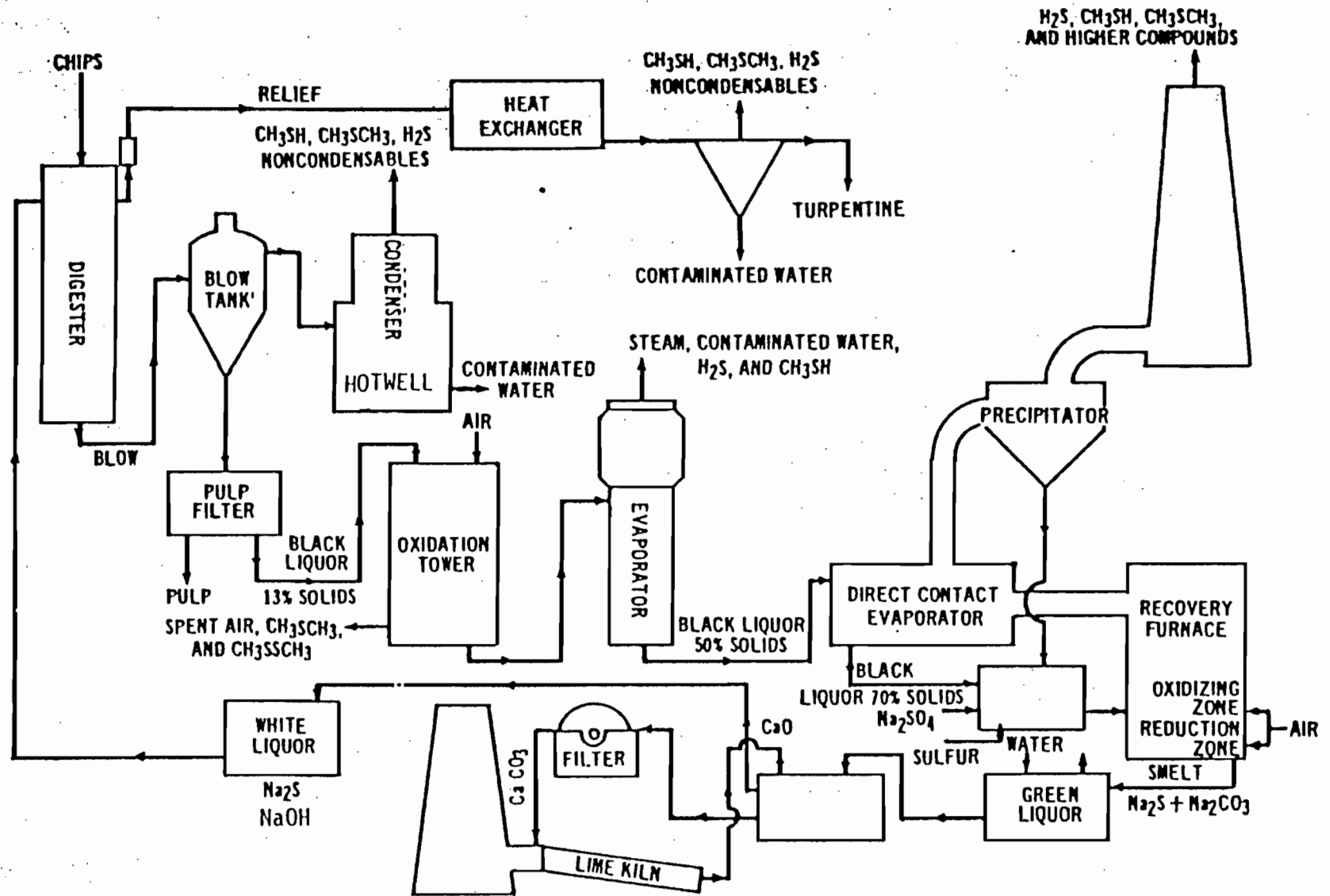


Figure 10.1-1. Typical kraft sulfate pulping and recovery process.

For process heating, for driving equipment, for providing electric power, etc., many mills need more steam than can be provided by the recovery furnace alone. Thus, conventional industrial boilers that burn coal, oil, natural gas, or bark and wood are commonly used.

Emissions And Controls¹⁻⁷ - Particulate emissions from the kraft process occur largely from the recovery furnace, the lime kiln and the smelt dissolving tank. These emissions are mainly sodium salts, with some calcium salts from the lime kiln. They are caused mostly by carryover of solids and sublimation and condensation of the inorganic chemicals.

Particulate control is provided on recovery furnaces in a variety of ways. In mills with either a cyclonic scrubber or cascade evaporator as the direct contact evaporator, further control is necessary, as these devices are generally only 20 to 50 percent efficient for particulates. Most often in these cases, an electrostatic precipitator is employed after the direct contact evaporator, for an overall particulate control efficiency of from 85 to more than 99 percent. Auxiliary scrubbers may be added at existing mills after a precipitator or a venturi scrubber to supplement older and less efficient primary particulate control devices.

Particulate control on lime kilns is generally accomplished by scrubbers. Electrostatic precipitators have been used in a few mills. Smelt dissolving tanks usually are controlled by mesh pads, but scrubbers can provide further control.

The characteristic odor of the kraft mill is caused by the emission of reduced sulfur compounds, the most common of which are hydrogen sulfide, methyl mercaptan, dimethyl sulfide and dimethyl disulfide, all with extremely low odor thresholds. The major source of hydrogen sulfide is the direct contact evaporator, in which the sodium sulfide in the black liquor reacts with the carbon dioxide in the furnace exhaust. Indirect contact evaporators can significantly reduce the emission of hydrogen sulfide. The lime kiln can also be a potential source of odor, as a similar reaction occurs with residual sodium sulfide in the lime mud. Lesser amounts of hydrogen sulfide are emitted with the noncondensable offgasses from the digesters and multiple effect evaporators.

Methyl mercaptan and dimethyl sulfide are formed in reactions with the wood component, lignin. Dimethyl disulfide is formed through the oxidation of mercaptan groups derived from the lignin. These compounds are emitted from many points within a mill, but the main sources are the digester/blow tank systems and the direct contact evaporator.

Although odor control devices, per se, are not generally found in kraft mills, emitted sulfur compounds can be reduced by process modifications and improved operating conditions. For example, black liquor oxidation systems, which oxidize sulfides into less reactive thiosulfates, can considerably reduce odorous sulfur emissions from the direct contact evaporator, although the vent gases from such systems become minor odor sources themselves. Also, noncondensable odorous gases vented from the digester/blow tank system and multiple effect evaporators can be destroyed by thermal oxidation, usually by passing them through the lime kiln. Efficient operation of the recovery furnace, by avoiding overloading and by maintaining sufficient oxygen, residence time and turbulence, significantly reduces emissions of reduced sulfur compounds from

this source as well. The use of fresh water instead of contaminated condensates in the scrubbers and pulp washers further reduces odorous emissions.

Several new mills have incorporated recovery systems that eliminate the conventional direct contact evaporators. In one system, heated combustion air, rather than fuel gas, provides direct contact evaporation. In another, the multiple effect evaporator system is extended to replace the direct contact evaporator altogether. In both systems, sulfur emissions from the recovery furnace/direct contact evaporator can be reduced by more than 99 percent.

Sulfur dioxide is emitted mainly from oxidation of reduced sulfur compounds in the recovery furnace. It is reported that the direct contact evaporator absorbs about 75 percent of these emissions, and further scrubbing can provide additional control.

Potential sources of carbon monoxide emissions from the kraft process include the recovery furnace and lime kilns. The major cause of carbon monoxide emissions is furnace operation well above rated capacity, making it impossible to maintain oxidizing conditions.

Some nitrogen oxides also are emitted from the recovery furnace and lime kilns, although amounts are relatively small. Indications are that nitrogen oxide emissions are on the order of 0.5 and 1.0 kilograms per air dried megagrams (1 and 2 lb/air dried ton) of pulp produced from the lime kiln and recovery furnace, respectively.⁵⁻⁶

A major source of emissions in a kraft mill is the boiler for generating auxiliary steam and power. The fuels used are coal, oil, natural gas or bark/wood waste. See Chapter 1 for emission factors for boilers.

Table 10.1-1 presents emission factors for a conventional kraft mill. The most widely used particulate control devices are shown, along with the odor reductions through black liquor oxidation and incineration of noncondensable offgases. Tables 10.1-2 through 10.1-7 present cumulative size distribution data and size specific emission factors for particulate emissions from sources within a conventional kraft mill. Uncontrolled and controlled size specific emission factors⁷ are presented in Figures 10.1-2 through 10.1-7. The particle sizes presented are expressed in terms of the aerodynamic diameter.

10.1.3 Acid Sulfite Pulping

Process Description - The production of acid sulfite pulp proceeds similarly to kraft pulping, except that different chemicals are used in the cooking liquor. In place of the caustic solution used to dissolve the lignin in the wood, sulfurous acid is employed. To buffer the cooking solution, a bisulfite of sodium, magnesium, calcium or ammonium is used. A diagram of a typical magnesium base process is shown in Figure 10.1-8.

Digestion is carried out under high pressure and high temperature, in either batch mode or continuous digesters, and in the presence of a sulfurous acid/bisulfite cooking liquid. When cooking is completed, either the digester is discharged at high pressure into a blow pit, or its contents are pumped into a dump tank at a lower pressure. The spent sulfite liquor (also called red liquor) then drains through the bottom of the tank and is treated and discarded,

TABLE 10.1-1. EMISSION FACTORS FOR SULFITE PULPING^a

EMISSION FACTOR RATING: A

Source	Type of control	Particulate		Sulfur dioxide (SO ₂)		Carbon monoxide (CO)		Hydrogen sulfide (S ²⁻)		RSH, RSR, RSSR (S ⁻)	
		kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton
Digester relief and blow tank	Untreated ^b	-	-	-	-	-	-	0.02	0.03	0.6	1.2
Brown stock washer	Untreated ^b	-	-	-	-	-	-	0.01	0.02	0.2 ^c	0.4 ^c
Multiple effect evaporator	Untreated ^b	-	-	-	-	-	-	0.55	1.1	0.05	0.1
Recovery boiler and direct evaporator	Untreated ^d	90	180	3.5	7	5.5	11	6 ^e	12 ^e	1.5 ^e	3 ^e
	Venturi scrubber ^f	24	48	3.5	7	5.5	11	6 ^e	12 ^e	1.5 ^e	3 ^e
	ESP	1	2	3.5	7	5.5	11	6 ^e	12 ^e	1.5 ^e	3 ^e
	Auxiliary scrubber	1.5-7.5 ^g	3-15 ^g					6 ^e	12 ^e	1.5 ^e	3 ^e
Noncontact recovery boiler without direct contact evaporator	Untreated	115	230	-	-	5.5	11	0.05 ^h	0.1 ^h	-	-
	ESP	1	2	-	-	5.5	11	0.05 ^h	0.1 ^h	-	-
Smelt dissolving tank	Untreated	3.5	7	0.1	0.2	-	-	0.1 ^j	0.2 ^j	0.15 ^j	0.3 ^j
	Mesh pad	0.5	1	0.1	0.2	-	-	0.1 ^j	0.2 ^j	0.15 ^j	0.3 ^j
	Scrubber	0.1	0.2	-	-	-	-	0.1 ^j	0.2 ^j	0.15 ^j	0.3 ^j
Lime kiln	Untreated	28	56	0.15	0.3	0.05	0.1	0.25 ^m	0.5 ^m	0.1 ^m	0.2 ^m
	Scrubber or ESP	0.25	0.5	-	-	0.05	0.1	0.25 ^m	0.5 ^m	0.1 ^m	0.2 ^m
Turpentine condenser	Untreated	-	-	-	-	-	-	0.005	.01	0.25	0.5
Miscellaneous ⁿ	Untreated	-	-	-	-	-	-	-	-	0.25	0.5

^aReferences 8-10. Factors expressed in unit weight of air dried unbleached pulp (ADP). RSH = Methyl mercaptan. RSR = Dimethyl sulfide. RSSR = Dimethyl disulfide. ESP = Electrostatic precipitator. Dash = No data.

^bIf noncondensable gases from these sources are vented to lime kiln, recovery furnace or equivalent, the reduced sulfur compounds are destroyed.

^cApply with system using condensate as washing medium. When using fresh water, emissions are 0.05 (0.1).

^dApply when cyclonic scrubber or cascade evaporator is used for direct contact evaporation, with no further controls.

^eUsually reduced by 50% with black liquor oxidation and can be cut 95 - 99% when oxidation is complete and recovery furnace is operated optimally.

^fApply when venturi scrubber is used for direct contact evaporation, with no further controls.

^gUse 7.5 (15) when auxiliary scrubber follows venturi scrubber, and 1.5 (3) when it follows ESP.

^hApply when recovery furnace is operated optimally to control total reduced sulfur (TRS) compounds.

^jUsually reduced to 0.01 g/kg (0.02 lb/ton) ADP when water low in sulfides is used in smelt dissolving tank and associated scrubber.

^mUsually reduced to 0.015 g/kg (0.03 lb/ton) ADP with efficient mud washing, optimal kiln operation and added caustic in scrubbing water. With only efficient mud washing and optimal process control, TRS compounds reduced to 0.04 g/kg (0.08 lb/ton) ADP.

ⁿIncludes knotter vents, brownstock seal tanks, etc. When black liquor oxidation is included, emissions are 0.3 (0.6).

TABLE 10.1-2. CUMULATIVE PARTICLE SIZE DISTRIBUTION AND SIZE SPECIFIC EMISSION FACTORS FOR A RECOVERY BOILER WITH A DIRECT CONTACT EVAPORATOR AND AN ESP^a

EMISSION FACTOR RATING: C

Particle size (um)	Cumulative mass % < stated size		Cumulative emission factor (kg/Mg of air dried pulp)	
	Uncontrolled	Controlled	Uncontrolled	Controlled
15	95.0	-	86	-
10	93.5	-	84	-
6	92.2	68.2	83	0.7
2.5	83.5	53.8	75	0.5
1.25	56.5	40.5	51	0.4
1.00	45.3	34.2	41	0.3
0.625	26.5	22.2	24	0.2
Total	100	100	90	1.0

^aReference 7. Dash = no data.

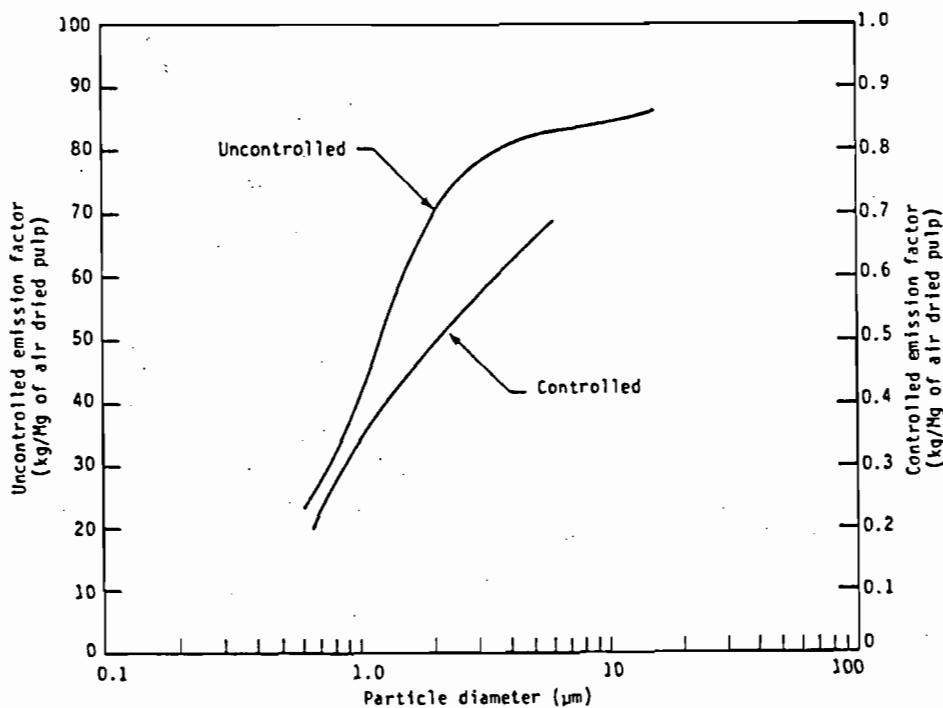


Figure 10.1-2. Cumulative particle size distribution and size specific emission factors for recovery boiler with direct contact evaporator and ESP.

TABLE 10.1-3. CUMULATIVE PARTICLE SIZE DISTRIBUTION AND SIZE SPECIFIC EMISSION FACTORS FOR A RECOVERY BOILER WITHOUT A DIRECT CONTACT EVAPORATOR BUT WITH AN ESP^a

EMISSION FACTOR RATING: C

Particle size (um)	Cumulative mass % \leq stated size		Cumulative emission factor (kg/Mg of air dried pulp)	
	Uncontrolled	Controlled	Uncontrolled	Controlled
15	-	78.8	-	0.8
10	-	74.8	-	0.7
6	-	71.9	-	0.7
2.5	78.0	67.3	90	0.6
1.25	40.0	51.3	46	0.5
1.00	30.0	42.4	35	0.4
0.625	17.0	29.6	20	0.3
Total	100	100	115	1.0

^aReference 7. Dash = no data.

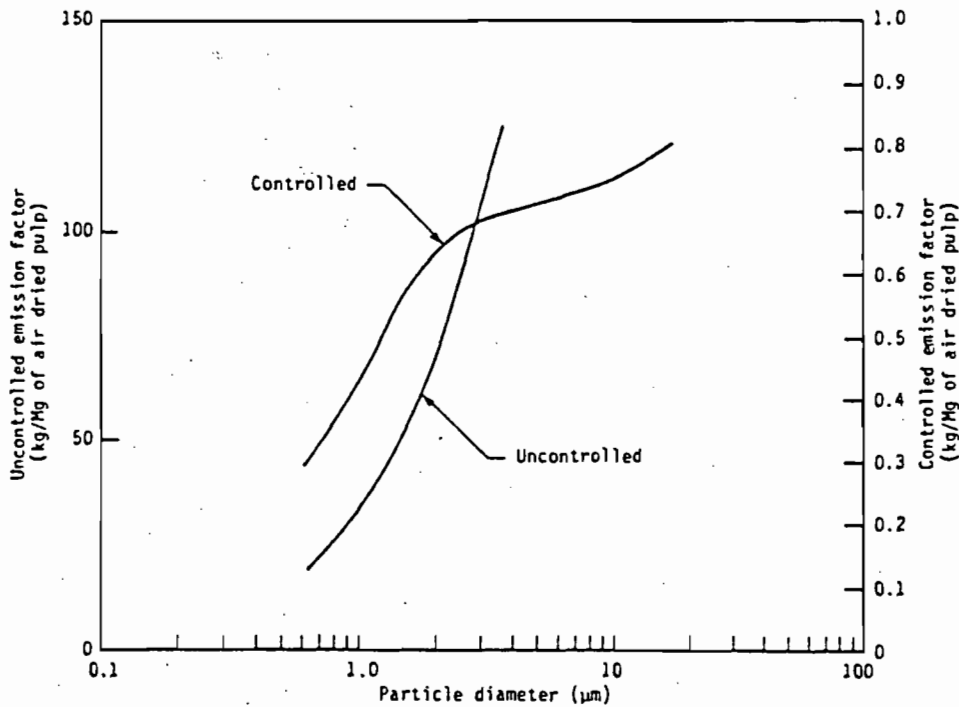


Figure 10.1-3. Cumulative particle size distribution and size specific emission factors for recovery boiler without direct contact evaporator but with ESP.

TABLE 10.1-4. CUMULATIVE PARTICLE SIZE DISTRIBUTION AND SIZE SPECIFIC EMISSION FACTORS FOR A LIME KILN WITH A VENTURI SCRUBBER^a

EMISSION FACTOR RATING: C

Particle size (um)	Cumulative mass % < stated size		Cumulative emission factor (kg/Mg of air dried pulp)	
	Uncontrolled	Controlled	Uncontrolled	Controlled
15	27.7	98.9	7.8	0.24
10	16.8	98.3	4.7	0.24
6	13.4	98.2	3.8	0.24
2.5	10.5	96.0	2.9	0.24
1.25	8.2	85.0	2.3	0.21
1.00	7.1	78.9	2.0	0.20
0.625	3.9	54.3	1.1	0.14
Total	100	100	28.0	0.25

^aReference 7.

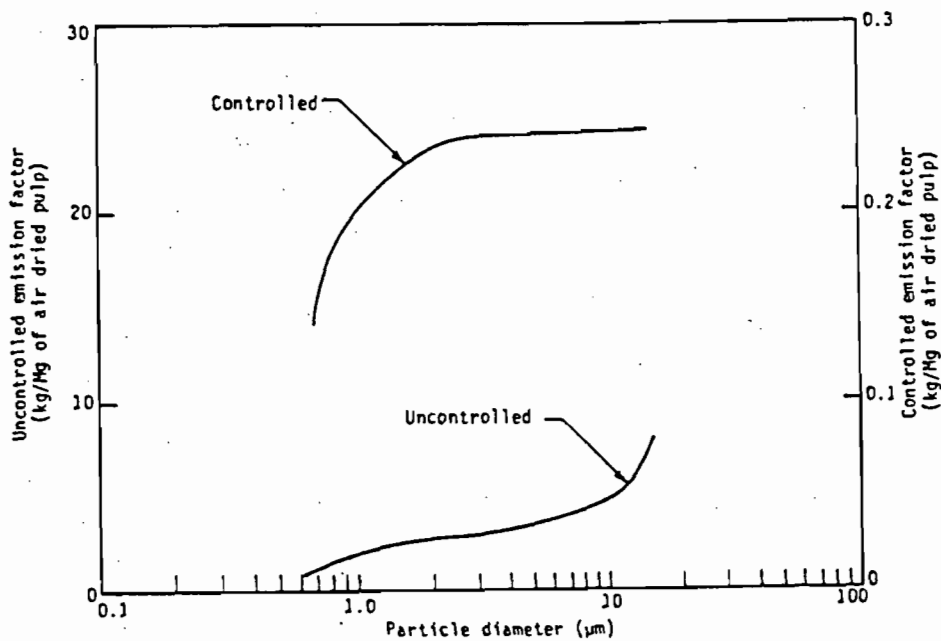


Figure 10.1-4. Cumulative particle size distribution and size specific emission factors for lime kiln with venturi scrubber.

TABLE 10.1-5. CUMULATIVE PARTICLE SIZE DISTRIBUTION AND SIZE SPECIFIC EMISSION FACTORS FOR A LIME KILN WITH AN ESP^a

EMISSION FACTOR RATING: C

Particle size (um)	Cumulative mass % \leq stated size		Cumulative emission factor (kg/Mg of air dried pulp)	
	Uncontrolled	Controlled	Uncontrolled	Controlled
15	27.7	91.2	7.8	0.23
10	16.8	88.5	4.7	0.22
6	13.4	86.5	3.8	0.22
2.5	10.5	83.0	2.9	0.21
1.25	8.2	70.2	2.3	0.18
1.00	7.1	62.9	2.0	0.16
0.625	3.9	46.9	1.1	0.12
Total	100	100	28.0	0.25

^aReference 7.

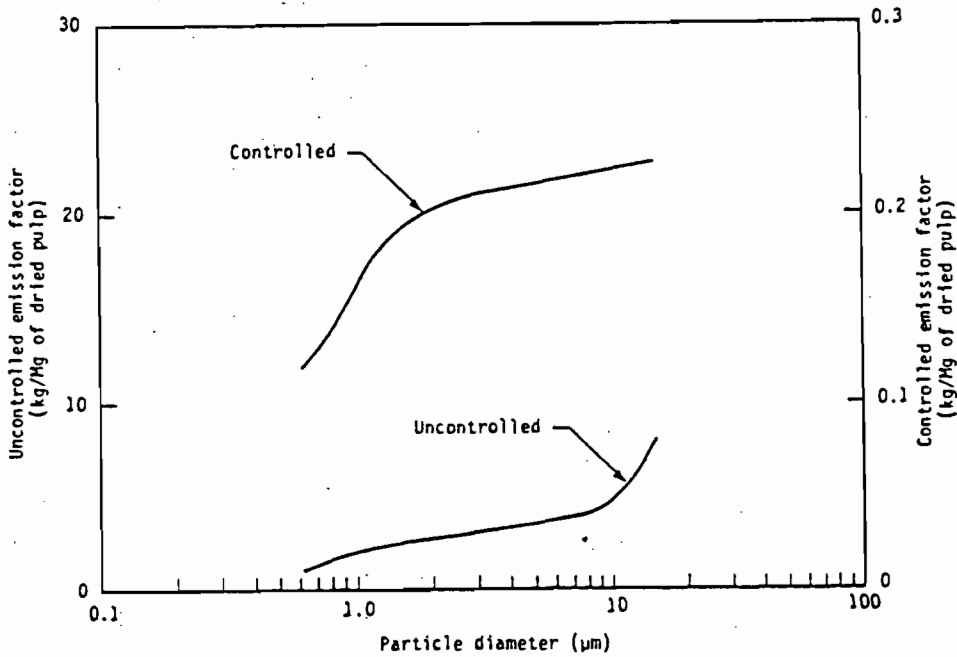


Figure 10.1-5. Cumulative particle size distribution and size specific emission factors for lime kiln with ESP.

TABLE 10.1-6. CUMULATIVE PARTICLE SIZE DISTRIBUTION AND SIZE SPECIFIC EMISSION FACTORS FOR A SMELT DISSOLVING TANK WITH A PACKED TOWER^a

EMISSION FACTOR RATING: C

Particle size (um)	Cumulative mass % \leq stated size		Cumulative emission factor (kg/Mg of air dried pulp)	
	Uncontrolled	Controlled	Uncontrolled	Controlled
15	90.0	95.3	3.2	0.48
10	88.5	95.3	3.1	0.48
6	87.0	94.3	3.0	0.47
2.5	73.0	85.2	2.6	0.43
1.25	47.5	63.8	1.7	0.32
1.00	40.0	54.2	1.4	0.27
0.625	25.5	34.2	0.9	0.17
Total	100	100	3.5	0.50

^aReference 7.

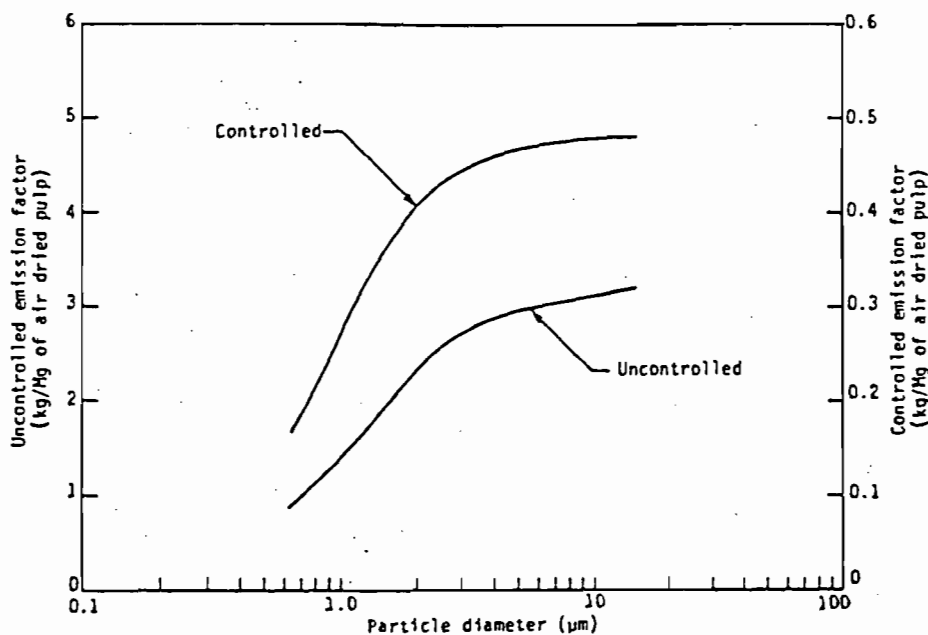


Figure 10.1-6. Cumulative particle size distribution and size specific emission factors for smelt dissolving tank with packed tower.

TABLE 10.1-7. CUMULATIVE PARTICLE SIZE DISTRIBUTION AND SIZE SPECIFIC EMISSION FACTORS FOR A SMELT DISSOLVING TANK WITH A VENTURI SCRUBBER^a

EMISSION FACTOR RATING: C

Particle size (um)	Cumulative mass % < stated size		Cumulative emission factor (kg/Mg of air dried pulp)	
	Uncontrolled	Controlled	Uncontrolled	Controlled
15	90.0	89.9	3.2	0.09
10	88.5	89.5	3.1	0.09
6	87.0	88.4	3.0	0.09
2.5	73.0	81.3	2.6	0.08
1.25	47.5	63.5	1.7	0.06
1.00	54.0	54.7	1.4	0.06
0.625	25.5	38.7	0.9	0.04
Total	100	100	3.5	0.09

^aReference 7.

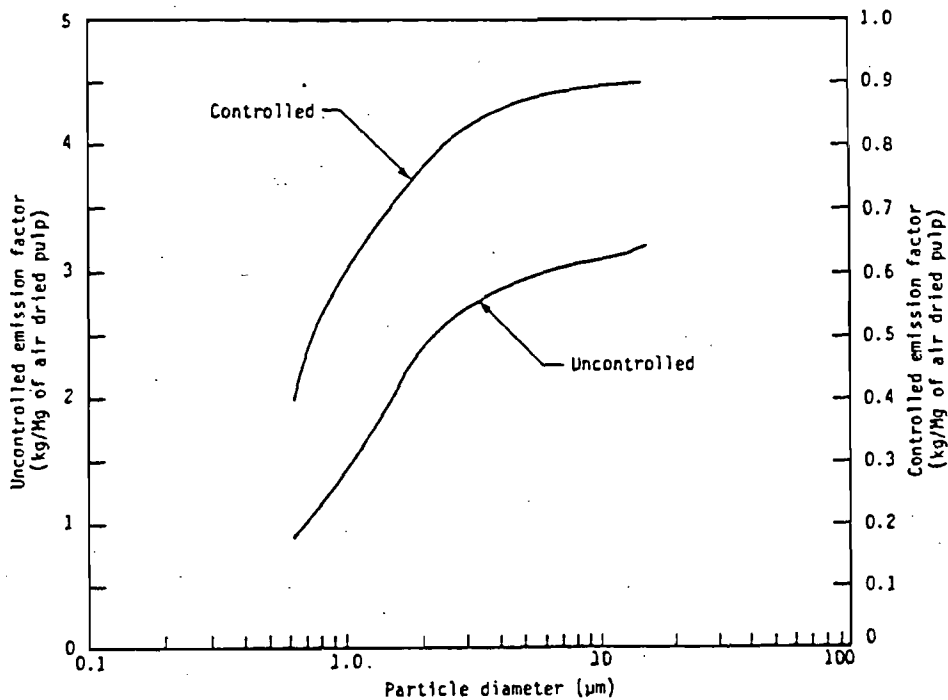


Figure 10.1-7. Cumulative particle size distribution and size specific emission factors for smelt dissolving tank with venturi scrubber.

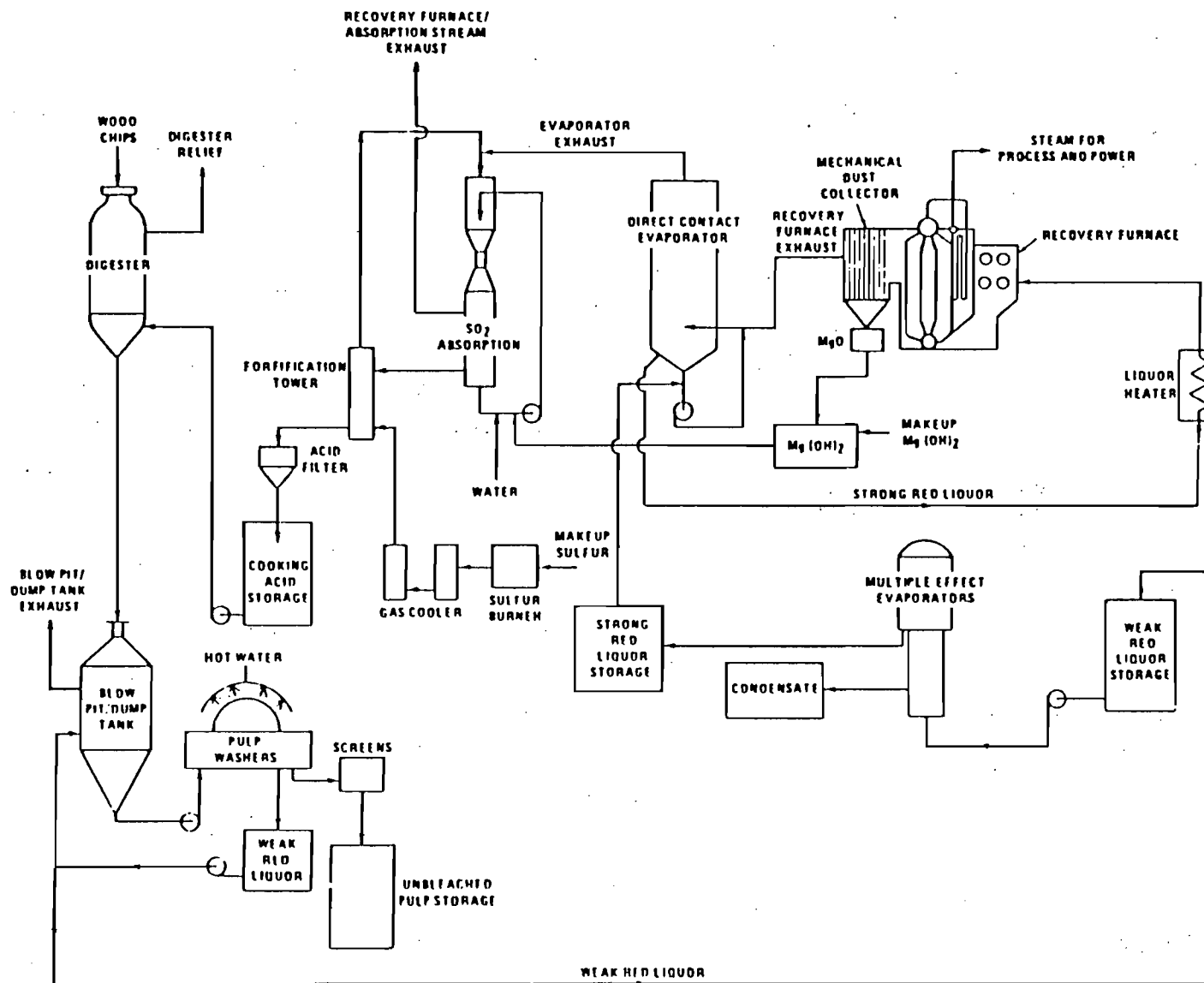


Figure 10.1-8. Simplified process flow diagram of magnesium-base process employing chemical and heat recovery.

incinerated, or sent to a plant for recovery of heat and chemicals. The pulp is then washed and processed through screens and centrifuges to remove knots, bundles of fibers and other material. It subsequently may be bleached, pressed and dried in papermaking operations.

Because of the variety of cooking liquor bases used, numerous schemes have evolved for heat and/or chemical recovery. In calcium base systems, found mostly in older mills, chemical recovery is not practical, and the spent liquor is usually discharged or incinerated. In ammonium base operations, heat can be recovered by combusting the spent liquor, but the ammonium base is thereby consumed. In sodium or magnesium base operations, the heat, sulfur and base all may be feasibly recovered.

If recovery is practiced, the spent (weak) red liquor (which contains more than half of the raw materials as dissolved organic solids) is concentrated in a multiple effect evaporator and a direct contact evaporator to 55 to 60 percent solids. This strong liquor is sprayed into a furnace and burned, producing steam to operate the digesters, evaporators, etc. and to meet other power requirements.

When magnesium base liquor is burned, a flue gas is produced from which magnesium oxide is recovered in a multiple cyclone as fine white power. The magnesium oxide is then water slaked and is used as circulating liquor in a series of venturi scrubbers, which are designed to absorb sulfur dioxide from the flue gas and to form a bisulfite solution for use in the cook cycle. When sodium base liquor is burned, the inorganic compounds are recovered as a molten smelt containing sodium sulfide and sodium carbonate. This smelt may be processed further and used to absorb sulfur dioxide from the flue gas and sulfur burner. In some sodium base mills, however, the smelt may be sold to a nearby kraft mill as raw material for producing green liquor.

If liquor recovery is not practiced, an acid plant is necessary of sufficient capacity to fulfill the mill's total sulfite requirement. Normally, sulfur is burned in a rotary or spray burner. The gas produced is then cooled by heat exchangers and a water spray and is then absorbed in a variety of different scrubbers containing either limestone or a solution of the base chemical. Where recovery is practiced, fortification is accomplished similarly, although a much smaller amount of sulfur dioxide must be produced to make up for that lost in the process.

Emissions And Controls¹¹ - Sulfur dioxide is generally considered the major pollutant of concern from sulfite pulp mills. The characteristic "kraft" odor is not emitted because volatile reduced sulfur compounds are not products of the lignin/bisulfite reaction.

A major SO₂ source is the digester and blow pit (dump tank) system. Sulfur dioxide is present in the intermittent digester relief gases, as well as in the gases given off at the end of the cook when the digester contents are discharged into the blow pit. The quantity of sulfur dioxide evolved and emitted to the atmosphere in these gas streams depends on the pH of the cooking liquor, the pressure at which the digester contents are discharged, and the effectiveness of the absorption systems employed for SO₂ recovery. Scrubbers can be installed that reduce SO₂ from this source by as much as 99 percent.

Another source of sulfur dioxide emissions is the recovery system. Since magnesium, sodium, and ammonium base recovery systems all use absorption systems to recover SO₂ generated in recovery furnaces, acid fortification towers, multiple effect evaporators, etc., the magnitude of SO₂ emissions depends on the desired efficiency of these systems. Generally, such absorption systems recover better than 95 percent of the sulfur so it can be reused.

The various pulp washing, screening, and cleaning operations are also potential sources of SO₂. These operations are numerous and may account for a significant fraction of a mill's SO₂ emissions if not controlled.

The only significant particulate source in the pulping and recovery process is the absorption system handling the recovery furnace exhaust. Ammonium base systems generate less particulate than do magnesium or sodium base systems. The combustion productions are mostly nitrogen, water vapor and sulfur dioxide.

Auxiliary power boilers also produce emissions in the sulfite pulp mill, and emission factors for these boilers are presented in Chapter 1.

Table 10.1-8 contains emission factors for the various sulfite pulping operations.

10.1.4 Neutral Sulfite Semichemical (NSSC) Pulping

Process Description^{9, 12-14} - In this method, wood chips are cooked in a neutral solution of sodium sulfite and sodium carbonate. Sulfite ions react with the lignin in wood, and the sodium bicarbonate acts as a buffer to maintain a neutral solution. The major difference between all semichemical techniques and those of kraft and acid sulfite processes is that only a portion of the lignin is removed during the cook, after which the pulp is further reduced by mechanical disintegration. This method achieves yields as high as 60 to 80 percent, as opposed to 50 to 55 percent for other chemical processes.

The NSSC process varies from mill to mill. Some mills dispose of their spent liquor, some mills recover the cooking chemicals, and some, when operated in conjunction with kraft mills, mix their spent liquor with the kraft liquor as a source of makeup chemicals. When recovery is practiced, the involved steps parallel those of the sulfite process.

Emissions And Controls^{9, 12-14} - Particulate emissions are a potential problem only when recovery systems are involved. Mills that do practice recovery but are not operated in conjunction with kraft operations often utilize fluidized bed reactors to burn their spent liquor. Because the flue gas contains sodium sulfate and sodium carbonate dust, efficient particulate collection may be included for chemical recovery.

A potential gaseous pollutant is sulfur dioxide. Absorbing towers, digester/blower tank system, and recovery furnace are the main sources of SO₂, with amounts emitted dependent upon the capability of the scrubbing devices installed for control and recovery.

Hydrogen sulfide can also be emitted from NSSC mills which use kraft type recovery furnaces. The main potential source is the absorbing tower, where a

TABLE 10.1-8. EMISSION FACTORS FOR SULFITE PULPING^a

Source	Base	Control	Emission factor ^b				Emission Factor Rating
			Particulate		Sulfur dioxide		
			kg/ADUMg	lb/ADUT	kg/ADUMg	lb/ADUT	
Digester/blow pit or dump tank ^c	All	None	Neg	Neg	5 to 35	10 to 70	C
	MgO	Process change ^d	Neg	Neg	1 to 3	2 to 6	C
	MgO	Scrubber	Neg	Neg	0.5	1	B
	MgO	Process change and scrubber	Neg	Neg	0.1	0.2	B
	MgO	All exhaust vented through recovery system	Neg	Neg	0	0	A
	NH ₃	Process change	Neg	Neg	12.5	25	D
	NH ₃	Process change and scrubber	Neg	Neg	0.2	0.4	B
	Na	Process change and scrubber	Neg	Neg	1	2	C
	Ca	Unknown	Neg	Neg	33.5	67	C
Recovery system ^e	MgO	Multicyclone and venturi scrubbers	1	2	4.5	9	A
	NH ₃	Ammonia absorption and mist eliminator	0.35	0.7	3.5	7	B
	Na	Sodium carbonate scrubber	2	4	1	2	C
Acid plant ^f	NH ₃	Scrubber	Neg	Neg	0.2	0.3	C
	Na	Unknown ^g	Neg	Neg	0.1	0.2	D
	Ca	Jenssen scrubber	Neg	Neg	4	8	C
Other ^h	All	None	Neg	Neg	6	12	D

^aReference 11. All factors represent long term average emissions. ADUMg = Air dried unbleached megagram. ADUT = Air dried unbleached ton. Neg = negligible.

^bExpressed as kg (lb) of pollutant/air dried unbleached ton (mg) of pulp.

^cFactors represent emissions after cook is completed and when digester contents are discharged into blow pit or dump tank. Some relief gases are vented from digester during cook cycle, but these are usually transferred to pressure accumulators and SO₂ therein reabsorbed for use in cooking liquor. In some mills, actual emissions will be intermittent and for short periods.

^dMay include such measures as raising cooking liquor pH (thereby lowering free SO₂), relieving digester pressure before contents discharge, and pumping out digester contents instead of blowing out.

^eRecovery system at most mills is closed and includes recovery furnace, direct contact evaporator, multiple effect evaporator, acid fortification tower, and SO₂ absorption scrubbers. Generally only one emission point for entire system. Factors include high SO₂ emissions during periodic purging of recovery systems.

^fNecessary in mills with insufficient or nonexistent recovery systems.

^gControl is practiced, but type of system is unknown.

^hIncludes miscellaneous pulping operations such as knotters, washers, screens, etc.

significant quantity of hydrogen sulfite is liberated as the cooking liquor is made. Other possible sources, depending on the operating conditions, include the recovery furnace, and in mills where some green liquor is used in the cooking process, the digester/blow tank system. Where green liquor is used, it is also possible that significant quantities of mercaptans will be produced. Hydrogen sulfide emissions can be eliminated if burned to sulfur dioxide before the absorbing system.

Because the NSSC process differs greatly from mill to mill, and because of the scarcity of adequate data, no emission factors are presented for this process.

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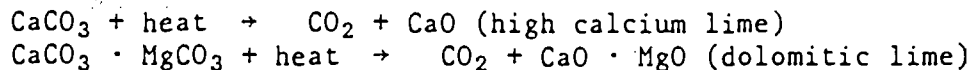
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8.15 LIME MANUFACTURING

8.15.1 General¹⁻⁴

Lime is the high temperature product of the calcination of limestone. There are two kinds, high calcium lime (CaO) and dolomitic lime (CaO · MgO). Lime is manufactured in various kinds of kilns by one of the following reactions:



In some lime plants, the resulting lime is reacted (slaked) with water to form hydrated lime.

The basic processes in the production of lime are 1) quarrying raw limestone; 2) preparing limestone for the kilns by crushing and sizing; 3) calcining limestone; 4) processing the lime further by hydrating; and 5) miscellaneous transfer, storage and handling operations. A generalized material flow diagram for a lime manufacturing plant is given in Figure 8.15-1. Note that some operations shown may not be performed in all plants.

The heart of a lime plant is the kiln. The prevalent type of kiln is the rotary kiln, accounting for about 90 percent of all lime production in the United States. This kiln is a long, cylindrical, slightly inclined, refractory lined furnace, through which the limestone and hot combustion gases pass countercurrently. Coal, oil and natural gas may all be fired in rotary kilns. Product coolers and kiln feed preheaters of various types are commonly used to recover heat from the hot lime product and hot exhaust gases, respectively.

The next most common type of kiln in the United States is the vertical, or shaft, kiln. This kiln can be described as an upright heavy steel cylinder lined with refractory material. The limestone is charged at the top and is calcined as it descends slowly to discharge at the bottom of the kiln. A primary advantage of vertical kilns over rotary kilns is higher average fuel efficiency. The primary disadvantages of vertical kilns are their relatively low production rates and the fact that coal cannot be used without degrading the quality of the lime produced. There have been few recent vertical kiln installations in the United States because of high product quality requirements.

Other, much less common, kiln types include rotary hearth and fluidized bed kilns. Both kiln types can achieve high production rates, and neither can operate with coal. The "calcimatic" kiln, or rotary hearth kiln, is a circular shaped kiln with a slowly revolving donut shaped hearth. In fluidized bed kilns, finely divided limestone is brought into contact with hot combustion air in a turbulent zone, usually above a perforated grate. Because of the amount of lime carryover into the exhaust gases, dust collection equipment must be installed on fluidized bed kilns for process economy.

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TABLE 8.15-1. EMISSION FACTORS FOR LIME MANUFACTURING^a

EMISSION FACTOR RATING: B

Source	Particulate ^b		Nitrogen oxides		Carbon monoxide		Sulfur Dioxide	
	kg/Hg	lb/ton	kg/Hg	lb/ton	kg/Hg	lb/ton	kg/Hg	lb/ton
Crushers, screens, conveyors, storage piles, unpaved roads, etc.	c	c	Neg	Neg	Neg	Neg	Neg	Neg
Rotary kilns ^d								
Uncontrolled ^e	180	350	1.4	2.8	1	2	f	f
Large diameter cyclone	81	160	1.4	2.8	1	2	f	f
Multiple cyclone	42	83	1.4	2.8	1	2	f	f
Electrostatic precipitator ^g	2.4	4.8	1.4	2.8	1	2	h	h
Venturi scrubber	2.4	4.8	1.4	2.8	1	2	h	h
Gravel bed filter ^g	0.53 ⁱ	1.1 ⁱ	1.4	2.8	1	2	h	h
Multiclone and venturi scrubber ^g	0.44	0.87 ^j	1.4	2.8	1	2	h	h
Baghouse	0.45 ^j	0.89 ^j	1.4	2.8	1	2	h	h
Cyclone and baghouse	0.055	0.11	1.4	2.8	1	2	h	h
Vertical kilns								
Uncontrolled	4	8	NA	NA	NA	NA	NA	NA
Calcinatic kilns ^k								
Uncontrolled	25	50	0.1	0.2	NA	NA	NA	NA
Multiple cyclone	3	6	0.1	0.2	NA	NA	NA	NA
Secondary dust collection ^l	NA	NA	0.1	0.2	NA	NA	NA	NA
Fluidized bed kilns	m	m	NA	NA	NA	NA	NA	NA
Product coolers								
Uncontrolled	20 ⁿ	40 ⁿ	Neg	Neg	Neg	Neg	Neg	Neg
Hydrators (atmospheric) ^p								
Wet scrubber	0.05	0.1	Neg	Neg	Neg	Neg	Neg	Neg
Crusher, screen, hammermill								
Baghouse	0.0005	0.001	Neg	Neg	Neg	Neg	Neg	Neg
Final screen								
Baghouse	0.0004	0.0008	Neg	Neg	Neg	Neg	Neg	Neg
Uncontrolled truck loading								
Limestone								
Open truck	0.75	1.5	Neg	Neg	Neg	Neg	Neg	Neg
Closed truck	0.38	0.76	Neg	Neg	Neg	Neg	Neg	Neg
Lime - closed truck	0.15 ⁱ	0.30 ⁱ	Neg	Neg	Neg	Neg	Neg	Neg

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TABLE 8.15-1 (cont.).

- ^aReferences 4-7. Factors for kilns and coolers are per unit of lime produced. Divide by two to obtain factors per unit of limestone feed to the kiln. Factors for hydrators are per unit of hydrated lime produced. Multiply by 1.25 to obtain factors per unit of lime feed to the hydrator. Neg = negligible. NA = not available.
- ^bEmission Factor Rating = D.
- ^cFactors for these operations are presented in Sections 8.20 and 11.2 of this document.
- ^dFor coal fired rotary kilns only.
- ^eNo particulate control except for settling that may occur in stack breeching and chimney base.
- ^fSulfur dioxide may be estimated by a material balance using fuel sulfur content.
- ^gCombination coal/gas fired rotary kilns only.
- ^hWhen scrubbers are used, < 5% of the fuel sulfur will be emitted as SO₂ even with high sulfur coal. When other secondary collection devices are used, about 20% of the fuel sulfur will be emitted as SO₂ with high sulfur fuels, and < 10% with low sulfur fuels.
- ⁱEmission Factor Rating = E.
- ^jEmission Factor Rating = C.
- ^kCalcimatic kilns generally have stone preheaters. Factors are for emissions after the kiln exhaust passes through a preheater.
- ^lFabric filters and venturi scrubbers have been used on calcimatic kilns. No data are available on particulate emissions after secondary control.
- ^mFluidized bed kilns must have sophisticated dust collection equipment for process economics, hence particulate emissions will depend on efficiency of the control equipment installed.
- ⁿSome or all cooler exhaust typically is used in kiln as combustion air. Emissions will result only from that fraction not recycled to kiln.
- ^pTypical particulate loading for atmospheric hydrators following water sprays or wet scrubbers. Limited data suggest particulate emissions from pressure hydrators may be approximately 1 kg/Mg (2 lb/ton) of hydrate produced, after wet collectors.

8.15-6

EMISSION FACTORS

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11.2.3 AGGREGATE HANDLING AND STORAGE PILES

11.2.3.1 General

Inherent in operations that use minerals in aggregate form is the maintenance of outdoor storage piles. Storage piles are usually left uncovered, partially because of the need for frequent material transfer into or out of storage.

Dust emissions occur at several points in the storage cycle, during material loading onto the pile, during disturbances by strong wind currents, and during loadout from the pile. The movement of trucks and loading equipment in the storage pile area is also a substantial source of dust.

11.2.3.2 Emissions and Correction Parameters

The quantity of dust emissions from aggregate storage operations varies with the volume of aggregate passing through the storage cycle. Also, emissions depend on three correction parameters that characterize the condition of a particular storage pile: age of the pile, moisture content and proportion of aggregate fines.

When freshly processed aggregate is loaded onto a storage pile, its potential for dust emissions is at a maximum. Fines are easily disaggregated and released to the atmosphere upon exposure to air currents from aggregate transfer itself or high winds. As the aggregate weathers, however, potential for dust emissions is greatly reduced. Moisture causes aggregation and cementation of fines to the surfaces of larger particles. Any significant rainfall soaks the interior of the pile, and the drying process is very slow.

Field investigations have shown that emissions from aggregate storage operations vary in direct proportion to the percentage of silt (particles < 75 μm in diameter) in the aggregate material.^{1 3} The silt content is determined by measuring the proportion of dry aggregate material that passes through a 200 mesh screen, using ASTM-C-136 method. Table 11.2.3-1 summarizes measured silt and moisture values for industrial aggregate materials.

11.2.3.3 Predictive Emission Factor Equations

Total dust emissions from aggregate storage piles are contributions of several distinct source activities within the storage cycle:

1. Loading of aggregate onto storage piles (batch or continuous drop operations).
2. Equipment traffic in storage area.
3. Wind erosion of pile surfaces and ground areas around piles.
4. Loadout of aggregate for shipment or for return to the process stream (batch or continuous drop operations).

TABLE 11.2.3-1. TYPICAL SILT AND MOISTURE CONTENT VALUES OF MATERIALS AT VARIOUS INDUSTRIES

Industry	Material	Silt (%)			Moisture (%)		
		No. of test samples	Range	Mean	No. of test samples	Range	Mean
Iron and steel production ^a	Pellet ore	10	1.4 - 13	4.9	8	0.64 - 3.5	2.1
	Lump ore	9	2.8 - 19	9.5	6	1.6 - 8.1	5.4
	Coal	7	2 - 7.7	5	6	2.8 - 11	4.8
	Slag	3	3 - 7.3	5.3	3	0.25 - 2.2	0.92
	Flue dust	2	14 - 23	18.0	0	NA	NA
	Coke breeze	1		5.4	1		6.4
	Blended ore	1		15.0	1		6.6
	Sinter	1		0.7	0	NA	NA
Limestone	1		0.4	0	NA	NA	
Stone quarrying and processing ^b	Crushed limestone	2	1.3 - 1.9	1.6	2	0.3 - 1.1	0.7
Taconite mining and processing ^c	Pellets	9	2.2 - 5.4	3.4	7	0.05 - 2.3	0.96
	Tailings	2	NA	11.0	1		0.35
Western surface coal mining ^d	Coal	15	3.4 - 16	6.2	7	2.8 - 20	6.9
	Overburden	15	3.8 - 15	7.5	0	NA	NA
	Exposed ground	3	5.1 - 21	15.0	3	0.8 - 6.4	3.4

^a References 2-5. NA = not applicable.

^b Reference 1.

^c Reference 6.

^d Reference 7.

among the piles (which may differ from the silt values for the stored materials) should be used.

For emissions from wind erosion of active storage piles, the following total suspended particulate (TSP) emission factor equation is recommended:

$$E = 1.9 \left(\frac{s}{1.5} \right) \left(\frac{365-p}{235} \right) \left(\frac{f}{15} \right) \text{ (kg/day/hectare)} \quad (3)$$

$$E = 1.7 \left(\frac{s}{1.5} \right) \left(\frac{365-p}{235} \right) \left(\frac{f}{15} \right) \text{ (lb/day/acre)}$$

where: E = total suspended particulate emission factor
s = silt content of aggregate (%)
p = number of days with ≥ 0.25 mm (0.01 in.) of precipitation per year
f = percentage of time that the unobstructed wind speed exceeds 5.4 m/s (12 mph) at the mean pile height

The coefficient in Equation 3 is taken from Reference 1, based on sampling of emissions from a sand and gravel storage pile area during periods when transfer and maintenance equipment was not operating. The factor from Test Report 1, expressed in mass per unit area per day, is more reliable than the factor expressed in mass per unit mass of material placed in storage, for reasons stated in that report. Note that the coefficient has been halved to adjust for the estimate that the wind speed through the emission layer at the test site was one half of the value measured above the top of the piles. The other terms in this equation were added to correct for silt, precipitation and frequency of high winds, as discussed in Reference 2. Equation 3 is rated C for application in the sand and gravel industry and D for other industries.

Worst case emissions from storage pile areas occur under dry windy conditions. Worst case emissions from materials handling (batch and continuous drop) operations may be calculated by substituting into Equations 1 and 2 appropriate values for aggregate material moisture content and for anticipated wind speeds during the worst case averaging period, usually 24 hours. The treatment of dry conditions for vehicle traffic (Section 11.2.1) and for wind erosion (Equation 3), centering around parameter p, follows the methodology described in Section 11.2.1. Also, a separate set of nonclimatic correction parameters and source extent values corresponding to higher than normal storage pile activity may be justified for the worst case averaging period.

11.2.3.4 Control Methods

Watering and chemical wetting agents are the principal means for control of aggregate storage pile emissions. Enclosure or covering of inactive piles to reduce wind erosion can also reduce emissions. Watering is useful mainly to reduce emissions from vehicle traffic in the storage pile area. Watering of the storage piles themselves typically has only a very temporary slight effect on total emissions. A much more effective technique is to apply chemical wetting agents for better wetting of fines and

longer retention of the moisture film. Continuous chemical treatment of material loaded onto piles, coupled with watering or treatment of roadways, can reduce total particulate emissions from aggregate storage operations by up to 90 percent.⁸

References for Section 11.2.3

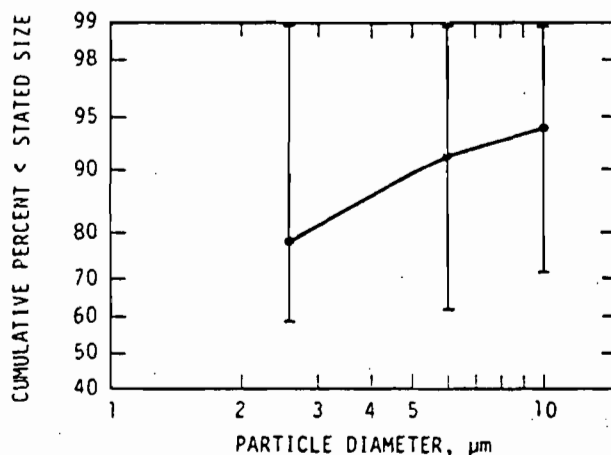
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TABLE C.2-2 (continued).

Category: 9
 Process: Condensation, Hydration, Absorption, Prilling and Distillation
 Material: All

Category 9 covers condensation, hydration, absorption, prilling, and distillation of all materials. These processes involve the physical separation or combination of a wide variety of materials such as sulfuric acid and ammonium nitrate fertilizer. (Coke ovens are included since they can be considered a distillation process which separates the volatile matter from coal to produce coke.)

REFERENCE: 1, 3



Particle size, μm	Cumulative % less than or equal to stated size (uncontrolled)	Minimum Value	Maximum Value	Standard Deviation
1.0 ^a	60			
2.0 ^a	74			
2.5	78	59	99	17
3.0 ^a	81			
4.0 ^a	85			
5.0 ^a	88			
6.0	91	61	99	12
10.0	94	71	99	9

^a Value calculated from data reported at 2.5, 6.0, and 10.0 μm. No statistical parameters are given for the calculated value.

C.2.3 How To Use The Generalized Particle Size Distributions For Controlled Processes

To calculate the size distribution and the size specific emissions for a source with a particulate control device, the user first calculates the uncontrolled size specific emissions. Next, the fractional control efficiency for the control device is estimated, using Table C.2-3. The Calculation Sheet provided (Figure C.2-2) allows the user to record the type of control device and the collection efficiencies from Table C.2-3, the mass in the size range before and after control, and the cumulative mass. The user will note that the uncontrolled size data are expressed in cumulative fraction less than the stated size. The control efficiency data apply only to the size range indicated and are not cumulative. These data do not include results for the greater than 10 μm particle size range. In order to account for the total controlled emissions, particles greater than 10 μm in size must be included.

C.2.4 Example Calculation

An example calculation of uncontrolled total particulate emissions, uncontrolled size specific emissions, and controlled size specific emission is shown on Figure C.2-1. A blank Calculation Sheet is provided in Figure C.2-2.

TABLE C.2-3 TYPICAL COLLECTION EFFICIENCIES OF VARIOUS PARTICULATE CONTROL DEVICES. ^{a,b}
(percent)

Type of collector	Particle size, μm		
	0 - 2.5	2.5 - 6	6 - 10
Baffled settling chamber	NR	5	15
Simple (high-throughput) cyclone	50	75	85
High-efficiency and multiple cyclones	80	95	95
Electrostatic precipitator (ESP)	95	99	99.5
Packed-bed scrubber	90	95	99
Venturi scrubber	90	95	99
Wet-impingement scrubber	25	85	95
Fabric filter	99	99.5	99.5

^a The data shown represent an average of actual efficiencies. The efficiencies are representative of well designed and well operated control equipment. Site specific factors (e.g., type of particulate being collected, varying pressure drops across scrubbers, maintenance of equipment, etc.) will affect the collection efficiencies. The efficiencies shown are intended to provide guidance for estimating control equipment performance when source-specific data are not available.

^b Reference: 10
NR = Not reported.

EXCERPTS FROM NCASI PUBLICATIONS

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technical bulletin

NATIONAL COUNCIL OF THE PAPER INDUSTRY FOR AIR AND STREAM IMPROVEMENT, INC., 260 MADISON AVENUE, NEW YORK, N.Y. 10016

A STUDY OF NITROGEN OXIDES EMISSIONS
FROM LIME KILNS

ATMOSPHERIC QUALITY IMPROVEMENT
TECHNICAL BULLETIN No. 107

APRIL 1980

Encl. # 5

$$E_{NO_2} = \frac{w(86) + x(130) + y(210) + z(260)}{100}$$

where:

- E_{NO_2} = is the applicable standard for nitrogen oxides when multiple fuels are combusted simultaneously (ng/J heat input);
- w = is the percentage of total heat input derived from the combustion of fuels subject to the 86 ng/J heat input standard;
- x = is the percentage of total heat input derived from the combustion of fuels subject to the 130 ng/J heat input standard;
- y = is the percentage of total heat input derived from the combustion of fuels subject to the 210 ng/J input standard; and
- z = is the percentage of total heat input derived from the combustion of fuels subject to the 260 ng/J heat input standard.

Since the NOx emissions on any source are determined as nitrogen dioxide (NO₂) on a parts per million (ppm) concentration basis, the data must be converted to the appropriate units of pounds NOx as NO₂ per million Btu heat input. This can be accomplished through the measurement of (a) excess oxygen, (b) the combustion gas flow rate, and (c) the quantity and heat content of the fuel burned. As specified in the Federal Register (116), the TRS and particulate matter concentrations determined after a kraft mill lime kiln control device must be adjusted to ten percent excess oxygen content whether it is greater or less than ten percent. This adjustment addresses the need to normalize pollutant emission concentration data for various degrees of gas stream dilution through transport ducts, fans and control devices. For this reason, the NOx three-hour average concentration data in this bulletin is presented on both a measured stack concentration and also adjusted to ten percent oxygen. At all sites tested, the stack flue gas oxygen level at the point of measurement was less than ten percent oxygen.

B. Lime Kiln Sites

The oxides of nitrogen emission results for the five kilns sampled are presented in Table 3. As specified in the Federal Register (34), the data was compiled into first, hourly averages and then into three-hour averages. The mean and range for each site are noted in the table. The NOx concentration in parts per million, measured at stack conditions, is directly above the NOx concentration mean adjusted to ten percent excess oxygen. Both the three-hour mean and range are given in Table 3 with units of pounds NOx per million Btu heat input and nanograms NOx per Joule

TABLE 3 OXIDES OF NITROGEN FIELD MEASUREMENTS FOR LIME KILNS SAMPLED

Location & Fuel Type	NOx (3) Hour Average Mean			NOx (3) Hour Average Range		
	(ppm)	(lb/10 ⁶ Btu)	(ng/J) ¹	(ppm)	(lb/10 ⁶ Btu)	(ng/J) ¹
1: Oil	185 (130)*	0.850	365	165- 215	0.750- 0.990	325- 425
2: Oil	80 (55)*	0.155	65	35- 145	0.065- 0.285	30- 120
3: Oil	50 (45)*	0.160	70	25- 65	0.085- 0.215	35- 90
4A: Oil	150 (100)*	0.310	135	110- 260	0.230- 0.545	100- 235
4B: Gas	145 (100)*	0.290	125	95- 195	0.195- 0.390	85- 165
5: Gas	310 (275)*	0.780	335	145- 430	0.334- 1.125	150- 485

1. 1 lb/10⁶ Btu = 430 nanograms per Joule heat input.

* Adjusted to 10 percent oxygen in the flue gas. The other ppm oxygen concentration data corresponds to actual stack oxygen levels shown in Table 2.

heat input for each of the five sites and six combustion modes studied. These NOx emission values correspond to the time testing interval noted in Table 2. The NOx mean and upper range found for each site in units of pounds NOx per million Btu are depicted in Figure 3. All of the lime kiln sources represented in this figure except Nos. 4B and 5 corresponded to 100 percent oil fuel firing. The two exceptions were kiln sites fired on 100 percent natural gas during the study period.

The dashed line at 0.30 pounds NOx per million Btu in Figure 3 indicates the standard for oil fired boilers. The lower dashed line at 0.20 pounds NOx per million Btu corresponds to the standard for natural gas fired boilers. As shown in the figure, three out of four of the kilns fired on oil had at least one three-hour interval over 0.30 pounds NOx per million Btu. Two of these three sites were found to have data means over the oil fired boiler standard. Both of the kilns which fired natural gas had a majority of their three-hour NOx averages which were above the standard for natural gas fired boilers.

The wide range and high three-hour average NOx emission levels found for the natural gas fired kiln at site No. 5 point toward a potential dependence of NOx concentrations over the normal range of this particular burner operation. A relationship between combustion zone temperature and NOx emission rate was obtained in a study by NCASI personnel with the use of an optical pyrometer and is presented in Figure 4. The relationship in the figure was based on a total of 37 data points. The solid portion of the curve indicates the use of linear regression techniques performed on 33 of these data points which were judged to follow a close linear distribution to give the following equation having a correlation coefficient, R, of 0.965:

$$\frac{\text{lb NOx}}{10^6 \text{ Btu}} = 2.17 \times 10^{-3} (\text{Temperature, } ^\circ\text{F}) - 3.58$$

The dashed portion of the center curve was a smooth fit approximation through the remaining four data points. Based on the data collected encompassing various modes of burner operation at this site, there was judged to be a potential for reduction of NOx emissions to less than 0.4 pounds per million Btu. Adjustment of the gas firing rate and the excess air levels supplied to the kiln's burner may enable the combustion zone temperature as measured by the optical pyrometer to be controlled at less than 1850°F. Below this temperature the NOx to combustion zone temperature relationship was judged to be insignificant for the limited amount of data collected. The normal combustion zone temperature for long kilns usually averages about 2000°F with as much as 2375°F required for short kilns. The minimum temperature at which calcium carbonate dissociates and the partial pressure of carbon dioxide reaches one atmosphere is 1670°F (123). Heat and radiation losses of up to 40% in combination with the energy required to evaporate 30 to 40% water carried in the lime mud charged to the kiln, makes the minimum combustion zone temperature somewhat higher than this value.

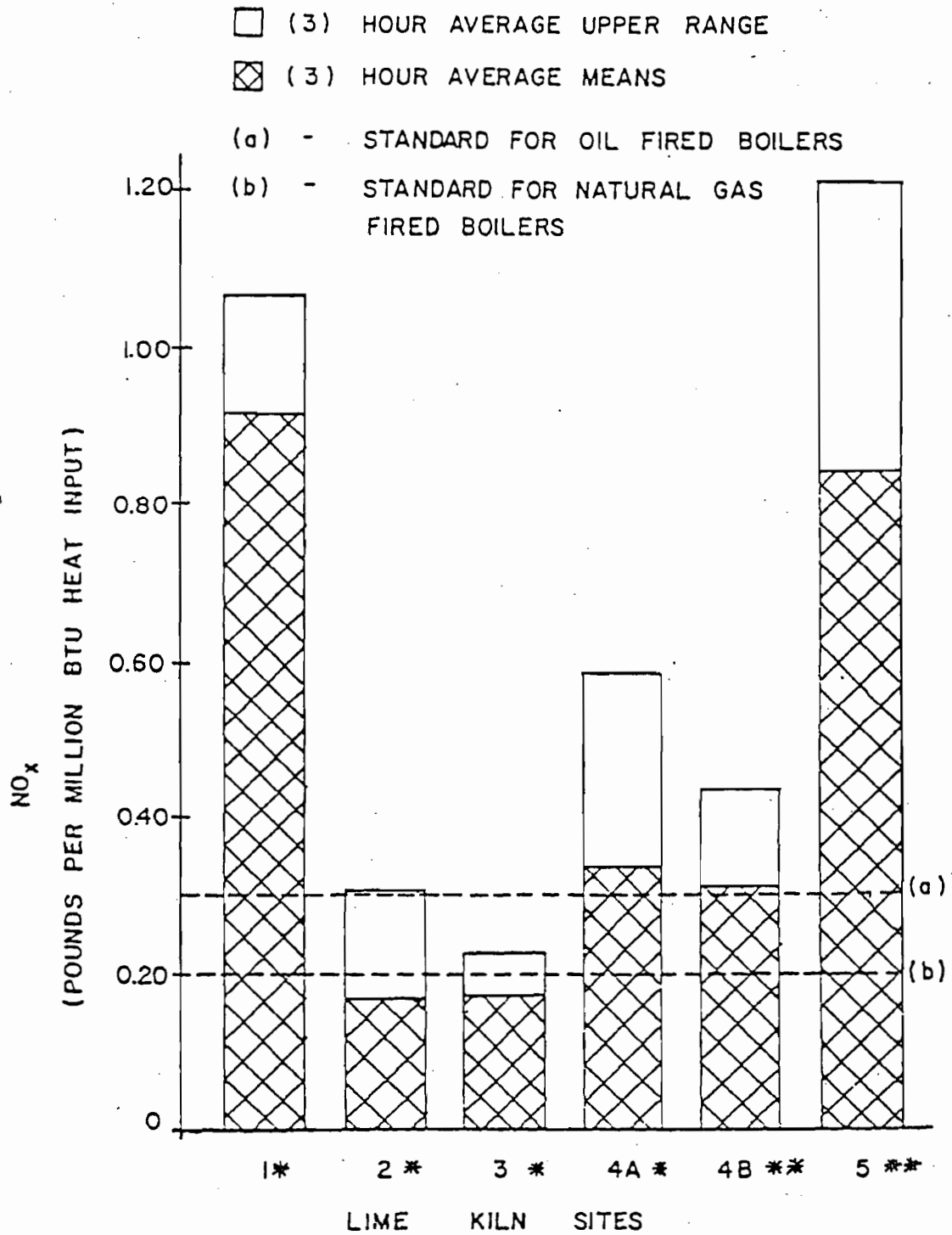


FIGURE 3. NO_x EMISSION LEVELS FOR KRAFT MILL LIME KILNS SAMPLED

* OIL FIRED
** NATURAL GAS FIRED

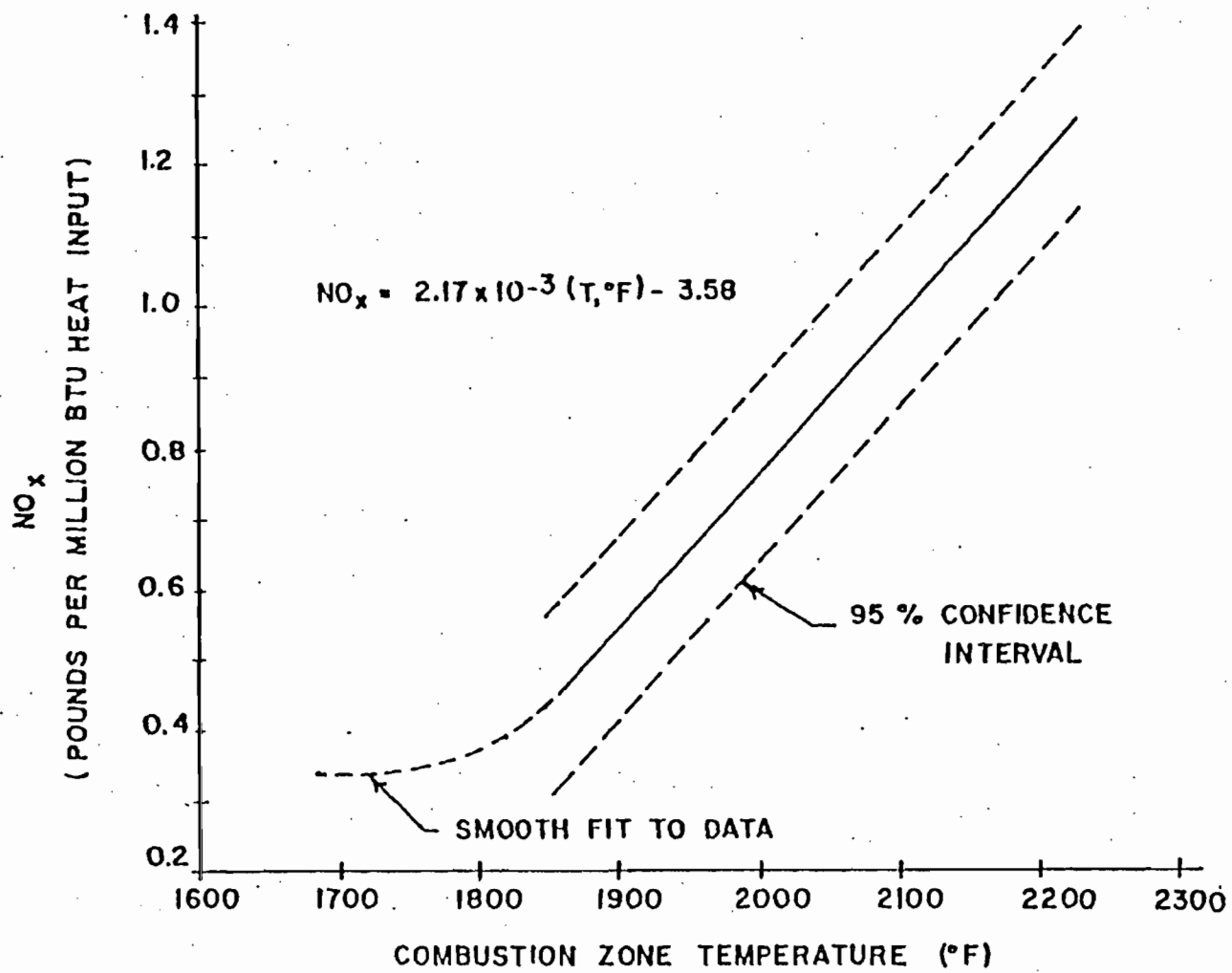


FIGURE 4. THE RELATIONSHIP BETWEEN COMBUSTION ZONE TEMPERATURE AND NO_x EMISSIONS

B. Kraft Recovery Furnaces

Carbon monoxide monitoring records from five kraft recovery furnaces were collected and analyzed. These recovery furnaces represent both DCE and non-DCE units with construction dates ranging from 1964 to 1977. Table 2 lists characteristics of these furnaces.

TABLE 2 RECOVERY FURNACE DESIGN INFORMATION

<u>Furnace</u>	<u>Manufacturer</u>	<u>Install- ment Date</u>	<u>Type</u>	<u>Rated Black Liquor Firing Rate lb/hr</u>	<u>Average Black Liquor Firing Rate lb/hr</u>	<u>Black Liquor Heat Value Btu/lb Dry Solids</u>
A	CE	1970	NDCE	100,000	80,000	5,717
B	CE	1964	DCE	100,000	103,000	5,955
C	CE	1977	NDCE	190,000	148,000	6,600
D	CE	1975	DCE	137,500	137,000	6,000
E	B & W (short)	1965	DCE	96,000	79,000	--

C. Lime Kilns

Carbon monoxide monitoring data from two recently constructed lime kilns were collected.

(1) Kiln A - Kiln A was a rotary kiln manufactured by Allis Chalmers and began operation in 1968. The kiln has a 9 ft diameter and 250 ft length with provisions for firing on either gas or oil. Noncondensable gases from the pulp mill were not burned in the kiln. The kiln was designed to produce 106 tons lime as CaO per day for the equivalent production of 425 TPD unbleached pulp. Particulate emissions were controlled with a Chemico venturi type scrubber, which used fresh water for makeup.

(2) Kiln B - Kiln B was rotary kiln manufactured by F. L. Smidth and Co., Inc. and began operation in early 1982. The kiln has a diameter of 11.83 ft (less 1.75 ft for the brick lining at the hot end) and a length of 341 ft. The kiln fires No. 6 oil or natural gas and has a lime production capacity of 325 tons per day as CaO. This kiln used lime product coolers to preheat the combustion air. Noncondensable gases from the pulp mill were not burned in this kiln.

increase. This was at about 350 ppm carbon monoxide. The kraft recovery furnaces studied that were equipped with non-direct contact evaporators operated with higher furnace exit gas oxygen concentrations than the NDCE-equipped furnaces. These furnaces maintained carbon monoxide below 400 ppm and TRS emissions were below 5 ppm throughout the study period.

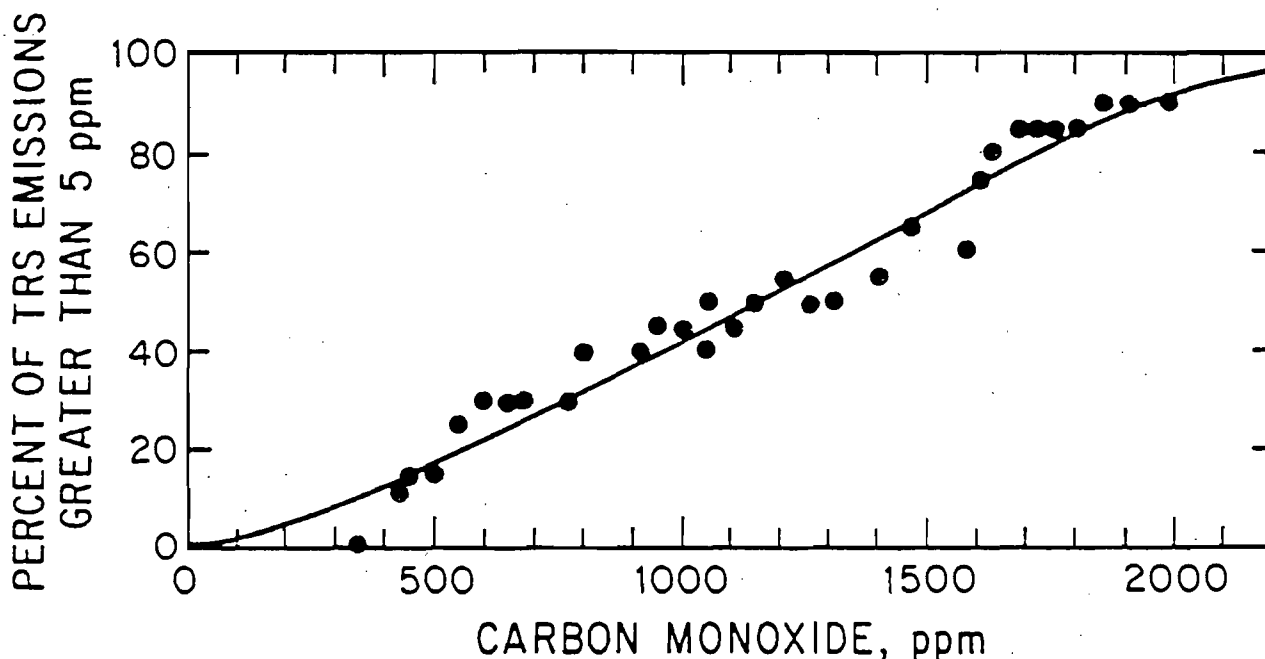


FIGURE 23

PERCENT OF TRS EMISSIONS GREATER THAN 5 ppm
AS A FUNCTION OF CARBON MONOXIDE CONCENTRATIONS
IN THE STACK GASES AT RECOVERY FURNACE C

Carbon monoxide-TRS emission relationships for these five units were inadequate to determine if carbon monoxide monitoring could serve as a surrogate for TRS monitoring. An additional study is required to determine if this is the case. Carbon monoxide monitoring, however, was indicated to be an effective tool to assist the furnace operator in reducing TRS emissions excursions from the furnace.

E. Lime Kiln Carbon Monoxide Emission

Averages of carbon monoxide emission data collected from two lime kilns during this survey, kilns A and B, representing 200 and 60 hours of data respectively, and two lime kilns during TGNMO emissions survey (5), kilns C and D, are listed in Table 6. Cumulative frequency distributions of 1 hr and 8 hr average

carbon monoxide emissions from kilns A and B are shown in Figures 24 and 25. Average 1 hr carbon monoxide emissions from kilns A and B were less than 0.03 lb/10⁶ Btu heat input greater than 70 percent of the time. Occasional process upsets, such as too little excess combustion air or unstable flame conditions resulted in occasional short-term, high concentrations of carbon monoxide. Carbon monoxide emissions during these momentary aberrations increased average emissions from baseline levels. Median 1 hr average carbon monoxide emissions were at 0.008 and 0.023 lb/10⁶ Btu for kilns A and B respectively. Lime kiln C was an older unit and did not have an operating oxygen monitor when sampled. This may have been in part responsible for the higher carbon monoxide emission rates measured.

TABLE 6 AVERAGE LIME KILN CARBON MONOXIDE EMISSIONS

<u>Kiln</u>	<u>Hours of Data</u>	<u>lb CO/10⁶ Btu</u>	<u>lb CO/ton Lime</u>	<u>lb CO/ADT Pulp</u>
A	60	0.038	0.17	0.051
B	200	0.041	0.19	0.058
C	14	0.080	0.41	0.120
D	8	0.020	0.12	0.035

F. Carbon Monoxide Emissions at Optimum Energy Recovery Efficiency

Recovery furnaces and wood-residue fired boilers can be optimized for energy recovery by balancing reduced stack heat losses from low excess combustion air use against energy losses from uncombusted carbon monoxide in the flue gases. Figure 26 shows stack energy losses from three kraft recovery furnaces as a function of the stack gas oxygen concentration and CO concentrations typical of the flue gas oxygen concentration shown for the indicated furnace. Each recovery furnace is indicated to have an optimum operating range. The carbon monoxide emission concentrations in the exit gas at maximum energy recovery were between 300 to 1000 ppm, which corresponded to between 1.1 to 3.8 lb CO/10³ lb bls. These values will vary somewhat with stack gas temperature. A higher stack gas temperature should result in a narrower range in carbon monoxide emission rates at maximum energy recovery. If recovery furnaces are optimized for energy recovery, it would be expected that carbon monoxide emission rate will be within the range mentioned above. A carbon monoxide concentration of 300 ppm or about 1 lb CO/10³ lb bls was

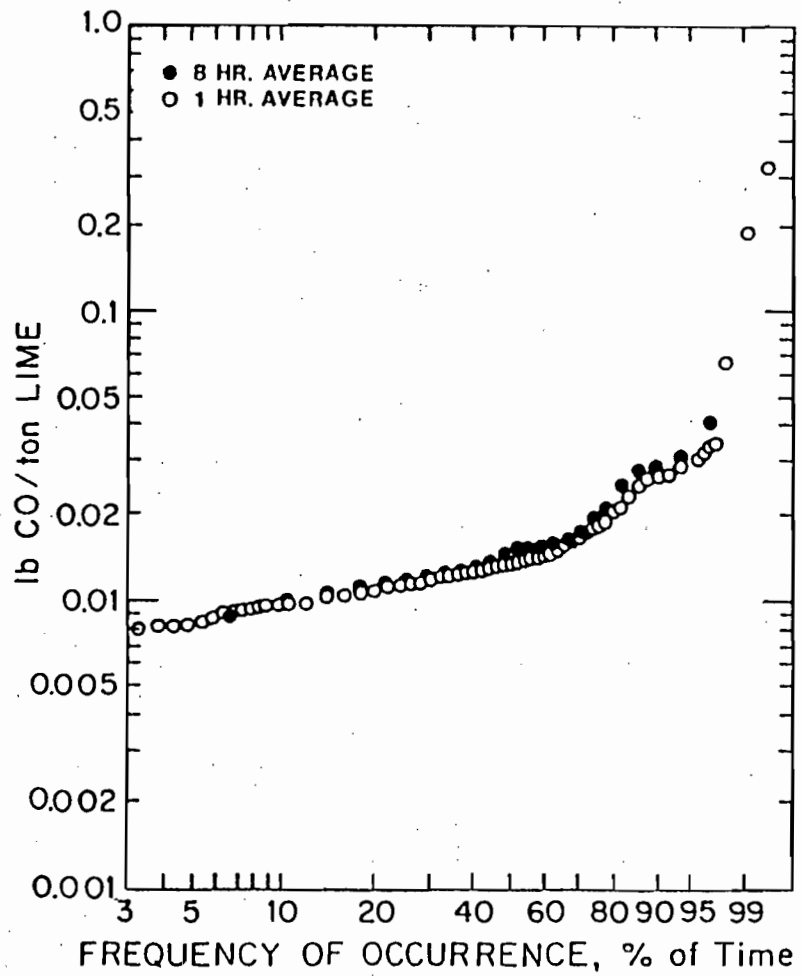


FIGURE 24

FREQUENCY OF OCCURRENCE OF CO EMISSIONS MEASURED AT LIME KILN A

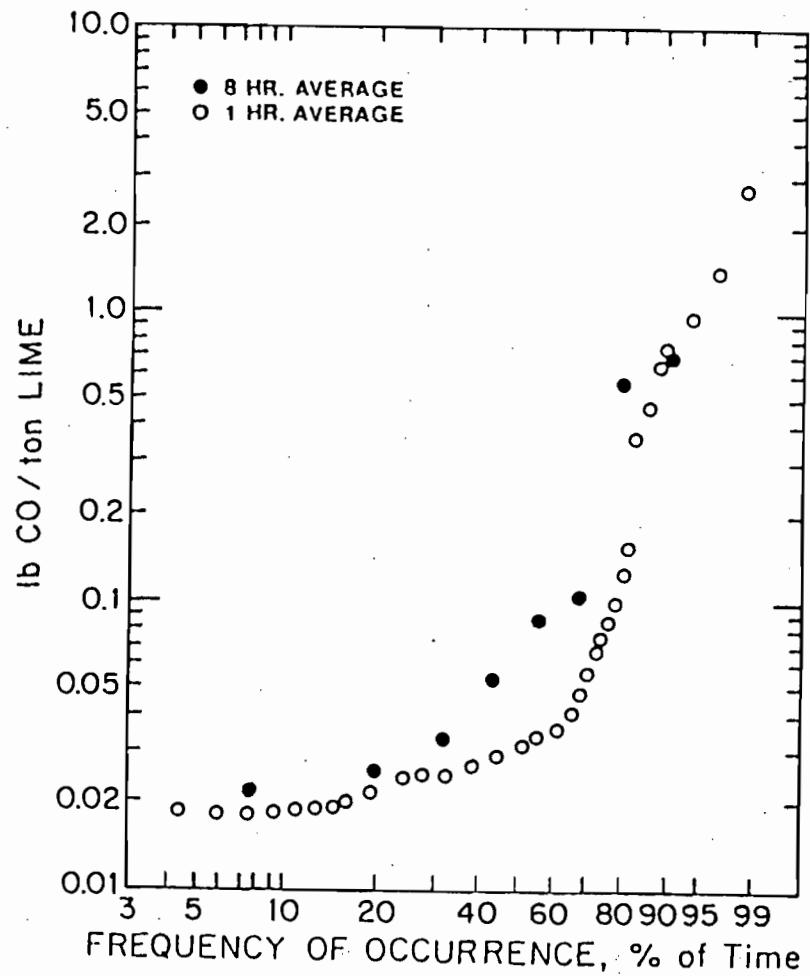


FIGURE 25

FREQUENCY OF OCCURRENCE OF CO EMISSIONS MEASURED AT LIME KILN B

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NATIONAL COUNCIL OF THE PAPER INDUSTRY FOR AIR AND STREAM IMPROVEMENT, INC., 260 MADISON AVENUE, NEW YORK, N.Y. 10016

A STUDY OF KRAFT PROCESS LIME KILN
TOTAL GASEOUS NON-METHANE ORGANIC EMISSIONS

TECHNICAL BULLETIN NO. 358

SEPTEMBER 1981

The National Council is currently surveying total gaseous non-methane organic emissions from selected sources in the forest products industry to provide a data base on potential emissions to be expected from various sources. It is the aim of this project to produce data consistent with the EPA reference method to be selected for the measurement of total gaseous non-methane organic compounds (TGNMO). The sampling and analysis procedures used in this study were in accordance with proposed EPA Method 25, published in the Federal Register October 3, 1980 (Appendix A) (2).

The EPA analytical procedure yields values for carbon monoxide, carbon dioxide, methane and total gaseous non-methane organics. The analytical procedure was altered to produce results for ethane and ethylene. Methane and ethane are not photoreactive and were not included in the results. The total gaseous non-methane organics (TGNMO) results are reported as methane. The following presents and discusses the sampling equipment, the procedures used, and results obtained from the kraft process lime kiln portion of this study. The kilns sampled were considered as representative of current kiln design and operating practices.

II KILN DESCRIPTIONS

Three lime kilns were sampled for TGNMO emissions both before and after wet scrubbers.

Kiln A is a rotary kiln manufactured by Allis Chalmers and began operation in 1968. The kiln is 9 ft. in diameter and 250 ft. long and can be fired on either gas or oil. Noncondensable gases from the pulp mill are not burned in the kiln. The kiln was designed to produce lime for production of 106 tons per day CaO (425 TPD of unbleached pulp). Fresh water was used throughout the causticizing system. Particulate emissions were controlled with a Chemico venturi type scrubber, which used fresh water for makeup.

Kiln B is a rotary kiln manufactured by Allis Chalmers and began operation in 1964. The kiln is 8 ft. in diameter and 250 ft. long and can be fired with either gas or oil. Noncondensable gases from the pulp mill were burned in the kiln. The kiln was designed to produce 90 tons per day CaO (360 tons pulp per day) but normally operated at 120 to 140 tons per day CaO. Evaporator condensates are used as makeup water throughout the causticizing system and in the scrubber. Particulate emissions were controlled with a Peabody bubble tray falling film scrubber.

Kiln C is a rotary kiln manufactured by Taylor Co. and began operation in 1980. The kiln is 11 ft. 6 in. in diameter and 330 ft. long. Combustion air was preheated by flowing over the outside of the hot end of the kiln. Noncondensable gases were burned in the kiln. The kiln was designed to produce 245 tons per day product (980 tons pulp per day). Fresh water was used for makeup throughout the causticizing system. Particulate emissions were controlled by

an Air Pollution Industries venturi scrubber operating at a 30 to 32 in. pressure drop. Fresh water was used throughout the causticizing system for makeup.

III SAMPLING AND ANALYSIS METHOD

The procedure used for data collection was similar to the one developed by the Southern California Air Pollution Control District and EPA method 25 (Appendix A) procedures. The principle of the procedure is to separate organic compounds at the time of collection into high and low molecular weight fractions using a cold trap (-78°C). The light components are captured in an evacuated tank. The trap containing condensed organics is burned to convert organics to CO₂ for analysis in the laboratory. The light organics captured in the evacuated tank are separated on a chromatographic column yielding concentrations for CO, CH₄, CO₂, C₂H₆ and C₂H₄. All other organics are eluted in one peak. Summation of the trap and tank organic results gives TGNMO stack concentrations. All results are reported as methane.

A. Sampling

Field samples were taken simultaneously in duplicate through separate 1/2 in. stainless steel probes. The stack end of the probes were filled with glass wool before each sample was drawn to prevent collection of particulates in the traps. Six feet of 1/8 in. stainless steel tubing ran from the probes to the traps which were submerged in granular dry ice. The connection between the probe and sampling line was kept inside the stack during sampling. Schematics of the trap construction and sampling assembly are presented in Figures 1 and 2, respectively. Condensable organics and water vapor were captured in the traps. From the traps the gas flowed through a rotometer, a flow control valve, and into a 17-liter evacuated stainless steel tank.

All screw connections in the sampling system were checked for leaks in the field before sampling by pressurizing with air at 30 psi and soaking the joints individually with soapy water. Leaks detected were eliminated prior to sampling.

Sampling flow rates were set at about 230 ml/min so that about 13 liters of sample were collected in the one hour sampling period. When a trap froze due to condensation of stack moisture, the trap inlet was heated momentarily with a propane torch to melt the ice. The sampling system was watched closely to maintain the proper flow rate. After sampling, the trap and 6-foot section of line to the probe were capped and transported to the laboratory packed in dry ice. Tank pressures were measured before and after sampling to determine sample size. Orsat analyses were made for CO₂ and O₂ during sampling.

$$SSc = \frac{Tc^2}{n} - \frac{T^2}{N}$$

$$SSt = \sum x^2 - \frac{T^2}{N}$$

$$SSr = SSt - SSc$$

Shown below is a table to calculate the mean squares and separate estimates of variance due to analytical or wood-residue boiler sources.

Source of Variation	Squares (SS)	Freedom (DF)	Square, (MS) (MS=SS/DF)	Mean Square Ratio (MSR)	Parameters Estimated
Boilers	SSc	c-1		$\frac{MSc}{MSr}$	$\sigma^2 + n\sigma_a^2$
Experimental	SSr	c(n-1)			σ^2

When the MSR is less than the appropriate F statistic from the F distribution tables, the variation appearing in the data is due to the randomness resulting from the analytical procedures and not necessarily from the source.

An estimate of the variance of the TGNMO from the boilers is calculated by:

$$S_a^2 = \frac{SSc/(c-1) - SSr/c(n-1)}{n}$$

An estimate of the variance of the analytical procedure (S_r^2) is given by σ^2 .

VI RESULTS

All the TGNMO ppm results were corrected for the CO₂ interference as shown in Appendix B. Average CO₂ interferences were 73, 62, and 34 ppm, which represented 75%, 19%, and 109% of the corrected TGNMO for kilns A-C, respectively. The subsequent data presented in this report has been corrected for the CO₂ interference.

Table 6 presents TGNMO emission data in terms of ppm CH₄, lb/ton lime produced, and lb/ton unbleached pulp, along with kiln operation information. The TGNMO emissions expressed as lb/ton unbleached pulp was calculated by assuming 0.3 tons of lime are required to produce 1 ton of pulp. Average TGNMO emissions from the kilns were 0.41, 1.6, and 0.24 lb/ton CaO produced or 0.12, 0.48, and 0.07 lb/ton pulp produced for kilns A-C, respectively. In terms of energy input to the kilns, the TGNMO emissions were 0.060, 0.30, and 0.037 lb/10⁶ Btu, respectively.

Kiln B produced the highest emissions. The high TGNMO emission rate from this kiln likely resulted from organics introduced to the lime mud by the use of evaporator condensates in the lime mud washing system and at the scrubber. These organics were driven into the gas stream at the cold end of the kiln where the lime mud is dried at the scrubber.

Fresh water was being used in sprays to further wash the mud on the lime mud filter for the first 5 data entries for lime kiln B in Table 6. The TGNMO emissions were higher when fresh water was being used than when evaporator condensates were being used on the lime mud filter sprays. This result is contrary to what may be expected if the organic compounds emitted were introduced to the process through the wash water.

The TGNMO emissions from kiln A could also be due in part to organic compounds contained in the water associated with the lime mud rather than from uncombusted fuel. This kiln and causticizing system was operating over capacity and there were green liquor dregs in the lime mud. Dregs are composed of unburned carbon and products of corrosion contained in the smelt from the recovery furnace. Between 40 to 56% of dregs are lost upon ignition (6). It is possible that the unburned carbon contained volatile organic compounds and were emitted at the cold end of the kiln during drying.

To assess if the TGNMO emissions were associated with the lime mud or a product of combustion, a laboratory study on the lime mud organic content was performed. A measured quantity of lime mud from kiln A was heated to drive off water and organic compounds into the sample preparation system in the TGNMO analysis procedure. Results showed a potential emission rate of 0.44 lb TGNMO per ton lime produced when heated. Corrected field sampling results showed emissions of 0.37 lb/ton lime produced at the time the lime mud sample was collected.

It appears that organics present in the lime mud may be responsible for a significant portion of TGNMO emissions from this kiln. More studies of a similar nature on other lime kilns and a variety of lime muds are advisable to better define this potential relationship.

TGNMO emissions from kiln C were the lowest of the three kilns studied. This kiln burned noncondensable gases. It is not known whether burning of noncondensable gases contributes to TGNMO

TABLE 6 LIME KILN TGNMO EMISSIONS AND OPERATING PARAMETERS

ppm CH ₄	TGNMO		Stack Flow DSCFM	Lime Produced Tons/hr	Gas Burned cfm	Oil Burned gpm	10 ⁶ Btu Input Ton CaO	TGNMO lb/10 ⁶ Btu
	lb/Ton CaO	lb/Ton Pulp						
<u>Kiln A</u>								
112	0.52	0.16	10,700	7.0	650		5.7	0.091
214	0.96	0.29	12,200	8.2	-	-		
82	0.37	0.11	12,200	8.2	-	-		
126	0.49	0.15	9,400	7.2		4.4	5.5	0.089
62	0.24	0.07	9,400	7.2		4.4	5.5	0.043
1	0.01	0.00	13,200	4.8		4.5	8.5	0.001
121	0.52	0.16	8,000	5.6	550		6.1	0.086
56	0.20	0.06	10,300	8.6		3.8	4.0	0.050
<u>Avg. 97</u>	0.41	0.12						0.060
<u>Kiln B</u>								
570	2.5	0.75	8,600	5.9	500		5.2	0.48
360	2.0	0.60	9,700	5.4	470		5.4	0.37
340	1.8	0.54	9,700	5.4	470		5.4	0.33
180	0.8	0.24	8,700	6.0	546		5.6	0.14
360	1.6	0.49	9,000*	6.0	460		4.7	0.34
250	1.6	0.49	10,400*	4.8	470		6.0	0.26
320	1.2	0.36	8,600	6.8	495		4.5	0.27
240	0.9	0.27	7,300	6.2	500		5.0	0.18
<u>Avg. 328</u>	1.6	0.48						0.30
<u>Kiln C</u>								
38	0.35	0.11	16,800	6.1		5.0	7.4	0.047
26	0.15	0.04	22,000	9.9		5.4	4.9	0.031
43	0.33	0.10	17,800	7.4		4.6	5.6	0.045
18	0.14	0.04	18,600	7.4		4.8	5.9	0.024
<u>Avg. 31</u>	0.24	0.07						

* Flow rates calculated from material balance

emissions. Possible contribution to TGNMO emission from lime mud contaminants was not investigated at this kiln.

TGNMO emission changes across the scrubbers on each lime kiln were monitored by simultaneous sampling before and after the scrubber. Table 7 shows the results. All three kilns showed a slight increase in emissions across the scrubber. The increases found, however, were not statistically significant. A large number of samples would be required to show a definite trend.

TABLE 7 CHANGE IN TGNMO EMISSIONS ACROSS SCRUBBER

	TGNMO Before Scrubber <u>ppm</u>	TGNMO After Scrubber <u>ppm</u>	<u>TGNMO Change</u>
<u>Kiln A</u>	1	63	+62
	122	163	+41
	56	90	+34
<u>Avg.</u>	60	105	+45
<u>Kiln B</u>	195	225	+30
	361	264	-97
	246	263	+17
	198	272	+74
<u>Avg.</u>	250	206	+ 6
<u>Kiln C</u>	20	40	+20
	44	57	+13
<u>Avg.</u>	32	48	+16

The precision of the data as indicated by duplicate samples was obtained from an analysis of variance. Results of the analysis of variance on the TGNMO data in terms of lb/ton CaO produced are listed in Table 8. These results indicated: (1) significant variation in the results not caused by random sampling and analysis error exist in the data from kilns A and B, (2) that the average of a single paired sample is within ± 0.14 , ± 0.64 , and ± 0.19 lb/ton CaO produced of the true value at the 95% confidence level for kilns A-C respectively, and (3) that the average TGNMO emissions reported for each lime kiln are within ± 0.22 , ± 1.33 , and ± 0.08 lb/ton lime produced of the true average at the 95% confidence level for kilns A-C respectively.